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11th October 2013

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INTRODUCTION

University of Novi Sad, Technical faculty “Mihajlo Pupin” from Zrenjanin, in partnership with Politechnica University from Timisoara in Romania, Obuda University from Hungary, Mogilev State University of Food Technologies from Belarus and Slovak University of Technology in Bratislava in Slovak Republic has organized the Third International Conference of Ecology of Urban Areas 2013 (URBANECO 2013). This partnership significaly improves the quality of conference organization and work, as well as contribution in area of regional cooperation with other universities and scientific institutions.

The objectives of the Conference URBANECO 2013 are: presentation of current knowledge and the exchange of experiences from the field of sustainable development of urban areas which is one of the major problems of modern civilization. The ecological aspect is the dominant factor in achieving sustainability. The importance of ecological aspect has developed a need for an International Conference "Ecology of Urban Areas 2013" which has the goal to integrate scientific, technological and experimental knowledge in this field. Another importance is gathering researchers from this field with aim of expanding regional and international cooperation, raising the level of professional and scientific work at University of Novi Sad and Technical faculty “Mihajlo Pupin”, expanding cooperation with institutions and encouraging young researchers within this field. Taking into account that this Conference is international, the importance of this event is obvious for the town of Zrenjanin, Banat region, Vojvodina and Serbia. Organization of URBANECO 2013 by University of Novi Sad, Technical faculty “Mihajlo Pupin” from Zrenjanin represents this scientific-educational institution as one of the major representatives of economic and social development in Banat.

Within this Collection of papers are presented all accepted papers received for III International Conference Ecology of Urban Areas 2013. The papers are divided into following sessions: Air quality, Management of solid urban waste, Water quality in urban areas (ground water, drinking water, waste water and facilities), System of ecological management (ISO 14000), Economics of sustainable development of urban areas, Noise and vibrations in urban areas, Electro and electro-magnetic pollution in urban areas, Climate changes and urban pollution, Spatial planning and greening in urban areas, Development of urban ecology through educative and information activities, ICT in the ecology of urban areas, Accidents in urban areas, Environmental aspects of traffic in urban areas, Impact of agricultural activities to urban area , Public health and the ecology of urban areas, Soil and degradation of soil, Nanotechnology in environmental protection, Transfer stations in the system of management of solid communal waste.

We would like to express our gratitude to the Ministry of Education, Science and Technological Development of Republic of Serbia; Ministry of Energy, Development and Environmemnatl Protection; Provincial Secretariat for Science and Technological Development; Provincial Secretariat for Protection of Environment and Sustainable Development.

Finally, we wish to thank all the authors of papers and participants in the Conference in hope that we will continue our cooperation successfully in the future and that each new year will bring better ideas and solutions to help raise awareness of the responsibility we hold today for the well-being of future generations.

President of the Organizing Committee
Ph.D Milan Pavlović

Zrenjanin, October 2013.

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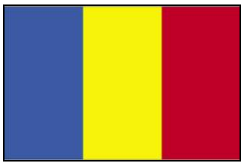
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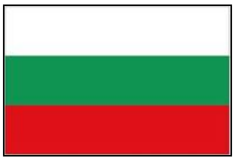
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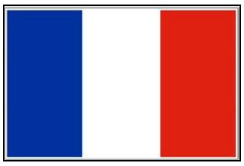
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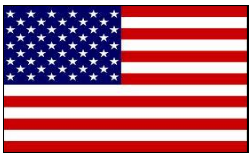
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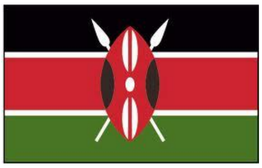
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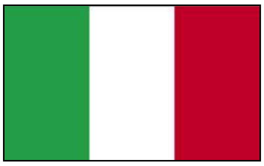
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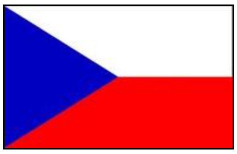
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CONTENTS

AIR QUALITY ... 13

PROPOSAL FOR THE NOX REDUCTION USING A SELECTIVE NON CATALYTIC REDUCTION INSTALATION OPERATING ON A LIGNITE FIRED BOILERS FROM THE TIMISOARA POWER PLANT 14
Daniel Dulcea, Ioana Ionel

MODELLING AIR QUALITY IN URBAN AREAS - APPLICATION FOR TIMISOARA ... 21
Ioana Ionel, Ion Vetres, Nicolae Stelian Lontis

DIAGNOSTICS OF AIR POLLUTANT REMOVABLE POTENTIAL AND ENERGY EFFICIENCY OF POLLUTANT TRANSPORT ... 30
Milan Pavlović, Ioana Ionel, Mirjana M. Ševaljević, Stojan N. Simić

REDUCING AIR POLLUTIONS IN MODERN BUSSES FOR URBAN TRANSPORT ... 36
Željko Marušić

IMPACT EXHAUST EMISSIONS OF MOTOR VEHICLES ON AIR QUALITY IN URBAN AREAS ... 40
Stojan Simić, Miroslav Stanojević, Branko Despotović

INCREASE OF AIR PRESSURE AS A METHOD FOR REDUCING DESTRUCTIVE EFFECTS OF EXPLOSIVE CLOUDS ... 46
Vojkan M. Zorić, Igor J. Šetrajčić

DISTRIBUTION OF THE CONCENTRATION OF SULPHUR DIOXIDE INTO THE ATMOSPHERE FROM POINT SOURCE ... 50
Stevo Jaćimovski, Slobodan Miladinović, Radovan Radovanović, Venezija Ilijazi

AIR QUALITY IN URBAN AREAS IN SERBIA: CURRENT STATE AND LEGAL PROTECTION ... 58
Ana Batrićević, Vera Batanjski

MATHEMATICAL MODELS IN THE ANALYSIS OF SPREADING THE AIR POLLUTION ... 68
Stevo Jaćimovski, Vjekoslav Sajfert, Jovan Šetrajčić, Marija Jaćimovski

LASER APPLICATIONS IN SOME ECOLOGICAL PURPOSES (LASER CLEANING AND ISOTOPE SEPARATION) WITH LINEAR AND NONLINEAR PHENOMENA AND LIDAR METHODS ... 79
Milesa Srećković, Sanja Jevtić, Zoran Fidanovski, Željka Tomić, Nikola Slavković, Vjekoslav Sajfert, Đurđe Milanović, Stanko Ostojić, Nebojša Mitrović

AIR QUALITY MONITORING IN ZRENJANIN ... 90
Igor Rodjenkov

A REAL TIME AIR POLLUTION DISPERSION MODELLING OF PC NUCLEAR FACILITIES OF SERBIA 97
Zoran Grsic, Predrag Milutinovic, Dalibor Arbutina, Miroljub Milinčič, Dragan Dramlic, Zoran Velikic, Stefan Dramlic

EXPOSURE ASSESSMENT FOR THE CHARACTERIZATION OF HEALTH RISK FROM AIR POLLUTION ... 105
Amelija Đorđević, Lidija Milošević, Ivan Krstić, Marija Rašić

IMPACT OF THERMAL POWER PLANTS “NIKOLA TESLA” ON SULPHUR DIOXIDE AIR POLLUTION IN BELGRADE ... 112
Dušan Todorović, Aleksandar Jovović, Dejan Radić, Marko Obradović, Nikola Karličić, Miroslav Stanojević

MANAGEMENT OF SOLID URBAN WASTE ... 119

WASTE MANAGEMENT IN THE EU AND SLOVAKIA ... 120
Ľubomír Šooš, Marta Murgašová

COST ANALYSISOF FACILITY FOR TREATMENT INFECTIOUS MEDICAL WASTEIN THE BIJELJINA REGION ... 127
Slobodan Trifković, Ljubiša Todorović, Aleksandar Djurić, Aleksandar Pavlović

ASSESSMENT OF THE EFFECTIVENESS OF TANNERY BASED SOLID WASTES MANAGEMENT IN ATIENO TANNERIES LIMITED NJIRU DISTRICT IN NAIROBI COUNTY, KENYA ... 133
Richard O. Oruko, Wilkister N. Moturi, John M. Mironga

TREATMENT OF EAF-DUST IN DC PLASMA FURNACE - OFF-GAS COMPOSITION MODELLING AND COMPARISON WITH REAL MEASUREMENTS 143
Vaso Manojlović, Željko Kamberović, Marko Simić, Dragana Ivšić-Bajčeta, Marija Korać, Milan Pavlović, Aleksandar Tomović

THE ASSESSMENT OF THE DANUBE AND TISZA WATER QUALITY IN SERBIA 149
Svetlana Vujović, Srđan Kolaković, Borislav Mašić, Slobodan Kolaković, Goran Jeftenić

DECREASING VULNERABILITY OF RECYCLING SYSTEM OF ELV IN SERBIA THROUGH THE INTEGRATION PROCESESS 155
Slavko Arsovski, Aleksandar Aleksić, Miodrag Lazić, Danijela Tadić

AWARENESS ON WASTE MANAGEMENT IN THE CITY OF ZRENJANIN 165
Mila Zakin, Ljiljana Radovanović, Jasmina Pekez, Živoslav Adamović, Ištvan Kucora

TEXTILE RECYCLING 173
Snežana Filip, Stanislava Sinđelić, Zoltan Kazi

WATER QUALITY IN URBAN AREAS (GROUND WATER, DRINKING WATER, WASTE WATER AND FACILITIES) 180

NUTRIENT REMOVAL FROM DOMESTIC WASTEWATER BY PURE (CHLORELLA VULGARIS) AND MIXED ALGAL CULTURES 181
Gece Cansu Ogut, Burak Cakirlar, Baris Kaymak, Tuba Hande Erguder, Sibel Uludag-Demirer, Durmus Kaya, Goksel N. Demirer

PROJECT PEDAGOGY EFFECTIVENESS EVALUATION IN HIGHER EDUCATION 191
Rita Bodáné Kendrovics

MODELING COMPETITION AMONG ACETICLASTIC METHANOGENIC SPECIES DURING ANAEROBIC DIGESTION OF MUNICIPAL BIOSOLIDS 202
Bryce Figdore, Vedat Yilmaz, Yasemin D. Yilmazel, Metin Duran

COUPLED PROCESS OF NUTRIENT REMOVAL AND BIOGAS PRODUCTION USING CHLORELLA VULGARIS 206
Özgül Çalıcıoğlu, Göksel N. Demirer

INFLUENCE OF ECOLOGICAL FACTORS TO PLANTS GROUPS IN INUDATION 216
Ivana Letic, Dusko Letic, Vesna Nikolic, Petar Sekulić, Ljubomir Letic

THE UNIQUE AND UNUSUAL PHYSICO-CHEMICAL CHARACTERISTICS OF ORGANIC EMERGING CONTAMINANTS 220
Mirjana Vojinović Miloradov, Ivan Spanik, Olga Vyviurska, Jelena Radonić, Ivana Mihajlović

OPTIMIZATION OF THE GREEN-PROCESS OF AMMONIA REMOVAL FROM WASTEWATER USING NANOPOROUS SORBENT 225
Kiril Lisichkov, Stefan Kuvendziev, Mirko Marinkovski, Gjorgji Zhezhov, Goran Nachevski, Snežana Filip

INFLUENCE OF PROCESS PARAMETERS ON AERATION ENERGY CONSUMPTION IN AEROBIC BIOLOGICAL TREATMENT OF MUNICIPAL WASTEWATER 231
Stojan Simić, Branko Despotović, Snježana Vujić

NATURAL REMOVAL OF SELECTED EMERGING POLUTANTS DUE TO THE RIVER BANK FILTRATION 238
Srđan Kovačević, Mirjana Vojinović Miloradov, Maja Sremački, Jelena Radonić, Anđelka Petković, Milan Dimkić

GROUNDWATER ARSENIC CONTAMINATION IN ZRENJANIN AREA 243
Jelena Kiurski-Milošević, Mirjana Vojinović Miloradov, Danijela Jašin, Aleksandra Šućurović, Gordana Ludajić

SORBENTS WITH MAGNETISM FOR FACILE SEPARATION HEAVY METALS FROM THE REACTION SYSTEMS 252
Aleksandra Šućurović, Jelena Tričković, Danijela Jašin, Jelena Kiurski-Milošević, Dragan Halas

INDICATORS OF HYDROGEN DEPOLARIZATION AND OXYGEN SURFACE POTENTIAL SEASONAL CHANGES IN URBAN RIVER WATER 257
Petar Ševaljević, Desanka Tošić, Tatjana Nikolin, Natalija Aćin, Mirjana Ševaljević

INVESTIGATION OF POSSIBILITIES OF EAFD PRETREATMENT BY PELLETIZATION AND HEAT TREATMENT FOR ZINC VALORIZATION........ 262
Marko Filipović, Željko Kamberović, Zoran Anđić, Marija Korać, Milan Pavlović

THE POTENTIAL OF CARBON NANOMATERIALS FOR REMOVAL OF HEAVY METALS FROM WATER/WASTEWATER 269
Aleksandra Šućurović, Danijela Jašin, Jelena Kiurski-Milošević, Ivana Marković, Gordana Ludajić

URBAN RIVER WATER INFLUENCE ON SEASONAL POLLUTANTS FREE ENERGY CHANGES 273
Milan Pavlović, Miladin Ševaljević, Tatjana Nikolin, Mirjana Ševaljević

HEAVY METAL REMOVAL FROM WATER/WASTEWATER BY NANOMATERIALS WITH POROUS AND POLYMER SUPPORTS 278
Aleksandra Šućurović, Jelena Tričković, Danijela Jašin, Jelena Kiurski-Milošević, Ivana Marković

THE STUDY OF SEASONAL DEPENDENCE OF NOM CONTENT IN GROUND WATER ON IRON AND MANGANESE........ 283
Zoran Protić, Isidora Protić, Natalija Aćin, Mirjana Ševaljević

THE CONCEPTS OF WATER QUALITY........ 287
Milan R. Vujašanin, Goran V. Janjić

ASSESSMENT OF VOLUME OF COMMUNAL WASTEWATER IN AUTONOMOUS PROVINCE OF VOJVODINA 293
Duško Medić

GAS CHROMATOGRAPHY SCREENING OF ORGANIC POLLUTANTS AND CHARACTERISATION OF NATURAL ORGANIC MATTERS PRESENT IN DANUBE WATER........ 302
Olivera Paunović

SYSTEM OF ECOLOGICAL MANAGEMENT (ISO 14000)........ 309

INTEGRATED MONITORING SYSTEM OF LARGE ADMINISTRATIVE-ECONOMIC REGION IN TECHNOGENESIS 310
Alexandr Mirontchik

SLOVENIAN STEEL PRODUCERS AND ENVIRONMENT........ 319
Borut Kosec, Gorazd Kosec, Igor Budak, Blaž Karpe, Mirko Soković

ENVIRONMENTAL MANAGEMENT SYSTEMS IN URBAN AREAS – PROCESS OF ISO 14000 STANDARDS SERIES IMPLEMENTATION........ 325
Živko Kondić, Veljko Kondić, Milan Kljajin, Milan Opalić

KINETICS OF CRYSTALLIZATION OF ZEOLITES OBTAINED FROM WHITE OPALIZED TUFF - MACEDONIA 335
Blagica Cekova, I. Nasev, Vesna Markoska

REVIEW OF METHODS FOR OCCUPATIONAL AND ENVIRONMENTAL RISK ASSESSMENT........ 339
Evica Stojiljkovic, Srdjan Glisovic, Tatjana Golubovic

OPTICAL AND LASER METHODS IN SUGAR CONTENTS MEASUREMENTS AND DIAGNOSTICS IN VARIOUS APPLICATION........ 344
Veljko Zarubica, Milesa Srećković, Vjekoslav Sajfert, Dragan Marinović, Miomir Vasiljević, Snežana Popović, Đurđe Milanović, Sanja Jevtić, Slobodan Obradović, Srđan Milanović

PROMOTION AND VISIBILITY OF PROJECTS IN THE FIELD OF ENVIRONMENTAL PROTECTION .. 350
Milan Nikolić, Dejan Đorđević, Edit Terek

IMPLEMENTATION OF THE IPPC AND EU DIRECTIVES IN LAW OF REPUBLIC OF SERBIA 356
Bogdana Vujić, Nadežda Ljubojev, Marko Simić

ECONOMICS OF SUSTAINABLE DEVELOPMENT OF URBAN AREAS........ 365

ROD PICKER – A NOVEL SOLUTION FOR SHORT ROTATION COPPICE PLANTATIONS 366
Ioana Ionel, Dumitru Tucu, Raul Ionel, Sorin Nanu

CLEAN TECHNOLOGIES AND REGIONAL ECONOMIC DEVELOPMENT........ 375
Dejan Đorđević, Dragan Ćoćkalo, Bojana Gligorović, Dragana Sajfert

CONCEPTUAL MODEL OF ECOLOGICAL MAINTENANCE DEVELOPMENT PROJECT OF THE ECONOMY IN UNDEVELOPED LOCAL COMMUNITY 381
Vojislav Stamenković, Nebojsa Gošnjić

SUSTAINABILITY OF RECYCLING IN VIEW OF ENERGY EFFICIENCY IN THE END-LIFE VEHICLE (ELV) 391
Dragiša Tolmač, Jasna Tolmač, Slavica Prvulović, Milan Pavlović

ADDITIONAL INFORMATION TOWARD INTER MUNICIPAL AGREEMENT EFFECTIVENESS 396
Nedeljko Ćurić

ECOLOGY - CONCEPT OF SUSTAINABILITY 400
Ivan Tasić, Dragana Glušac, Dijana Karuović, Jelena Jankov, Dajana Tubić

MULTICRITERIA DECISION MAKING FOR SUSTAINABLE ENVIRONMENTAL PROTECTION 406
Milorad Miloradov, Serafim Opricovic, Nemanja Stanisavljevic

THE UTILIZATION OF RECYCLED PULYETHYLENE TEREPHTHALATE (PET) AS A MATERIAL IN THE BUILDING INDUSTRY 416
Aleksandar Tomović, Zlatibor Veljković, Milan Pavlović, Dragan Jevtić, Marko Simić, Vaso Manojlović

POSSIBILITY OF USAGE OF WIND AS ENERGY 424
Ivan Đurić

NOISE AND VIBRATIONS IN URBAN AREAS 432

ENVIRONMENTAL ASPECTS AND NOISE IN THE OPERATION OF A WATER JET CUTTING MACHINE 433
Viara Požidajeva, Katarina D. Živković, Dragan Živković

NOISE AS FACTOR OF LIVING IN URBAN AREAS 442
Rakić Boris, Ivanović Lozica, Josifović Danica, Ilić Andreja

CLIMATE CHANGES AND URBAN POLLUTION 450

THE SOCIAL ASPECTS AND ROLE OF GREEN INFRASTRUCTURE IN MITIGATING CLIMATIC CHANGES AT REGIONAL LEVEL 451
Miglena Zhiyanski, Vania Doichinova, Konstantin Petrov

SATELLITE OBSERVATION OF THE EARTH – A TOOL FOR CLIMATE CHANGES MITIGATION AND URBAN POLLUTION MANAGEMENT 459
Snežana Komatina Petrović, Halid Žigić

SPATIAL PLANNING AND GREENING IN URBAN AREAS 468

TOWARDS SUSTAINABLE URBAN MODEL – A FRAMEWORK FOR DEVELOPING INDICATORS FOR PLANNING AND DESIGNING NETWORKS OF GREEN SPACES IN URBAN CENTERS IN SERBIA 469
Slobodan Milutinović, Petar Vranić, Milica Maksić

MODERN ACQUISITION TECHNOLOGY OF SPATIAL DATA AS A BASIS OF URBAN PLANNING 479
Toša Ninkov, Vladimir Bulatović, Zoran Sušić, Dejan Vasić

AN APPROACH FOR RESEARCHING URBAN AND METROPOLITAN AREAS UNDER THE CONDITIONS OF DYNAMIC CHANGES 486
Jasna Petrić, Nikola Krunić

DEVELOPMENT OF URBAN ECOLOGY THROUGH EDUCATIVE AND INFORMATION ACTIVITIES 496

ECOLOGICAL ASPECTS OF ENGINEERING DESIGN 497
Eleonora Desnica, Milan Nikolić, Edit Terek, Ljiljana Radovanović

ENGLISH VOCABULARY PRACTICE FOR STUDENTS OF ECOLOGY 502
Erika Tobolka

GENERAL CHARACTERISTICS OF ANIMAL PROTECTION FROM KILLING AND ABUSE IN SERBIAN LEGAL SYSTEM 508
Nadežda Ljubojev, Dragica Ivin, Marijana Dukić-Mijatović

ICT IN THE ECOLOGY OF URBAN AREAS 517

APPLICATION OF ICT AS A NECESSARY TOOL OF EMERGENCY RESPONSE IN URBAN AREAS..... 518
Vesela Radović, Bogdana Vujić, Dušanka Lečić

USING BASELOG SYSTEM IN ECOLOGY 525
Zoltan Kazi, Biljana Radulovic, Ivana Berkovic

ACCIDENTS IN URBAN AREAS 532

THE SIGNIFICANCE OF BIOINDICATORS IN THE PREVENTION OF ENVIRONMENTAL DISASTERS533
Judit Németh-Katona

ENVIRONMENTAL IMPACT ASSESSMENT OF ACCIDENTS IN FOOD PROCESSING INDUSTRY - EXAMPLES OF GOOD ENGINEERING PRACTICE 540
Tatjana Golubović, Srđan Glišović, Evica Stojiljković

ARROGANT URBANISM AND DISAPPEARING OF GREEN OASES IN RESIDENTIAL AREAS 544
Katarina Jevtić-Novaković, Marina Nikolić-Topalović, Sara Đalović

ENVIRONMENTAL ASPECTS OF TRAFFIC IN URBAN AREAS 551

HEAVY METALS ACCUMULATION IN ENVIRONMENTAL OBJECTS OF AREAS ADJACENT TO THE HIGHWAYS 552
Alexandr Mirontchik

IMPROVEMENTS OF NEW ECE REGULATION FOR BETTER ASSESSMENT OF VEHICLE NOISE EMISSION IN URBAN AREAS 560
Slobodan Janković, Velimir Petrović, Vladimir Šinik

MANAGING THE YELLOW LANES BY MEANS OF “CAR SHARING“ STRATEGY AND BY APPLYING FUZZY LOGIC 566
Branko Davidović, Duško Letić, Aleksandar Jovanović

REGIONAL CLUSTER AS AN ORGANIZATIONAL MODEL FOR INCREASING THE EFFICIENCY OF THE MOTOR VEHICLES RECYCLING 573
Marko Simić, Milan Pavlović, Aleksandar Tomović, Vaso Manojlović , Marko Filipović

FACTORS THAT INFLUENCE THE VULNERABILITY OF THE MOTOR VEHICLES RECYCLING SYSTEM IN SERBIA 578
Aleksandar Tomović, Milan Pavlović, Marko Simić, Aleksandar Pavlović

TRANSFER STATIONS IN THE SYSTEM OF MANAGEMENT OF SOLID COMMUNAL WASTE ... 585

POLYOLEFINS’ PROCESSING IN TERMS OF ENVIRONMENTAL PROTECTION...... 586
Nina Djapić, Zlatibor Veljković

SOIL AND DEGRADATION OF SOIL 590

ECOLOGICAL MONITORING OF SEWAGE SLUDGE AMENDMENT TO SOIL ON HEAVY METAL ACCUMULATION AND CONSEQUENT RESPONSES OF HELIANTHUS ANNUUS PLANT...... 591
Hosam E.A.F. Bayoumi Hamuda, Csilla Patkó, István Patkó

EFFECTS OF NITRIFICATION INHIBITORS AND NITRATE SOURCES ON ROOT COLONIZATION OF FABA BEAN BY RHIZOBIUM LEGUMINOSARUM...... 601
Hosam E.A.F. Bayoumi Hamuda

PUBLIC HEALTH AND THE ECOLOGY OF URBAN AREAS 609

MULTIELEMENT PROFILES OF CHILDREN IN URBAN ENVIRONMENTAL CONTEXT...... 610
Tatsiana Krukouskaya, Elena Sinevich, Sergey Zagorsky, Sergey Melnov, Maria Golovach

CHANNEL TYPE UV REACTOR FOR SUGAR SYRUP STERILIZATION...... 620
Đurđe Milanović, Vjekoslav Sajfert, Slobodan Obradović, Srđan Milanović, Ivan Kunosić

NANOTECHNOLOGY IN ENVIRONMENTAL PROTECTION...... 628

ENERGY IN NANOSCIENCE AND TECNOLOGY 629
Vjekoslav Sajfert, Dušan Popov, Dragana Sajfert, Miodrag Popov, Ljljana Mašković

NANOSCIENCE, NANOTECHNOLOGY AND ECOLOGY 640
Vjekoslav Sajfert, Jovan P. Šetrajčić, Stevo K. Jaćimovski, Nicolina Pop, Branimir Sajfert

ELECTRO AND ELECTRO-MAGNETIC POLLUTION IN URBAN AREAS 648

RADIATION OF ELECTROMAGNETIC FIELDS AT RADIO FREQUENCIES 649
Kemal Dervić, Vladimir Šinik, Željko Despotović, Momčilo Bjelica, Vojin Kerleta

MEASURING THE ELECTROMAGNETIC FIELD IN URBAN AREAS 657
Svetislav Lazarev, Luka Nenadović

RADIOFREQUENCY RADIATION OF GSM NETWORKS 662
Vladimir Šinik, Željko Despotović, Slobodan Janković, Momčilo Bjelica, Vojin Kerleta

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PROPOSAL FOR THE NOX REDUCTION USING A SELECTIVE NON CATALYTIC REDUCTION INSTALATION OPERATING ON A LIGNITE FIRED BOILERS FROM THE TIMISOARA POWER PLANT

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ABSTRACT

This paper focuses to the reduction and removing of harmful substances - pollutants – such as nitrogen oxides (NOX) contained in the flue gas produced by the power plants in Romania, by injecting different chemicals into the hot flue gases, using specialized injectors. Given the low level of NOX concentration required by law at the level of 200 mg / Nm3 (in reference to 6 % O2) in the output flue gases, primary measures, consisting of a judicious management of combustion air and combustion in stage, are not sufficient. Intervention is required such as secondary measures. One of the best solutions to reduce NOX is to use a selective non catalytic reduction (SNCR) technology, applied to the flue gases in a separate plant. The pollutant NOX can be reduced using agents such as ammonia (gas, liquid) or urea solution. Such a facility will be installed into three Lignite fired boilers of the Power plant Timisoara South (CET Timisoara Sud). Because of the simple storage and handling, not mentioning the security and price, the urea solution is preferred, comparing to the ammonia solution. The urea solution is sprayed directly into the combustion chamber, in zones with controlled (known) temperature profiles, depending on the flue gas composition. The present article is dealing with concrete numerical proposals versus the implementation of the technology SNCR in three industrial facilities of the Power plant CET Timisoara Sud.

Key words: *nitrogen oxides, urea, selective non catalytic reduction SNCR, pollutants, lignite fired boilers.*

INTRODUCTION

Forty years after Lyon's patent [5] defining the conditions for selective, non-catalytic NO reduction to N2 by ammonia (SNCR, excess air conditions, 850 to 1100º C), there is continuing industrial interest in its use as a low cost and effective control technique.

The paper presents as background the necessity of the SNCR technology and a general description of a SNCR plant, but further, also specific peculiarities, which are currently under installation implementation in CET Timisoara Sud, for three units. The main objective presented in this paper is to reach a high reduction of the NOx degree, with a minimum consumption of reagent. This can be only achieved with an even distribution of reagent in the flue gas at the right temperature. One will pay special attention to find the right position for the injection levels, assuring the right temperature to inject the urea solution on this three lignite fired boilers. It is very important to find the right position and depict the region with optimum temperature window, knowing that, if the temperature in the combustion chamber is too high, a conversion of the NH3-radicals from the urea solution into NOx takes place. This can possibly cause an increase of the NOx - concentration in the exhaust. If the temperature levels are too low, the NH3-radicals will not be conversed, and the NH3 will be emitted to the atmosphere, as ammonia slip and known also as secondary pollutant, being also very dangerous for the climate change and ozone depletion.

SNCR performance depends on factors specific to each source, flue gas temperature, available residence time for the reagent and flue gas to mix and react, amount of reagent injected, reagent distribution, uncontrolled NOx level, and CO and O2 concentrations.

Efficiency of these plants was installed and tested in over 300 utility-scale boilers worldwide,[1], but most SNCR installations in commercial operation are in small scale boilers and in fluidized bed boilers. Experience of SNCR in large coal-fired plants is limited. In Europe, some large coal-fired plants have been equipped with SNCR. In Romania there are no SNCR installation installed on large coal-fired plants up to now. The first steps are presently proposed for the mentioned analyzed case in this paper.

MATERIAL AND METHODS

Global production of biodiesel

The SNCR-plant proposed is consisting of following components:

- Storage tank for reducing agent,
- Circulation pumps for reducing agent (redundant),
- Booster pumps for water (if necessary),
- Air compressor station (if necessary),
- Mixing and Metering Module,
- Injection lances with binary nozzle,
- Pipelines for reducing agent, water and pressurized air (buyer),
- Armatures to regulate and control the fluids,
- PLC (Programmable Logic Controller) for the controlling of the plant.

The reducing agent is filled into the non-pressurized tanks (1) with volumes generally large enough to store the expected consumption for one week base-load operation. The tank is equipped with all necessary armatures and alarms, and is located in a catch basin which can take the total content of the tank if required, so that the reagent cannot get into the ground water. The reducing agent pumping unit contains two pumps (2), from which only one is in operation. The second one is reserve so that the SNCR plant can stay in operation in case of the failure of a pump.

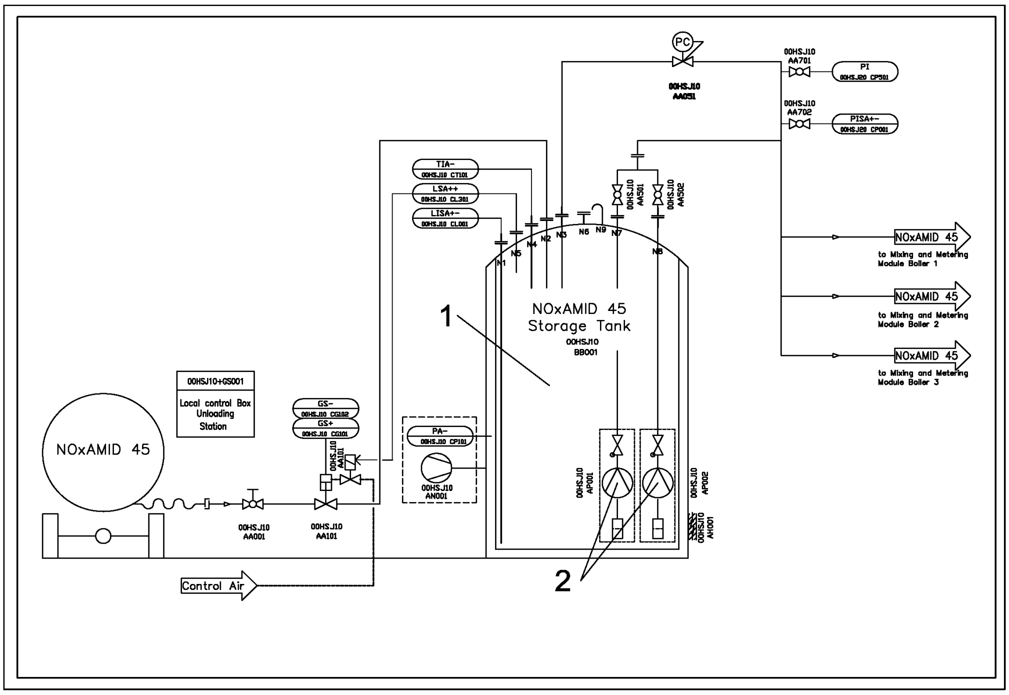

Figure 1. P&I scheme for urea solution storage and pumping:
a) storage tank, b) pumps, (Power plant CET Timisoara Sud) [2]

The reducing agent will be conveyed via circulation pipeline from the storage tank to the Mixing and Metering Module. The Module contains all necessary measuring equipment and valves for the injection of the reducing agent. The injection is situated in the combustion chamber at a temperature between 900 – 1,000 °C. The PLC for measuring and controlling is placed in a control cabinet. The separate control cabinet is located nearby the storage tank.

The SNCR process uses injection nozzles which assure the necessary size and velocity of the liquid droplets, correlated to both the boiler geometry and the flue gas conditions [2]. Each injection lance is equipped with one or more nozzles to ensure an equal distribution of the diluted reducing agent in the flue gas. Because of the easy handling, mostly compressed air instead of steam is being used for atomizing.

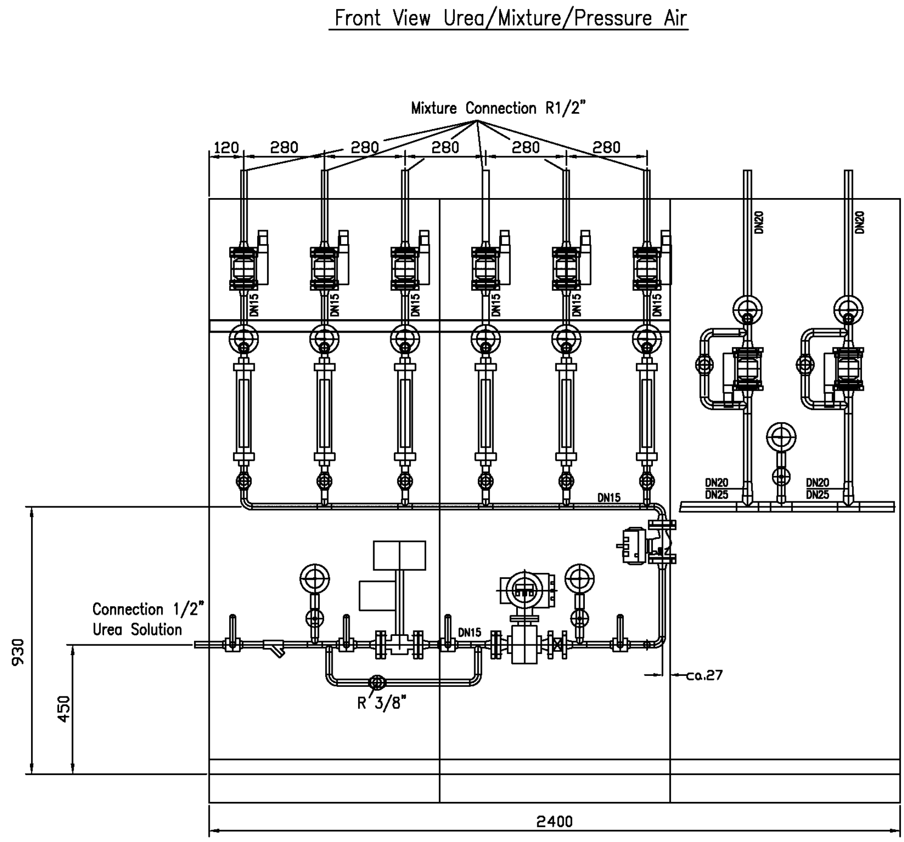

Figure 2. Mixing and Metering Module front View (Power plant CET Timisoara Sud) [2]

Figures 3 and 4 represent the flow of the injection, generated at different levels. Depending on the temperature, the reducing agent will be injected in one of the injection levels. The injection takes place at the level of the optimal temperature range of 900 to 1,000°C. The quantity and positioning of the lances depends on the dimensions of the furnace cross section, the required NOx reduction and the operating conditions. The lances are equipped with an outer mixing chamber where the reduction fluid is atomized by pressurized air. The reduction fluid will pass one or more outlets at the lance tip. The quantity and direction of these nozzles are designed according the injection geometry. The media (air / reducing agent-water mix) are transported to the lances through flexible steel hoses.

Because of the time delay between the injection and the NOx concentration measurement at the stack, the necessary reducing agent flow has to be pre-calculated in order to follow the changing operating conditions as closely as possible.

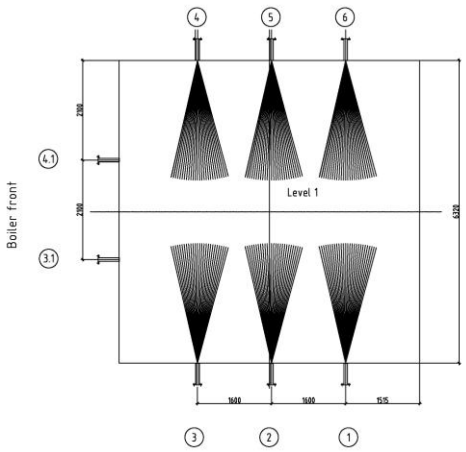

Figure 3. Injection Level 1 (Power plant CET Timisoara Sud) [2]

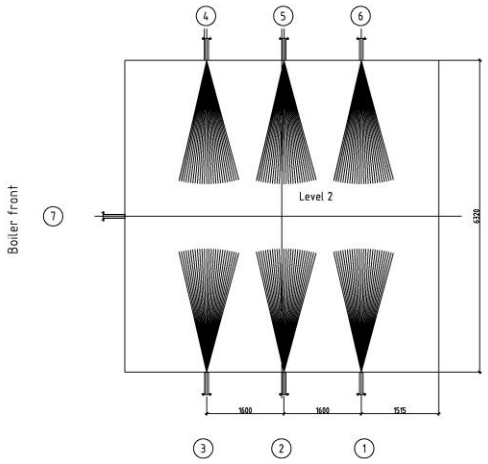

Figure 4. Injection Level 2 (Power plant CET Timisoara Sud) [2]

Regardless of the reducing agent, urea or ammonia water, most SNCR systems use a boiler load signal and a preset NOx set point in order to calculate the required flow of reducing agent. This flow is thus corrected constantly by the NOx signal from the clean flue gas. The design and scope of process control systems may vary depending on the requirements of the user. It can be designed for independent operation but also it can be incorporated into the overall control system of the power plant, respectively boiler. The SNCR NOx reduction plant will be designed to reduce NO emissions at 3 boilers during operation with pulverized coal only or in combination with natural gas support. The boilers are designed to operate within the range (50 - 100) % of the maximum capacity. The SNCR NOx reduction plant will not influence the availability of the boilers and their main operating parameters. The indicated flue gas flow rates refer to 1 boiler in standard condition for operation 100 % with pulverized coal. The indication of the mass concentration of the NOx emission is likewise related to standard temperature and pressure (0°C; 1.013 bar) in the dry flue gas and to 6 % of vol. O2 for operation with pulverized coal. Table 1 is indicating data referring to the guaranteed and real fuel parameters.

Table 1. Given Data and Guaranteed Fuel Parameters [2]

Guaranteed Fuel Parameters		
Net heat capacity of coal	8.026	MJ/kg
Moisture content of coal	43,24	% mass
Ash content of coal	16.34	% mass
Volatile matter	21.0	% mass
C content of coal	24.3	% mass
S content of coal	1.5	% mass
H content of coal	2.13	% mass
N content of coal	0.7	% mass
O content of coal	11.79	% mass
Fuel Parameters Range		
Net heat capacity of coal	7.327-8.793	MJ/kg
Moisture content of coal	32-34	% mass
Ash content of coal	16-30	% mass
Volatile matter	18-23	% mass
C content of coal	19-25	% mass
S content of coal	0.9-1.5	% mass
H content of coal	1.6-2.5	% mass
N content of coal	0.5-0.7	% mass
O content of coal	10-12	% mass
Natural gas fuel		
Lower heating value	35,6	MJ/Nm³

The reducing agent proposed is NOxAMID45 with the following characteristics [2]:

- Chemical characterization: 45 weight-% urea solution with additive
- Density: 1.126 kg/m3,
- pH: app. 9,
- Boiling temperature: 106 - 110 °C,
- Crystallization point: + 11 °C,
- Ignition point: not applicable,
- Explosion limit: not applicable,
- Color: colorless,
- Odor: slightly NH3 odor,
- Form: watery liquid,
- Water risk class according to WHG: Class 1 (WHG: Wasserhaushaltsgesetz; German water law),
- Consumption estimate of reducing agent for a line: 69 kg/h maxim.

The reducing agent is diluted with process water to insure an effective droplet distribution over the injecting cross section at any NOx baseline value.

The specifications are:

- Pressure: 6 bar (at injection level),
- Temperature: approximately: 10-30°C,
- Carbon hardness: < 260 ppm CaCO3,
- total hardness: < 350 ppm CaCO3,
- Consumption estimate of process water for a line at 100 t/h boiler load: 1,450 kg/h maximum.

The compressed air (6 bars) is used for atomizing the diluted reducing agent and for the control of various components inside the SNCR system. For the control air of the pneumatic drives, compressed dried air without oil is necessary. The transfer point is at the Mixing and Metering Module. Compressed air should also be available for the pneumatic ball-valve in the unloading pipeline at the tank.

Specifications are as follow:

- Pressure: 6 bar (at injection level),
- Pressure-related dew point: -40 °C,
- Temperature: 10-40 °C
- Consumption estimate of compressed air for a line at 100t/h boiler load : 230 Kg/h.

Ecological aspects

After burning coal the quantity of nitrogen oxides, are 95% is the form of NO and 5% NO2. But nitrogen monoxide in the presence of oxygen from air and under the influence of ultraviolet rays becomes nitrogen dioxide a very toxic gas for people and the environment [4].

Given the low level of NO3 concentration required 200 mg / m3N (in reference to 6 % O2) by law in the output flue gases, the proposed SNCR system guarantees a NOX concentration in dry clean gas at stack outlet (referred to 6 % O2) as maximum daily average of 200 mg /m3, at 100 t/h boiler load. The NH3 slip in dry clean gas at stack outlet (referred to 6 % O2) is presumed, according our calculations, by a daily average maxim at 100 t/h boiler load of 20 mg /m3N.

RESULTS AND DISCUSSION

We monitored NOx in the flue load operation without and with SNCR instalation. Monitoring was done within 24 hours. In the first chat we can see the NOx level measured without SNCR installation. Average amounts of NOx measured at the stack was 504.18 mg/ Nm3.

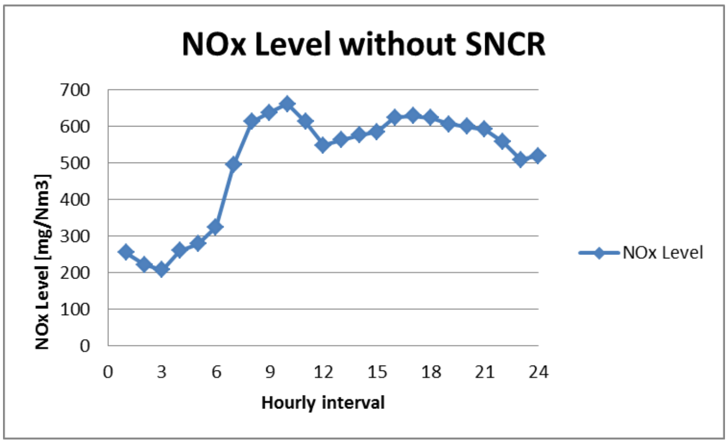

Figure 5. NOx level at full load without SNCR (Power plant CET Timisoara Sud)

In the second chart we can see the NOx mesureg with SNCR installation with boilers at full capacity.

Average amounts of NOx measured at the stack was in one day 293.60 mg/ Nm3.

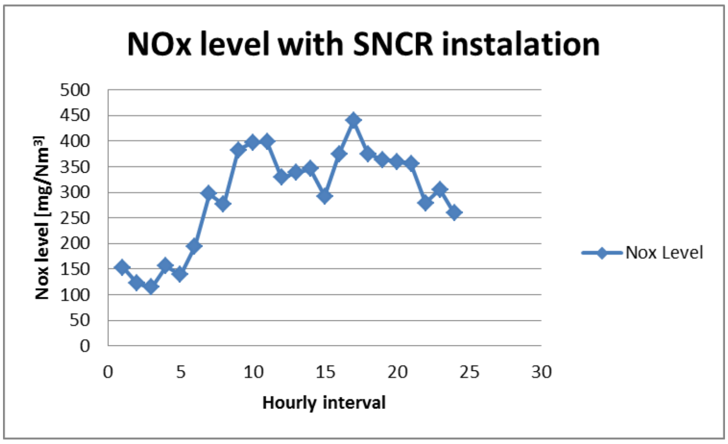

Figure 6. NOx level at full load with SNCR (Power plant CET Timisoara Sud)

In the third chart we can see the urea consumption versus NOx level measured with SNCR installation with boilers at full capacity. Average amounts of NOx in one day measured at the stack was 293.60 mg/ Nm3. The total amount of urea solution consumed in one day was 2454.4 l/day. Averege amount of urea solution to reduce 1 mg/Nm3 of NOx was 0.485 l.

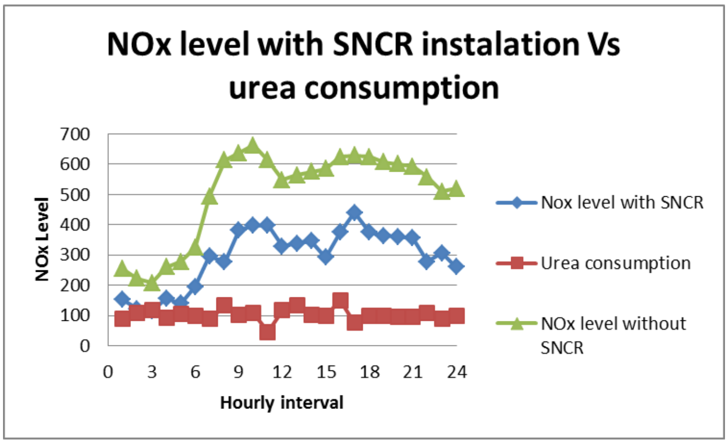

Figure 7. NOx level at full load with SNCR Vs urea consumption
(Power plant CET Timisoara Sud)

In the next chart we can see the NOx level reached with the SNCR installation and the NOx level required.

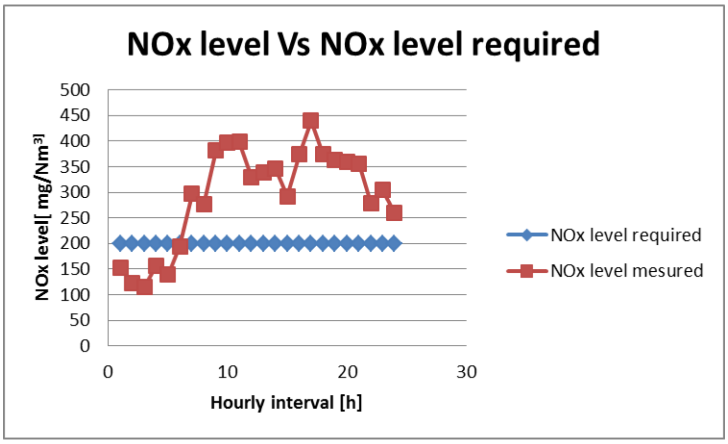

Figure 8. NOx level achived at full load with SNCR Vs NOx level required (Power plant CET Timisoara Sud)

The removal rate of nitrogen oxides contained in the flue gas is around 55%. On this boilers will be also installed primary measures for nitrogen oxides reduction, such as overfire air with a removal rate around 40-50% and flue-gas recirculation with a removal rate around 15-20%. Only after this upgrading we managed to get the amount of NOx required by the law.

CONCLUSION

For solid fuel fired boilers without large variations of load and a stable fuel quality, the SNCR technique is regarded as BAT to reduce NOx emissions as follows: SNCR-BREF May 2005, paragraph 3.4.2.2.[3]

In the world engineers make efforts to optimize the SNCR system with other technologies for controlling NOX and other air pollutants. Some examples that presently one is trying to implement them in Romania in the following years refer to:

1. Gas reburning in combination with SNCR may achieve a reduction up to 70%. This is one of the problem that we will try to resolve in CET Timisoara Sud [1]
2. A SNCR Station can also control others pollutants such as S02, chlorides, heavy metals, and dioxins and furans. That’s possible co-injecting lime slurry with aqueous urea. [1]
3. In many cases the waste water from the power plants can’t be discharged into local streams, rivers, and sewers. The waste water can be injected in the furnaces with simultaneous control of NOx[1]

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MODELLING AIR QUALITY IN URBAN AREAS - APPLICATION FOR TIMISOARA

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ABSTRACT

The paper offers a general out view into the air quality problematic, focussing on special modelling aspects, that enable to detect in real time or broadcast estimated level of pollutants. The research is focussed on the Timisoara study case, thus the results of comparative strategies, depending on local climatic and topography, can be predicted. In addition some new aspects concerning odours determination, by means of specific cells, is presented.

Key words: *Air quality monitoring, pollutants, modeling, odors.*

AIR POLLUTION - A CONSTANT NEED FOR RESEARCH

The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. Recent developments in air pollution modeling and its application are explored in contributions by researchers at the forefront of their field [1], [2], [4]. The present paper is focused on local (urban modeling) data assimilation and air quality forecasting model assessment and evaluation; aerosol transformation, the relationship between air quality and human health and the effects of climate change on air quality being well known.

Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, odors, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment.

An extensive body of scientific evidence shows that long- and short-term exposures to fine particle pollution, also known as fine particulate matter (PM2.5), can cause premature death and harmful effects on the cardiovascular system, including increased hospital admissions and emergency department visits for heart attacks and strokes. Scientific evidence also links PM to harmful respiratory effects, including asthma attacks [6-9].

Figure 1 indicates the major PM sources, depicting the origin of the particles, according to their diameter [4], [5].

Figure 2 [10], [11], [13] brings into attention the damaging effects of cigarette indoor smoking [10].
Ozone can increase the frequency of asthma attacks, cause shortness of breath, aggravate lung diseases, and cause permanent damage to lungs through long-term exposure. Elevated ozone levels are linked to increases in hospitalizations, emergency room visits and premature death.
Both pollutants cause environmental damage, and fine particles impair visibility.
Fine particles can be emitted directly or formed from gaseous emissions including sulfur dioxide or nitrogen oxides. Ozone, a colorless gas, is created when emissions of nitrogen oxides and volatile organic compounds react.

For unhealthy peak levels of sulfur dioxide and nitrogen dioxide, it is demonstrated that they cause multiple adverse respiratory effects including increased asthma symptoms, and are associated with increased emergency department visits and hospital admissions for respiratory illness. Both pollutants cause as well environmental damage, and are byproducts of fossil fuel combustion.

Airborne **lead** pollution now meets national air quality standards, except in areas near certain large lead-emitting industrial facilities. Lead is associated with neurological effects in children, such as behavioral problems, learning deficits and lowered IQ, and high blood pressure and heart disease in adults.

The entire nation meets the carbon monoxide air quality standards, largely because of emissions standards for new motor vehicles under special legislation (Clean Act in USA and EC CEN normative in Europe).

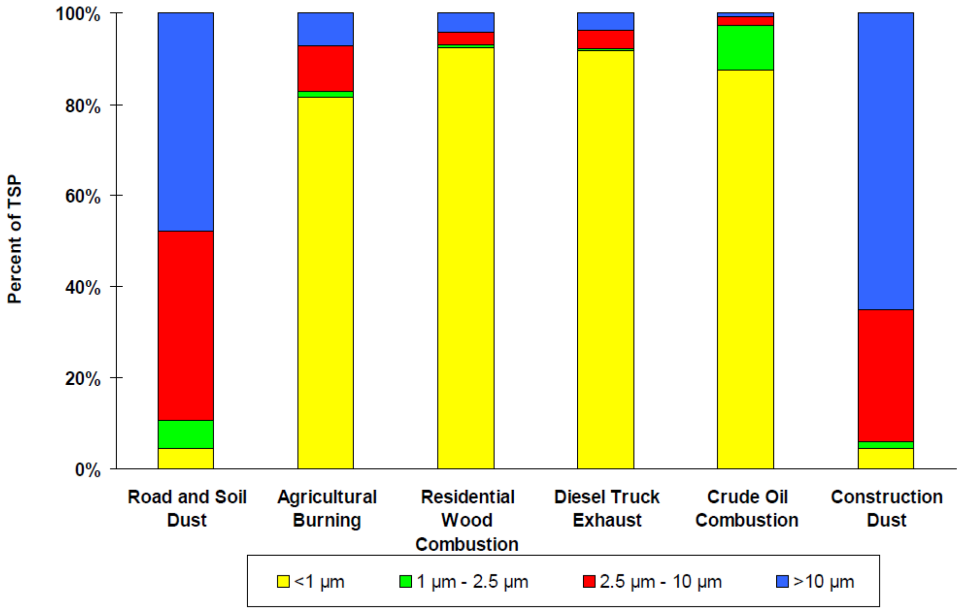

Figure 1. Size distribution of different solid particles (PM) [4]

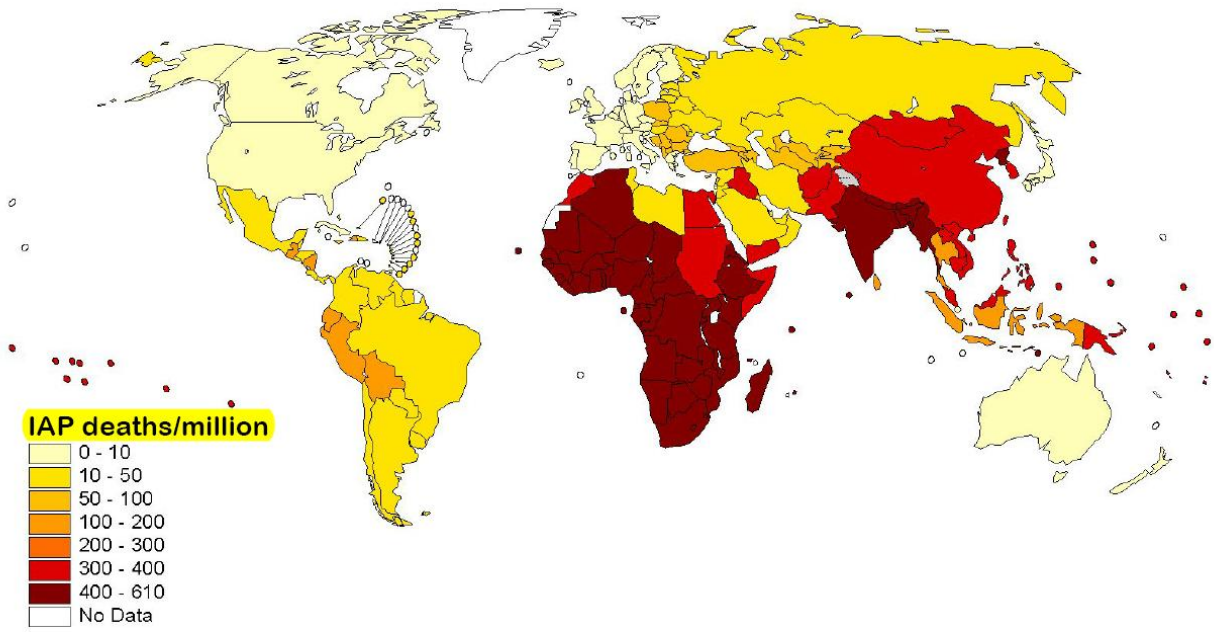

Figure 2. Death from indoor pollution from fossil fuel combustion [10], [11]

STATUS OF COMMON POLLUTANT PROBLEMS IN BRIEF

Legislation is becoming more and more restrictive in reference to pollutants and recently also concerning the Odor Dispersion and Emissions Monitoring System. According to French Environment law L220-2: ''Atmospheric pollution is comprised of [...], introduction by Man, directly or indirectly, or the presence of, in the atmosphere and enclosed spaces, chemical, biological or physical agents which may have a harmful impact and cause olfactory nuisance'', meaning that not only regular pollutants, such as NO_x, SO_2, SO_3, CO, ozone, VOC, PM10, PM2.5, etc., are of importance for the quality of the environment, but also the odors causing discomfort [3].

A substance in the air that can be adverse to humans and the environment is known as an air pollutant. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as primary or secondary. Usually, primary pollutants are directly produced from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulfur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone — one of the many secondary pollutants that make up photochemical smog. Some pollutants may be both primary and secondary: that is, they are both emitted directly and formed from other primary pollutants.

Major primary pollutants produced by human activity include [2], [3], [8-12]:

- Sulfur oxides (SO_x) - especially sulfur dioxide - is a chemical compound produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulfur compounds, their combustion generates sulfur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain.[2] This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
- Nitrogen oxides (NO_x) are generated from high temperature combustion, and are also produced naturally (thunderstorms). Especially NO_2 is a sharp, reddish-brown toxic gas and one of the most prominent air pollutants.
- Carbon monoxide (CO) - is a colorless, odorless, non-irritating but very poisonous gas, considered a product by incomplete combustion of fuel such as natural gas, coal, oil or wood. Vehicular exhaust from automotive systems is a major source of carbon monoxide.
- Volatile organic compounds – VOC's are an important outdoor air pollutant, and are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhance global warming. Other hydrocarbon VOC's are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukemia through prolonged exposure. 1,3-butadiene is another dangerous compound which is often associated with industrial uses.
- Particulates, alternatively referred to as particulate matter (PM), atmospheric particulate matter, or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulates can be manmade or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 percent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease [2], [7] altered lung function and lung cancer.
- Persistent free radicals connected to airborne fine particles could cause cardiopulmonary disease [3], [4].
- Toxic metals, such as lead and mercury, especially their compounds.
- Chlorofluorocarbons (CFCs) - harmful to the ozone layer emitted from products currently banned from use.

- Ammonia (NH_3) - emitted from agricultural processes - is a compound both caustic and hazardous, encountered as a gas with a characteristic pungent odor, contributing significantly to the nutritional needs of organisms (foodstuffs and fertilizers). Odors — such as from garbage, sewage, and industrial processes
- Radioactive pollutants - produced by nuclear events or war and natural processes such as the radioactive decay..

Secondary pollutants include:

- Particulates created from gaseous primary pollutants and compounds in photochemical smog. The word "smog" is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.
- Ground level ozone (O_3) formed from NO_x and VOCs (mainly due to traffic sources running fossil fuel), is a key constituent of the troposphere and an important constituent of certain regions of the stratosphere commonly known as the Ozone layer. Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant, and a constituent of smog.
- Peroxyacetyl nitrate (PAN) - similarly formed from NO_x and VOCs.

Minor air pollutants include:

- A large number of minor hazardous air pollutants. Some of these are regulated in USA under the Clean Air Act and in Europe under the Air Framework Directive.
- A variety of persistent organic pollutants(POPs) , which can attach to particulates, are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. They persist in the environment, are capable of long-range transport, bio-accumulate in human and animal tissue, bio-magnify in food chains, and have potential significant impacts on human health and the environment.

AIR QUALITY MONITORING BY SIRANE

Today, pollution levels in many areas of Romania and in Timisoara as well, exceed national air quality standards for at least one of the six common pollutants. In Timisoara special concern raised about PM. Thus an infringement from the EC is expected, if the situation is not solved, meaning the NB of episodes with overvalues is not reduced, as well the regular value of PM10 are under the limits.

The research accomplished in the frame of the international project AIRQ, jointly selected and funded by the French National Research Agency ANR and the Executive Agency for Higher Education, Research, Development and Innovation Funding UEFISCDI (international program (www.mec.upt.ro/airq), aims to improve the operational modeling and monitoring of urban air quality in Timisoara, comprising:

1. The construction of a proper emission cadastre over the urban site of Timisoara taking into account some local specificities, mainly the local fleet and the industrial effluents description
2. The implementation of a detailed parameterization for the turbulent exchanges between the urban canopy flow and the turbulent boundary layer. This advanced parameterization should account for the specificities of the poorly documented configurations generally met in suburban areas
3. The code validation as well as operational simulation over the city of Timisoara thanks to local data recordings, mainly : standard meteorological recordings, LIDAR measurements, concentrations sampling for the following pollutants: SO_2, NO, NO_2, NO_x, CH_4, NMHC, THC, PM10, PM4, PM2.5 and PM1.0.

Firstly one focused on road traffic emission and main industrial sources, then all another sources (secondary industrial emission, residential emission, etc.) Sources are then modulated according to different “geometrical” categories:

- Large point sources (LPS): it is emitters clearly identified and quantified on an annual basis (combustion unit with ducted discharge, thermal power plant, oil refinery, industrial complex, cement, etc.).
- Large Linear sources (LLS): it is the main road with important daily traffic, in urban areas or on highway. Traffic is generally known through permanent or periodic counts;
- Surface Sources : These sources are constituted by all other sources that are not grouped as LPS or LLS, i.e. which cannot be individualized (e.g. small industrial plants, crafts, activities domestic –heating-, leisure activities, traffic on local roads with low average importance defined as secondary roads emission, agricultural areas, forest areas, etc). Emissions from these sources were mainly grouped as a cadastral with spatial resolution of 1km * 1km. Some can also treated at specific surface sources.

ODORS MONITORING CAPACITY

One of the possibilities to use the numerical model developed is also to depict the odors, especially based on measurements with special developed instruments/sensors, and tracking back the origin (reverse modeling), according meteorological data. Under the circumstances of increasingly coercive legislation, the need for continuous monitoring of pollutant concentration in the air has increased considerably over recent years, driven by health and safety concerns (toxic gases) and odor related nuisance or discomfort. Although gas exposure limit values are generally measured in parts per million (ppm), odor nuisance is measured by the parts per billion (ppb) presence of indicators gases, a concentration that is one thousand times lower.

Industrial players are therefore faced with the problem of measuring very low concentrations of gas (ppb) over a very wide area on a continuous basis, when the laboratory machines generally used for this purpose do not provide continuous data.

On the other hand, according to data emitted by Olivier Zaouak [4] (Table 1) up to 20 % of the population is annoyed by diffuse environmental odors.

Table 1: Different olfactory effects of compounds present in the air [4]

Compound	Lowest human olfactory threshold	Smell
H_2S	0.42 to 0.41 ppbv	Rotten egg
CH_3SH	0.07 ppbv	Cabbage, garlic
NH_3	1.5 to 2.6 ppmv	Pungent, irritant

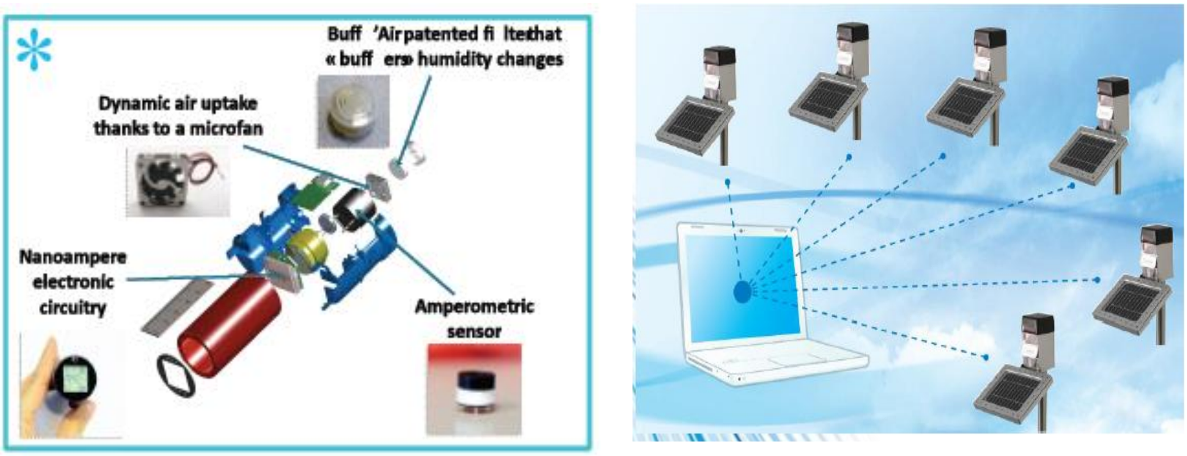

Figure 3. The Cair Clip CARPIOL sensor as compact devices designed to measure low concentrations of H_2S, NH_3 and methyl-mercaptan (CH_3SH), [4]

Reduced sulfur compounds (RSC) are primary irritants, especially hydrogen sulphide (H_2S) and methanethiol (CH_3SH) because of their high olfactory impact at very low concentrations (a few ppbv) Increasing demand for highly sensitive sensors able to monitor these species at very low ppbv-levels was answered by the Cair Clip CARPIOL devices.

Figure 3 brings the schematics of the CARPIOL devices.

EXPERIMENTAL RESULTS

Figures 4-7 bring first results from the modeling research. It consists of depicting regional pollution levels (for different species) according to the input data, specific for Timisoara. The data are not relevant yet, as the program is under construction still, but they surly proof the possibility of answering to the general scope: to depict specific pollution levels in urban area of Timisoara, after the validation of the program, through in situ measurements.

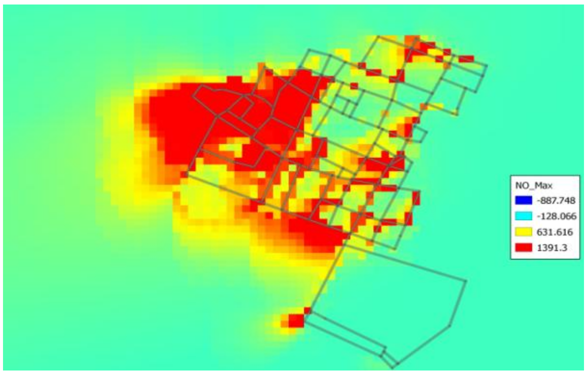

Figure 4. Dispersion of max concentrations of NO

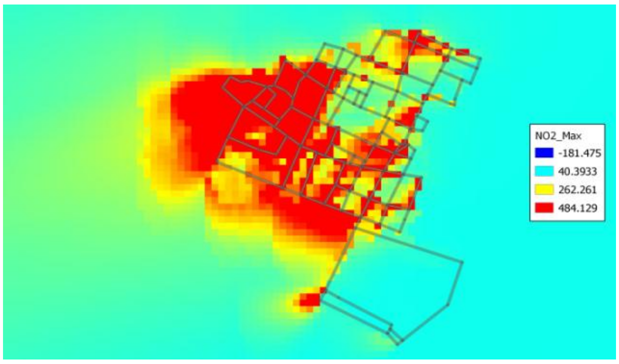

Figure 5. Dispersion of max concentrations of NO_2

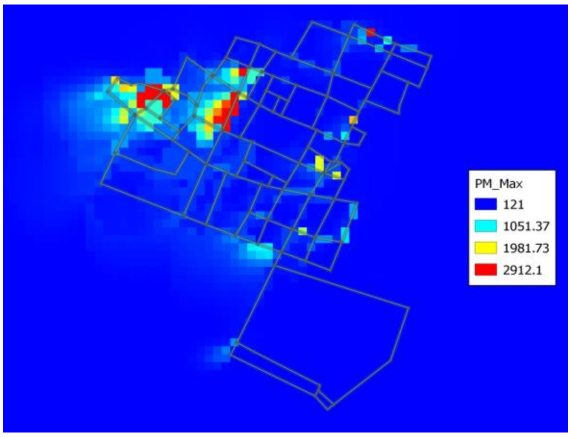

Figure 5. Dispersion of max concentrations of PM max

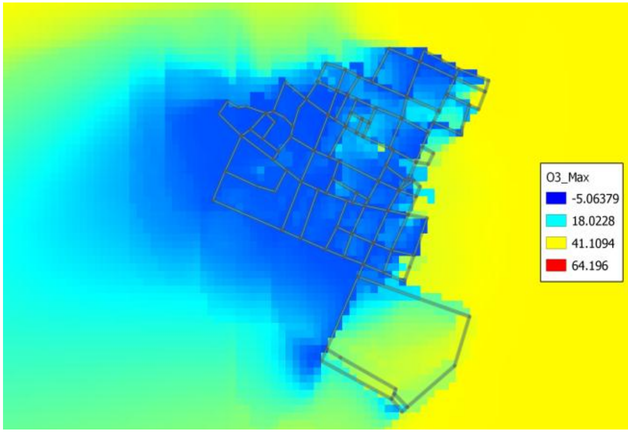

Figure 6. Dispersion of max concentrations of O_3 max

Different kind of data/information was used to construct the emission inventory:
- Data to help to map some emission source over the whole domain or to facilitate the construction of the cadastre: Distribution of the population of the study area, Geographical location of large industrial areas and activity on the study area,
- Data to extrapolate some value in 2010 from past years or to extrapolate inventory to 2013: Evolution of the population by territorial units (urban and rural), Evolution of the number of industrial workers in the area, Evolution of regional GDP (and GDP).

Energy balance as exhaustive as possible was required. The objective was, to get data, for the year 2010, on:
- The energy consumption per year in the area, by sector and by fuel type.
- The total amount of fuel consumed in the area expressed in tons per year and fuel
- The distribution of fuel consumption in the area by industry (SNAP classification)

"Fuel" means fuel oil, light fuel oil, gasoline, heating oil, diesel, kerosene, natural gas (butane), coal, wood, etc., consistent with the NAPFUE 94 nomenclature.

In order to calculate the emissions from road traffic, COPERT IV use emission factors and various parameters were used, such as:
- The vehicle fleet known as much as possible in detail (sixty types of vehicles is possible)
- The level of emissions control (EURO I, EURO II, EURO III, EURO IV, etc ...)
- The types of vehicles (passenger car, light of heavy duty vehicles, motorcycles, buses, etc ...)
- The types and consumption of fuels (gasoline or oils)
- The physical and chemical characteristics of these fuels
- The average specific consumption of each types of vehicles depending on their size and speed (liter / 100 km)
- The average speed running on different road types (urban, rural, highway)
- The annual mileage of each type of vehicle
- The distribution of mileage done by each type of vehicle on different road types (urban, rural, highway)
- The maximum and minimum monthly temperatures

Among these various data, the two main ones are:
- *The regional vehicle fleet, including the following breakdown*:
    - The different types of vehicles (passenger cars, light duty vehicles, heavy duty vehicles, motorcycles, buses, etc ...)
    - For each type of vehicle, the consumption of fuels (gasoline or oils), otherwise the average annual mileage made by each type of vehicle on each road type (urban, rural or intercity highway) and the specific consumption of each type of vehicle
    - For each type of vehicle and fuel, the level of emission control (EURO I, EURO II, EURO III, EURO IV, etc ...)

Ideally this information must be available over the Timisoara area, if not national data could be used as an alternative.
- *On each main roads (at least those who are selected to be explicitly modeled), it is necessary to obtain (or calculate) the emissions for different pollutants: if emissions of road sections are not known, it is then necessary to retrieve the following data:*
    - Average speeds limit for each roads
    - Traffic data as AADT (Annual Average Daily Traffic) that corresponds for each section to the number of vehicles per day. In general, this information is available for the whole road network if a traffic model is used. If this is not the case, the goal is to recover all the available counting data: manual or automatic counting, on the longest period as possible. These data could be used in a traffic model to calculate the AADT for each modeled section. Note that if there are major axes across the study area (e.g. a highway), it is important to have an estimation of the flow of vehicles on these roads in and out of the field, to assess the traffic coming from outside the zone.

At this stage, it was acquired traffic data for 2010 on more than 500 roads (around 75% of the total road network presented before)

Main industrial emitters (Large point sources, LPS)

These correspond to stack emission for main industrial emitters. For each source, it must be known:
- The height of discharge above ground level
- The temperature of the discharge
- The velocity rate

- The inner diameter of the chimney
- The emission in units of mass per unit time (flow in g / s or kg / day). In the absence of emission data, it must then recover the amount of fuel consumed in the year by the unit (or the whole site), and the type of fuel
- The temporal profiles of the emission source, or at minimum for the industrial site (any information relating to periods of activity on the site is interesting, for example if work is based on 3 x 8h cycle, closed period, seasonal influences, days of the week, etc.)

Secondary sources

Firstly, this corresponds to small and medium industrial enterprises other than LPS. Global emission from these industries will be calculated distributed in space and time based on various information such as:

- Spatial database of enterprises in the study area
- distribution of firms by geographic area
- SNAP code of each industrial site
- Consumption of fuel for these site

Secondly, this corresponds to emission from secondary road network, that is to say emission from roads which are not simulated as LLS. Global emission was calculated from Energy balance table calculated for road sectors and emission calculated for LLS. Spatial allocation of this emission can be done either from GIS road network if LLS are less in number than these data, either from another information such as land use or density population by territorial units. *Thirdly*, this could correspond to the residential and tertiary sectors. One will use the energy consumption table described above to calculate associated emissions, and then distribute it spatially based on the population density for example. Lastly, this could be natural emission, or specific ones of interest for the region. For example, it was identified that there is problem of sand emission after winter season from roads in the region of Timisoara.

CONCLUSION

The general remarks are as follows:

- Continuing to educate the public, especially children, on how to protect themselves from excess exposure to UV radiation through the SunWise program.
- Continuing to foster domestic and international partnerships to protect the ozone layer.
- Encouraging the development of products, technologies, and initiatives that reap co-benefits in climate change and energy efficiency.

In particular the authors demonstrated:

- The possibility to focus on a urban area by special numerical approach, suitable to predict or compare different strategies of city developments.
- Application of the updated, novel development of the version of SIRANE, based on validation and specific topographic and meteorological data, the result might contribute in depicting solution for reducing pollution level, especially concerning PM.

The research presented is based on an international project led by a consortium of 3 partners involved in the field of atmospheric modeling and measures: LMFA, France, Numtech, France, and UPT, Romania. The research –still ongoing - addresses the question of urban atmospheric pollution by improving the existing operational model SIRANE. The updated numerical tool will be tested and applied over the site of Timisoara, Romania. This requires updating two physical modules, one for the “in-street” flow velocity, one for the turbulent exchanges, so as to relate the two mentioned parameters to the street characteristics. Operational data over Timisoara are also required in order to run the SIRANE software both in the validation phase and for air quality simulations. To that purpose, the necessary data started to be collected and adapted according to the methodologies in use all over Europe. A review of the available methods was also achieved for that purpose.

ACKNOWLEDGEMENT

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DIAGNOSTICS OF AIR POLLUTANT REMOVABLE POTENTIAL AND ENERGY EFFICIENCY OF POLLUTANT TRANSPORT

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ABSTRACT

The diagnostics is carried out of air pollutant removable potential and energy efficiency of pollutant introduction in air,on the basis: - of the daily pollutants mass concentration monitoring results, in sixth day period in the various seasons and locations in Romania and Serbia; - and of the solar constant effective in chemisorbed successive pollutant introduction rate constants as indicator of equal hydrogen and surface oxygen depolarization potentials.

Key words: *Air monitoring, Energy efficiency of pollutant transport, Solar constant, Thermal effects*.

INTRODUCTION

In our previous paper pollutant removable and immisiong rate constants ratio determining pollutant free energy enabled to obtain the functional dependences between reversible pollutant potential $\Delta E^{\theta}{}_{p,k}$ on pollutant measured contents in air, γ_{pol}, with the strong correlation coefficients, R^2=0,78 - 1 (Milan Pavlović, Ioana Ionel, Mirjana Ševaljević, Nicolae Stelian Lontis, Aleksandar Đurić, ICEEM 007, 2013):

$$\Delta E^{\theta}{}_{p,k} = tg \cdot \gamma_p + \Delta E^{\theta}{}_{\gamma=0} \qquad (1)$$

The basic aims of electrochemical research is to influence on the energy efficiency of energy conversion. In this case pollutant mass transport in daily steady state, γ_p as measure of deviation of the cell voltage reversible value is examined i.e. direct measure of irreversibilty degree, enabling pollutant removal and/or introduction in air due to the pollutant mass diffusion transport and heat energy transport. The measured pollutant transport rate constants, ± k_p control the conversion in pollutant depletion current equal to hydrogen/oxygen depolarization current density, $j_p = \Delta j_{H+/O2}$ of hydrogen reversible depolarization work, A_{Hdep} on chemisorbed oxygen surface, $E^{\theta}{}_{H2-}$:

$$A_{Hdep} = \frac{j_p \cdot E^{\theta}_{H2}}{k_p} \qquad (2)$$

And control energy efficiency of pollutant transport, $E_{e,p}$:

$$E_{e,p} = \frac{\gamma_p}{A_{Hdep}} \qquad (3)$$

Depending on solar power on earth surface, P_s = (1353 ±30)W/m^2 , i.e.solar constant , the depletion pollutant with zero affinity control current j_p= $j_{H+/O2}$ depending on selective pollutant removable potential, $E^{\theta}{}_{\gamma=0}$:

$$\Delta j_e = \frac{P_s}{\Delta E^{\theta}_{\gamma=0}} \qquad (4)$$

Pollutant depletion current control hydrogen migration and electron titration currents according to its impulses conservation law: $\Delta j_m = \Delta j_e \cdot (m_e/m_H)$ (4a)

and electric pemitivity of chemisorbed oxygen, (ε_r=10,3), (Miroslav Stanojević et al, 2013):

$j_p = j_{H+/O2-} = \Delta j_m / 10{,}3$ (4b)

that give:

$$\Delta j_p = \frac{P_s \cdot m(e)}{\Delta E^{\theta}_{\gamma=0} \cdot m(H) \cdot \varepsilon_r(O_2^{-})} \quad (5)$$

The combining of the Eqs. (2-5) enables diagnostics of solar energy efficiency in pollutant transport, depending on pollutant removable, $E^{\theta}_{\gamma=0}$ and hydrogen depolarization potential ratio, E^{θ}_{H2}:

$$E_{e,p} = \pm 3{,}885 \frac{k_p \cdot \gamma_p \cdot E^{\theta}_{\gamma=0}}{E^{\theta}_{H2}}, g / kWhm \quad (6)$$

The pollutant temperature change due to the contact with Ohm resistance according to Joule –Lenc law where: $C_p \Delta T_p = C_p \Delta T_{N2 \cdot e} = I_F \cdot \Delta U \cdot \tau = \Delta j^{\theta}_m E^{\theta}_0 / k_{mH+}$ could be determined on the basis of the slope of linear function of hydrogen migration current density, j_m on the depolarization and pollutant removable potentials ratio, $E^{\theta}_{H2}/E_{\gamma=0}$ (giving the value of tg = $\Delta j^{\theta}_m E^{\theta}_0 / E^{\theta}_{H2}$) using in Joules heat determination on the basis of depolarized hydrogen reversible potentials determined in our previously paper.

EXPERIMENTAL RESULTS

The equipments are part of the air quality monitoring mobile laboratory and procedures used are in full compliance with ISO/CEN 17025:2005 standard for quality assurance in analytic laboratories. The laboratory is the property of “Politehnica” University of Timisoara and more details and information’s (including certifications) can be found on www.mediu.ro.

Table 1: The calculated data for the range of the relative electric permitivity of water active centers, 0,55<$\varepsilon_{r,PLTE}$< 8,85 *controlling zero pollutant affinity (* Milan Pavlović et al 2013)

Pollut.	$E^{\theta}_{c=0}$ V	E^{θ}_{H2} V	$E^{\theta}_{\gamma=0}/E_{H2}$	j_{migr} A/m^2	$j_{H+/O2}$ A/m^2	± k_{st}, day^{-1}	$\gamma_{p,s}$ mg/m^3	ΔT_p K, Eq.(12)	E_e, g /kWm	$\varepsilon_{r,PLTE}$
CH_4	0,0895	0,32	0,28	8,23	0,80	0,029	3,85	0,47	0,000121	6,26
CO	-0,02	0,31	-0,06	-36,85	-3,58	0,12	0,34	-0,10	-0,000010	0,55
CO	-0,0763	0,31	-0,25	-9,66	-0,94	0,12	1,47	-0,39	-0,000171	2,4
NMHC	-0,4366	0,31	-1,41	-1,69	-0,16	0,34	0,29	-2,23	-0,000540	0,48
NMHC	0,0532	0,31	0,17	13,85	1,34	0,34	0,47	0,27	0,000106	0,76
NMHC	0,0774	0,31	0,25	9,52	0,92	0,15	0,83	0,40	0,000121	1,35
THC	0,9232	0,32	2,89	0,80	0,08	0,01	4,48	4,86	0,000503	7,3
THC	-0,1433	0,32	-0,45	-5,14	-0,50	0,033	5,25	-0,76	-0,000303	8,55
THC	-0,0378	0,32	-0,12	-19,50	-1,89	0,075	3,78	-0,20	-0,000132	6,15

Table 2: The calculated data for the range of the relative electric permitivity of water active centers, 7,74<$\varepsilon_{r,PLTE}$<34 *controlling zero pollutant affinity (*Milan Pavlović ICEEM 007, 2013)

Pollut.	$E^{\theta}_{c=0}$ V	E^{θ}_{H2} V	$E^{\theta}_{\gamma=0}/E_{H2}$	j_{migr} A/m^2	$j_{H+/O2}$ A/m^2	$\pm k_{st}$, day^{-1}	$\gamma_{p,s}$ mg/m^3	ΔT_p K, Eq.(12)	E_e, g /kWm	$\varepsilon_{r,PLTE}$
PM10	0,0128	0,32	0,04	57,57	5,59	12,81	5,59	0,07	0,0000111	20,86
O_3	0,0301	0,32	0,09	24,48	2,38	14,31	2,38	0,16	0,0000119	23,3
SO_2	-0,0272	0,32	-0,09	-27,09	-2,63	10,44	-2,63	-0,14	0,0000096	17
SO_2	0,0396	0,32	0,12	18,61	1,81	7,31	1,81	0,21	0,0000062	11,9
NO	0,0418	0,32	0,13	17,63	1,71	4,2	1,71	0,22	0,0000036	6,88
NO	0,0698	0,32	0,22	10,56	1,03	12,9	1,03	0,37	0,0000114	21
NO	0,0504	0,33	0,15	14,62	1,42	18,26	1,42	0,27	0,0000151	30,4
NO_2	-0,1908	0,32	-0,60	-3,86	-0,37	16,58	-0,37	-1,01	0,0000143	27
NO_2	0,0038	0,32	0,01	193,93	18,83	4,75	18,83	0,02	0,0000035	7,74

Table 3: The calculated data for the range of the relative electric permitivity, 54,4<$\varepsilon_{r,PLTE}$< 608) *of water active centers, controlling zero pollutant affinity (*Milan Pavlović ICEEM 007, 2013)

Pollut.	$E^{\theta}_{c=0}$ V	E^{θ}_{H2} V	$E^{\theta}_{\gamma=0}/E_{H2}$	j_{migr} A/m^2	$j_{H+/O2}$ A/m^2	$\pm k_{st}$, day^{-1}	$\gamma_{p,s}$ mg/m^3	ΔT_p K, Eq.(12)	E_e, g /kWm	$\varepsilon_{r,PLTE}$
PM10	-0,0333	0,38	-0,09	-22,1	-2,15	66,34	-2,15	-0,21	0,000050	108
PM10	0,6933	0,35	1,98	1,06	0,10	44,78	0,1	4,01	0,000034	72,9
CO_2	2,2767	0,81	2,81	0,32	0,03	373	30	30,73	31,44	608
CO_2	-3,3484	0,62	-5,40	-0,22	-0,02	389	-20	-34,21	42,01	389
NO_2	-0,0902	0,34	-0,27	-8,17	-0,79	33,42	-0,79	-0,51	0,000028	54,4
NO_x	0,2177	0,36	0,60	3,39	0,33	50,68	0,33	1,29	0,000039	82,5

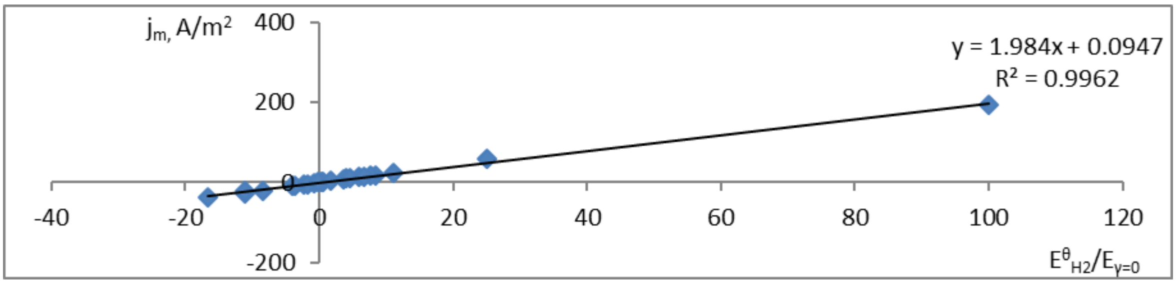

Figure 1. Functional dependences of hydrogen migration solar current density, j_m *on hydrogen depolarization and pollutant removable potentials ratio,* $E^{\theta}_{H2}/E_{\gamma=0}$

The minimal ratio of $E^{\theta}_{H2}/E_{\gamma=0}$ for CO_2 and THC of 0,18-0,35 correspond to the minimal migration hydrogen ions cathode current densities of CO_2 ,-0,22 A/m^2 and anode current density to 0,3 A/m^2 and of THC to 0,8 A/m^2 (see Tables 1-3). Zero pollutant removable potential decrease migration hydrogen ions cathode current up to the Eq. in Fig.1to $y_0=j_0$:

j_0= 94,7 mA (7)

On the basis of the obtained linear function slope (y = 1,984x + 0,094, R² = 0,996):

tg = $\Delta j^{\theta}_{m} E^{\theta}_{0} / E^{\theta}_{H2}$ =1,984 (8)

The removable pollutant and hydrogen depolarization potential ratio on the Ohm resistances could exchanged heat $C_p\Delta T_p$ give an temperature excitation signals (Rotenberg, Z.A, 1997) .

In present paper it is predicted according to Joule –Lenc law (where $C_p(N_2)_{average}$ = 35,7J/molK):
$C_p\Delta T_{N2}{\cdot}e = C_p\Delta T_p = I_F{\cdot}\Delta U{\cdot}\tau = \Delta\, j^{\theta}_{m}E^{\theta}_{0}/k_{\;mH+}$

that gives after combining with Eq(8):

$$C_p\Delta T_p = 1{,}98\, E^{\theta}_{H2}/\, k_{\;mH+} \qquad (9)$$

where:

$$\Delta T_p = 1{,}98\, E^{\theta}_{H2}\, /\, k_{\;mH+}C_p = 1{,}98\, F{\cdot}E^{\theta}_{H2}\, /\, i_{\;mH+}{\cdot}C_p(N_2) \qquad (10)$$

The relaxation of electron and hydrogen ion kinetic energies to thermal value gives:

$$\Delta T_{e\;(N2)} = \Delta T_{H+} = (m_H/m_e)^{1/2}{\cdot}\Delta T_{ePLTE} \qquad (11)$$

and the relaxation electron temperature to thermal value in hydrogen depolatization on oxygen surface gives: $\Delta T_p = \Delta T_{ePLTE}(O_2^-) = \Delta T_{ePLTE}{\cdot}\varepsilon_r(O_2^-)$ that enable pollutant temperature change determination:

$\Delta T_p = 1{,}98\, FE^{\theta}_{H2}/42{,}8{\cdot}10{,}3{\cdot}i_{mH+}35{,}7$

$$\Delta T_p = 12{,}14{\cdot}E^{\theta}_{H2}\ /i_{mH+} \qquad (12)$$

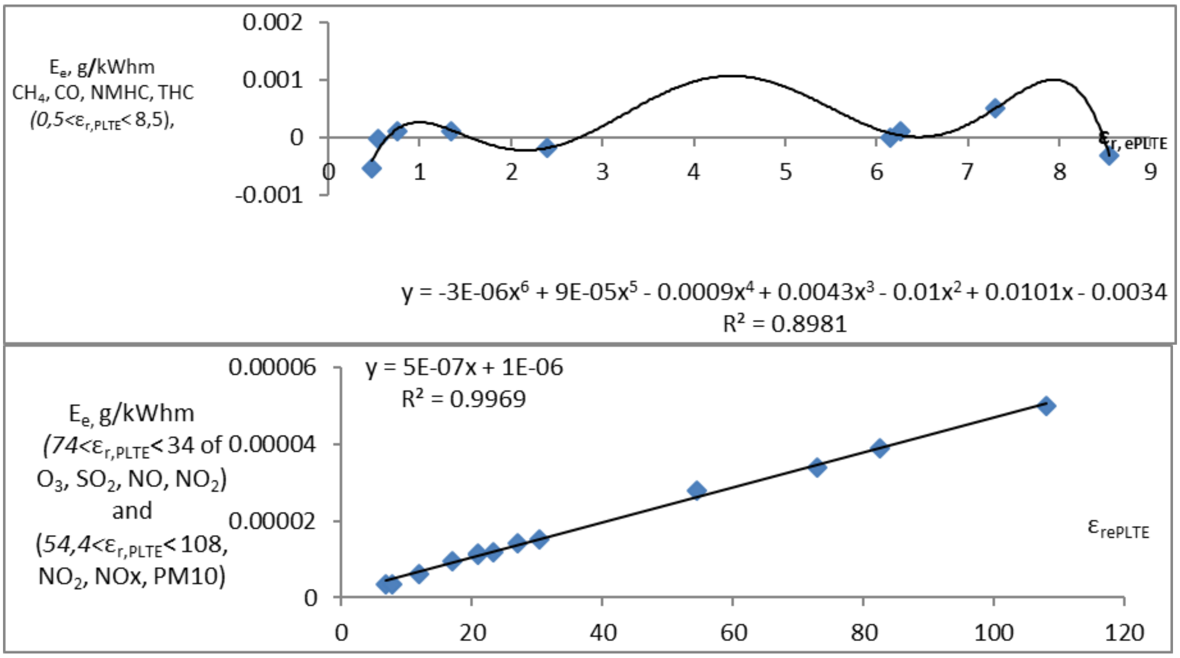

Figure 2. The functional dependences between pollutant energy efficiency E_e, g/kWhm on the relative electric permitivity range corresponding to the pollutants zero affinity, given in the Tables 1-3

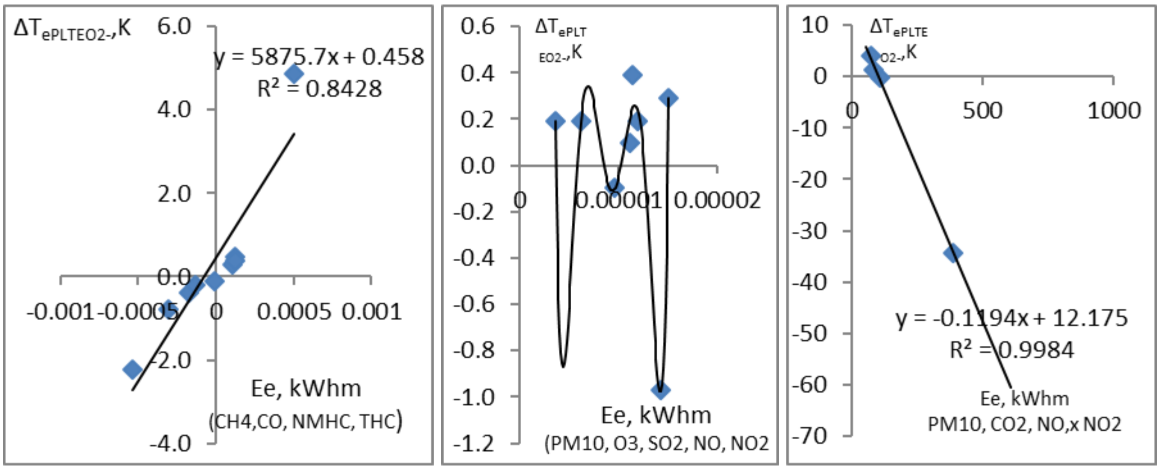

Figure 3. The dependences of pollutant temperature change effective in the hydrogen depolarization, on the calculated energy efficiency of pollutant transport E_e, g/kWhm (corresponding to the pollutants zero affinity (0,5<$\varepsilon_{r,PLTE}$< 8,5), Table 2 (7,74<$\varepsilon_{r,PLTE}$< 34) and Table 3 (54,4<$\varepsilon_{r,PLTE}$< 108)

CONCLUSION

The concluding remarks are as follows:

- The diagnostics of organic energy efficiency of pollutant immision indicate to the the range of Ee= (6E-5 to 1E-4)g/kWhm where pollutant removable potentials correspond approximately to thermal value, $E_{\gamma=0}$=RT/F and hydrogen depolarization potential equal to reversible potential of hydrated superoxide anion,$E^{\theta}_{H2}=E^{\theta}_{(O2-)aq}$= 0,33V .
- The diagnostics of the deviation work detrmined with pollutant removable potential $\Delta j^{\theta}_{mH+}E^{\theta}_{0}/k_p$ of reversible received solar energy in electron titration on depolarized hydrogen, enable the slope function, y = 1,984x + 0,0947 obtained with strong correlation coefficient , R² = 0,9962: tg = $\Delta j^{\theta}_{m}E^{\theta}_{0}/E^{\theta}_{H2}$ = 1,984 that gives the migration current power on pollutant as Ohm resistance where $C_p\Delta T/\tau_p = \Delta j^{\theta}_{m}E^{\theta}_{0} = 1{,}984\, E^{\theta}_{H2}$
- Energy efficiency of inorganic pollutant transport linearly increase with relative electric permitivity, between inner and outer Helmholtz layer, $\varepsilon_{r,PLTE}$ = 7-30 (O_3, SO_2, NO, NO2) as well as on condensation water active centers at t= 100 ^oC $\varepsilon_{r,H2O}(NO_2)$=54, at t= 50 ^oC $\varepsilon_{r,H2O}$(PM10) = 70, at t= 0^{o}C where $\varepsilon_{r,H2O}$ (NOx)= 87,7 and at temperatures decreasing below t=0^{0}C, at $\varepsilon_{r,H2O}$ (PM10) = 108 up to $\Delta t(CO_2)$ = -34,3K $\varepsilon_r(CO_2)$ =389 . At the increasd relative pollutant electric permitivity corresponding to zero affinity, $\varepsilon_r(CO_2)$ =608 exothermic process increase pollutant temperaturte for 31,4 K.
- During the linearly energy efficiency of pollutant transport increasing with increased relative electric permitivity (corresponding to pollutant zero affinity), the alternating increasing abd decreasing pollutant temperaturs are found.

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III International Conference
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REDUCING AIR POLLUTIONS IN MODERN BUSSES FOR URBAN TRANSPORT

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ABSTRACT

Decreasing of air pollutions in urban transport is one of the main tasks in improving the life quality in cities. Satisfactory results could be achieved only by systematic approach, by optimising the all aspects of urban transport. This article is focused on measures of achieving an Euro 6 emission norm standard in modern diesel engines, as a key ecological factor in cities without electro-powered transport network and sufficient LPG and CNG supply for transport means. In those urban areas the modern buses with minimised mass, internal mechanical losses and tyre rolling resistance, powered by Euro 6 diesel engines, could be a good solution, especially in combination with other ecological measures and improvements.

Key words: *urban traffic, pollutions, diesel engine, environmental friendly*.

INTRODUCTION

Solutions for decreasing of pollutions in urban transport are well known and particularly focused on two measures:

- redirecting from individual to group (public) transportation
- redirecting from conventional vehicles, with internal combustion motor to electric powered vehicles

First measure clearly defines that more persons per vehicle reduce pollutions per person and vehicle. So is important that every city has well organised public transport with content of individual transport as low as possible (extensive use of public transport).

With second measure - introducing of electric powered vehicles for public transport (trolley-bus, tram, city-train, metro) direct pollution is reduced to zero. Although that solves problem of pollution in cities, real problem is only transformed to the location where electrical energy is produced. In principle this option reduces total pollutions, especially if electrical vehicles are on rails (as a result of lower rolling resistance), and electric is produced effectively, especially if produced from renewable sources. The best solution offers metro.

However, those integral and systematic solutions seek a huge and long term investments, which in most of urban regions of southern-east Europe will not be affordable for a longer period. This not means that convenient solutions are not affordable.

MEASURES FOR REDUCING OF POLLUTIONS IN URBAN TRANSPORT

Bus transport is a dominant transport solution for most urban areas in south-east European countries and that will be not changed at least in next ten years. It doesn’t mean that convenient solutions are not affordable. This not means that convenient solutions are not affordable. Even, with relatively small investments and optimizing of bus transport could be achieved fairly acceptable ecologic solutions for minimising of harmful and deleteriously pollutions: emissions of carbon dioxide (CO2), carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (CnHm).

All could be achieved with following three activities:

- improvement of road infrastructure
- improvement in organisation of urban transport
- implementation of ecological advances and environmental friendly buses

Improvement of road infrastructure is a first key factor in minimising of pollutions, especially by reducing of arrests in traffic and increasing of average speed. The most important is avoidance of road congestions and blockades by separate levelling of critical road intersections, and increasing of road capacity.

Reparation of road surface is very important for increasing of roughness in order to increase the tyre adhesion (coefficient of friction) and active safety: shortening of braking distance, avoidance of tyre slipping. Minimising of the road imperfections (mounts, swales, holes...) is also important to enable the use of low friction resistance tyres, with low deformability and high rigidity, with characteristic similar to the rail wheels.

Improving of traffic organisation is a second important factor and the best results could be achieved by separating the beginnings and endings of working and school times for the biggest groups of citizen, that use public and private transport. For that reason is important to optimize the regulation of traffic lights on critical road intersections, or to control them directly.

Previous two factors should be enclosed by integral traffic study which includes the adaptation of all the aspects of urban activities and life to increasing the efficiency and reducing the traffic crowds in peak periods.

This paper is focused on the third factor - implementing of environmental friendly buses with Euro 6 eco-norm diesel engines, underlining that best results are possible by optimising and optimising the other two factors, and in synergy of all three factors.

CHARACTERISTICS OF ENVIRONMENTAL FRIENFLY BUSES

Performances, efficiency and ecological characteristics of modern buses are achieved by two main measures:

Reducing of urban buses driving resistances

On each motor vehicle while driving act five main driving resistances: roll resistance, air resistance, inertia resistance (acceleration), climbing resistance and resistance in transmission. On vehicles for urban transport dominant are roll resistance (depends of vehicle mass and roll resistance factor), and inertia resistance (depends of acceleration and mass).

Air resistance is on vehicle for urban transport irrelevant, as depends of square speed and at low speed, in total resistance participate with less than one percent. Climbing resistance is unavoidable and depends of terrain configuration. Transmission resistance is reduced with optimal construction of transmission mechanism, especially by reducing of internal friction and other internal losses

So, for ecological characteristics in urban areas the roll and inertia resistance are the most dominant with two influence factors: mass and roll resistance factor. Mass is reduced by optimizing of vehicle construction with higher content of high tensile steel, light metals, polymer materials and special material such as CFRP (carbon-fibre-reinforced-polymer). Roll resistance factor is reduced by using of ‘green’ tyres with low roll resistance.

Increasing efficiency of urban busses diesel engines

Increasing efficiency of modern diesel engines, by simultaneous reducing of fuel consumption and emissions are achieved by following measures in motor construction:

Increasing of injection pressure and precision

Fourth generation of common-rail injection system in modern diesel engines uses piezo-injectors, which enables the increasing pressure to more than 2000 bar and precision of fuel injection. By optimising the injection process in three phases (pre-injection or pilot-injection, main injection, post injection) in up to ten separate impulses, self igniting of fuel and whole process of fuel injection is improved. This brings advances in reducing of fuel consumptions and emissions, and improving of engine performances

Homogeneous fuel-air mixture

For maximal diesel engine efficiency is important to improve the homogeneity of fuel-air mixture. Completely and correctly combustion in each part of cylinder could be achieved if everywhere is achieved stoichiometric air-fuel ratio: 14,5:1. Actual diesel engines use in average 1/3 of air more to assure that every drop of fuel, which is individual source of ignition, acquire enough amount of oxygen. The whole process will never be completely homogeneous, always would be some areas with more, and some with less oxygen. First leads to emission of nitrogen oxides (NOx), and second to emission of hydrocarbons (CnHm) and carbon monoxide (CO), By precious regulation of injection, according to engine speed, load and temperature, and improving of piston and combustion chamber geometry homogeneity of mixture could be improved, with benefits in performances, consumption and emission.

Cooling of the returned exhaust gases

Cooling of exhaust gasses entering cylinder through EGR valve reduces amount of carcinogenic nitrogen oxides (NOx), for two reasons: creating of nitrogen oxides stimulate high temperatures and oxygen, and exhaust gasses reduces both. Their content could be higher than 60 percent, and their cooling stimulate both. Reduction of exhaust gas temperature for 10°C reduces content of NOx for 10 percent and by increasing of their density is easier to achieve higher rate of returned exhaust gases.

Regulation of compressed air intercooling

By compressing in the second stroke intake air simultaneously raises it’s temperature and expand, what is inconvenient and decreases a mass that can be inserted in cylinder decreases. That is a reason to insert intercooler to cool the compressed air. However, standard cooling without regulation is adapted for average conditions - so in some working cycles is too intensive, and in other too week. Therefore is important to adapt intensity of intercooling to load, speed and temperature of motor. This can be done by butterfly valves and regulators for directing a compressed air in bigger or smaller volume of cooler. Intercoolers with additional liquid cooling cold be adapted by regulating a speed of liquid pump.

Selective regulation catalysator

It is important to improve the technology of eliminate particulates (soot) from exhaust gases in filters of fungous silicon carbide - by arresting and short-time burning of particulates by precise injecting drops of fuel. The most important improvement is inserting of SRC (Selective Catalytic Reduction), with two stages. In first the most of nitrogen oxides are reduced to nitrogen. Remaining amount of nitrogen oxides are eliminated in second stage by inserting a urine-based fluid which generates ammonia (NH_3). Result of reaction with remaining nitrogen oxides is nitrogen and water vapour.

HARMFUL AND DELETERIOUSLY POLLUTIONS IN TRAFFIC

Ecological norms in traffic

First ecological norm Euro 1 was introduced in July 1992. For all the diesel engines content of carbon monoxide (CO) was limited to 2,72 g/km. Hydrocarbons (HnCm) and nitrogen oxides (NOx) were limited in total to 0,97 g/km, a and particulates (soot) to 0,14 g/km. Beginning of 1996 norm Euro 2 was introduced with limits 1 g/km CO, 0,70 g/kg HC+NOx (for direct injected engines0,90) and 0,08 g/km for particulates (direct injected engines 0,10). Norms Euro 3, introduced 2000, limited CO to 0,64, HC+NOx to 0,56, NOx to 0,50 and particulates to 0,05 g/km. Norm Euro 4, introduced 2005, limited CO emission to 0,50, HC+NOx to 0,30, NOx to 0,25 and particulates to 0,025 g/km. Actual Euro 5 norm has same CO limit of 0,50, however NOx content is limited to 0,180, HC+NOx to 0,230, and particulates to 0,005. Euro 6 norm, predicted for September 2014 will have the same limit for CO and pollutions. However content of NOx is limited to only 0,080 g/km. That accents the importance of high quality combustion and precise after treatment of exhaust gases.

Reduction of pollutions in urban traffic

By using of modern buses powered by Euro 6 diesel engines, the pollutions in urban traffic could be reduced to convenient level. This is the best solution for regions and areas without electro-powered transport network, and with limited investing sources. For that is important to solve problems in areas with low traffic capacity or huge crowds and to improve a capacity of main roads.. Introducing of modern and environmental friendly busses, with targeted improvement of road infrastructure and optimisation of traffic regulation in rush hours can solve the most of traffic and environmental problems. This is the best solution with investments that are on disposal.

CONCLUSION

In urban areas without optimal traffic infrastructure, especially for electric powered vehicles for public transport (trolley-bus, tram, city-train, metro), and with limited investing resources and possibilities also could be achieved convenient ecological results, important for citizen in urban areas. The best results, with limited investments could be achieved by targeted improvement of critical traffic areas, by separate levelling of critical road intersections, and increasing of road capacity, and simultaneous improvements in traffic regulation, together with stratification of beginnings and endings of working and school times for the biggest groups of citizen that use public and private transport. For that reason is important to optimize the regulation of traffic lights on critical road intersections, or to control them directly. With those accessible improvements the implementing of environmental friendly buses with Euro 6 eco-norm diesel engines, could have the most convenient results with limited investments.

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IMPACT EXHAUST EMISSIONS OF MOTOR VEHICLES ON AIR QUALITY IN URBAN AREAS

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ABSTRACT

Exhaust gases emitted by motor vehicles is one of the major air pollutants in urban areas due to the high concentration of vehicles with different driving modes. This paper presents the requirements, in the last twenty years, that were set to the constructor of internal combustion engine, manufacturers of conventional fuels and the use of alternative fuels in order to reduce pollutants in the exhaust gases of motor vehicles. In addition to technical design of engines, use fuel and lubricant higher quality level, it is necessary to take appropriate organizational measures at the level of individual urban areas in order to reduce emissions from passenger cars, commercial vehicles and public transport vehicles.

Key words*:* *urban areas, motor vehicles, emissions, exhaust gases.*

INTRODUCTION

One of the greatest pollutant of human living and working environment is a combination passenger and commercial traffic. On exhaust emissions from motor vehicles the greatest impact have:

- Technical solutions that are used in internal combustion engines,
- Type of engine,
- Type and quality of fuels,
- Concentration of the vehicles in certain zones,
- Conditions and driving modes, etc.

Mass motorization of humanity that began the fifties led to the pollution of the big cities the exhaust gases emitted by motor cars and trucks. This is forcing lawmakers to seventies introduce legislation to limit emissions from motor vehicles. In light of the last decade of the twentieth century was marked by a series of legislative measures, which are accompanied by appropriate technical solutions, which attempt to reduce air pollution.

Reducing the negative impact of motor vehicles on the environment generated by a number of constructional and technological innovations. Structural changes have included a number of changes in certain systems such as fuel system and air and improve the process of forming a mixture of fuel and air, changes in piston assemblies, improving the combustion process, the introduction of electronic systems, exhaust gas after treatment, the application of new materials, improving the lubrication system and cooling system, etc..

In order to preserve the environment most of the technological development in this area is focused on the structural changes the engine, setting stricter requirements for manufacturers of conventional fuels, and the use of alternative fuels in motor vehicles.

This paper presents the legislation, technical solutions to reduce emissions, the importance of the traffic in the urban areas and the effects of using alternative fuels in motor vehicles in order to protect human health and working environment.

REGULATIONS EXHAUST EMISSIONS

Road traffic and harmful components in the exhaust gas cars and trucks significantly affect the environment pollution. This problem is especially pronounced in urban areas, where a relatively small area there is a large concentration of vehicles.

In addition to satisfying application requirements of the internal combustion engines of motor vehicles, today in the modern world the priority requirements relating to the protection of human health and environment. When it comes to this issue are three main factors that contribute significantly to reducing the negative impact of motor vehicles on the environment:
- Extended oil change intervals,
- Fuel economy and
- Reduction of emissions.

Extension of change interval is achieved primarily by using high quality engine oil. To extend oil drain intervals influenced improved construction solutions and the use of new construction materials in the manufacture of internal combustion engines. Extension of the period of replacement is achieved by applying oils having outstanding thermo-oxidative properties, low volatility and less degradation of reserve alkalinity.

Fuel economy and its greater utilization reduces the amount of pollutants emitted into the atmosphere. Reduction of fuel consumption has contributed to modern technology and design of the engine, such as a system for direct fuel injection. Significant fuel savings is achieved by applying low-flow engine oil viscosity grades SAE 0W-30 and 5W-30 and use multigrade oil for the transmission and differential viscosity grades SAE 75W-90.

Requires the introduction of the EURO emission standards and their strict application significantly reduced pollution, primarily in urban areas. Table 1 presents the requirements of EURO emissions for gasoline and diesel engines used in passenger cars.

Table 1: EURO regulations on exhaust emissions of engines of passenger cars

Regulation	Start the application	CO, g/km	HC, g/km	HC & NO_x, g/km	NO_x, g/km	Solid particles, g/km
	Gasoline engine					
EURO I	july 1992.	3,16	-	1,13	-	-
EURO II	january 1996.	2,20	-	0,50	-	-
EURO III	january 2000.	2,30	0,20	-	0,15	-
EURO IV	january 2005.	1,00	0,10	-	0,08	-
EURO V	september 2009.	1,00	0,10	-	0,06	0,005
EURO VI	september 2014.	1,00	0,10	-	0,06	0,005
	Diesel engine					
EURO I	july 1992.	3,16	-	1,13	-	0,18
EURO II	january 1996.	1,00	-	0,70	-	0,08
EURO III	january 2000.	0,64	-	0,56	0,50	0,05
EURO IV	january 2005.	0,50	-	0,30	0,25	0,025
EURO V	september 2009.	0,50	-	0,23	0,18	0,005
EURO VI	september 2014.	0,50	-	0,17	0,08	0,005

From Table 1. it can be seen that the maximum concentration of pollutant in the exhaust manifold reduced to the originally permitted value.

TEHNICAL SOLUTION OF THE EXHAUST SYSTEM

In order to reduce emissions from motor vehicles in the European Union are set increasingly stringent demands on the designers of internal combustion engines, fuel and lubricant manufacturers.

To the composition and quantity of emissions was under control, the inevitable were some changes in the engine design. These changes were related to the treatment system for combustion of fuel, and introduced turbochargers and air coolers, so. *intercooler*. These changes in engine designs reduce the environmental impact of exhaust gases, it was possible to a certain level, which was not satisfactory. Then the producer of fuel required to complete the reconstruction of facilities in order to improve the quality of fuel. Due to the chemical composition of the fuel options for improving the quality were limited.

Constructors are further changes in engine designs on systems processing emissions to the desired level. Gasoline engines operating with stoichiometric mixture at $\lambda = 1$ is used for the treatment of three-component catalyst that reduces the content of CO, HC and NO_x, while those with poorer mixture ($\lambda_{max} = 3$) using an absorption catalyst to further reduce NOx. Figure 1. shows the system for processing exhaust gases of gasoline engines with two catalytic converters that meet Euro 6 regulations.

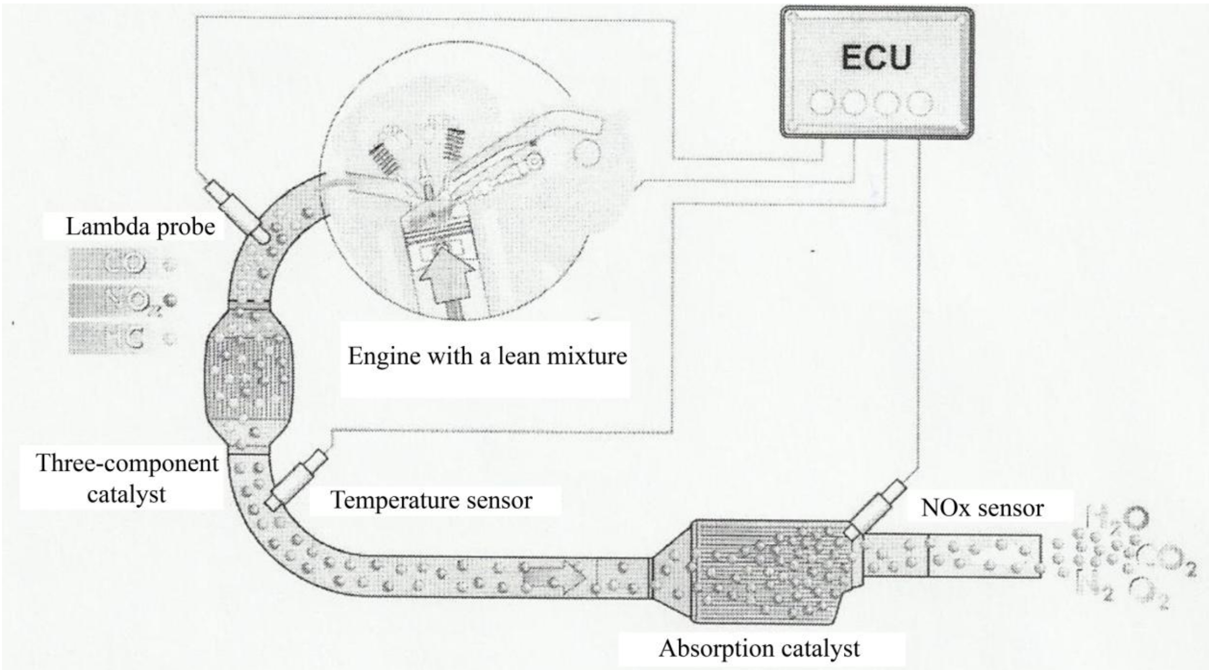

Figure 1. The system for processing exhaust gases of gasoline engines that meets the EURO 6 regulations [1]

Systems for exhaust aftertreatment for diesel engines are sensitive to the composition of the fuel, so it was necessary to significantly reduce the sulfur content in the fuel. Since diesel engines operate with lean mixture at $\lambda > 1$ is almost complete combustion and emissions of CO and HC are low. The main problem is the particulate matter (soot) and nitrogen oxides (NO_x). For the reduction of nitrogen oxides in the exhaust gases of diesel engines, used oxidation catalyst DOC (Diesel Catalyst oxydation). Since these engines are operated with high excess air ratio, three-component catalyst used in gasoline engines can not meet the requirements for reduction of nitrogen oxides. To reduce the amount of particles used in particle filter DPF (Diesel Particulate Filter), and the reduction of nitrogen oxide device refund part of exhaust gases in the intake EGR (Exhaust Gas Recirculation) or more efficient device based on the principle of selective catalytic reduction SCR (Selective Catalytic reduction). Figure 2 shows the system for processing exhaust gas of diesel engines that meet Euro 5 regulations.

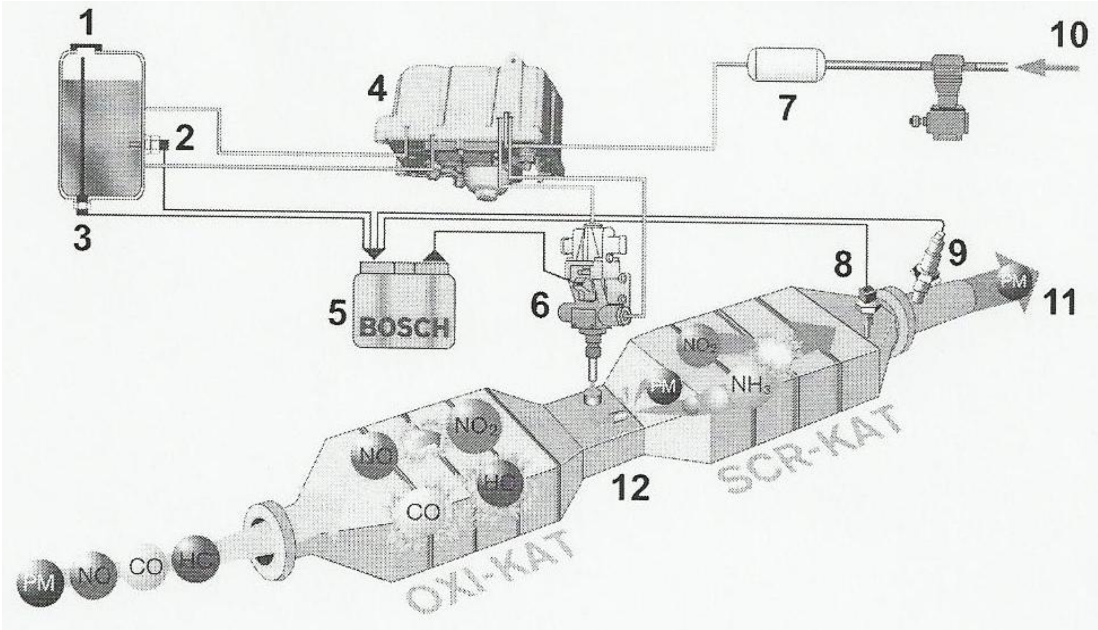

Figure 2. The system for processing exhaust gases of diesel engines that meet Euro 5 regulations: 1 - container of dissolved urea (AdBlue), 2 - temperature sensor, 3 - fullness tank sensor, 4 - module for air intake, 5 - controller, 6 - module for dispensing, 7 - container for air, 8 - temperature sensor, 9 - control emissions, 10 - air supply, 11 - surfaced exhaust, 12 - pipe diffuser

Oxidation catalyst (DOC) is used to cutback amounts of nitrogen oxides in the exhaust pipe systems for combustion, exhaust particulate filter (DPF) for the temporary retention of particles and subsequent combustion and SCR catalyst and ASC (Selective Catalytic Reduction and Ammonia Slip Catalyst) for NOx reduction.
Figure 3. shows the system for processing emissions diesel engine that meets Euro 6 regulations.

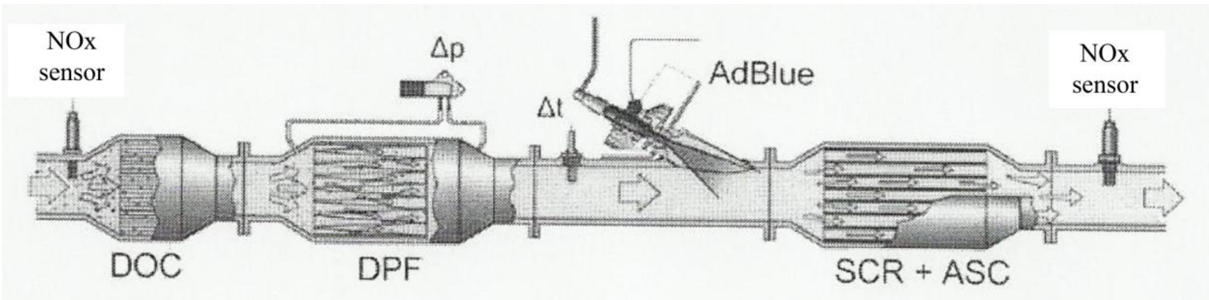

Figure 3. The system for processing exhaust gases of diesel engines that meet Euro 6 regulations [2]

In addition to these innovative designs equipment to reduce emissions of internal combustion engines of passenger cars and commercial vehicles, can also be applied to some non-conventional solutions based on the use of alternative fuels.

REDUCE EMISSIONS USING ALTERNATIVE FUELS

Daily reduction of natural fossil fuel reserves, and the never-ending rise in the cost of their operation causes more intensive research to using alternative energy sources for vehicles. In this way, most of the reduced imports of crude oil and petroleum products and also help to reduce the emission of toxic substances that are released by burning her.

The alternative fuel powered internal combustion engine includes all fuels except gasoline and diesel fuel, which can effectively burn in the engine and having the possibility of mass production (eg. natural gas, methanol, ethanol, hydrogen, biofuels). To an alternative fuel successfully applied to drive passenger cars and commercial vehicles need to be met a number of conditions. The basic criteria essential for evaluating the applicability of alternative fuels for powering internal combustion engines are:

- Emissions,
- Fuel consumption,
- The price of alternative fuels,
- Performance vehicles powered by alternative fuel,
- Conversion costs or production vehicles,
- The method and the possibility of storing fuel in the vehicle (tank for alternative fuels),
- Rechargeable fuel vehicles and the necessary infrastructure,
- General safety and security vehicles, etc.

Alternative fuels that are now in the implementation of the operation of internal combustion engines are:

- Alcohol fuels (methanol and ethanol),
- Liquefied petroleum gas (LPG),
- Natural gas,
- Vegetable oils,
- Hydrogen, etc.

All the above alternative fuels, due to the relatively simple chemical structure compared to gasoline and diesel fuel, have the potential to reduce emissions of harmful components in the exhaust gases. Due to the smaller contents of carbon atoms, the combustion of alternative fuels produced a small amount of carbon dioxide, and hydrogen in the use of carbon dioxide derived exclusively from burning oil for lubrication. It is important to emphasize that the use of alternative fuels can not fully achieve so. "Zero" emissions of harmful exhaust gases by the structure of the hydrocarbon fuel and engine design that requires a degree of lubrication. Figure 4. gives a comparative view of exhaust gases in the event of the application of conventional fossil and alternative fuels in motor vehicles.

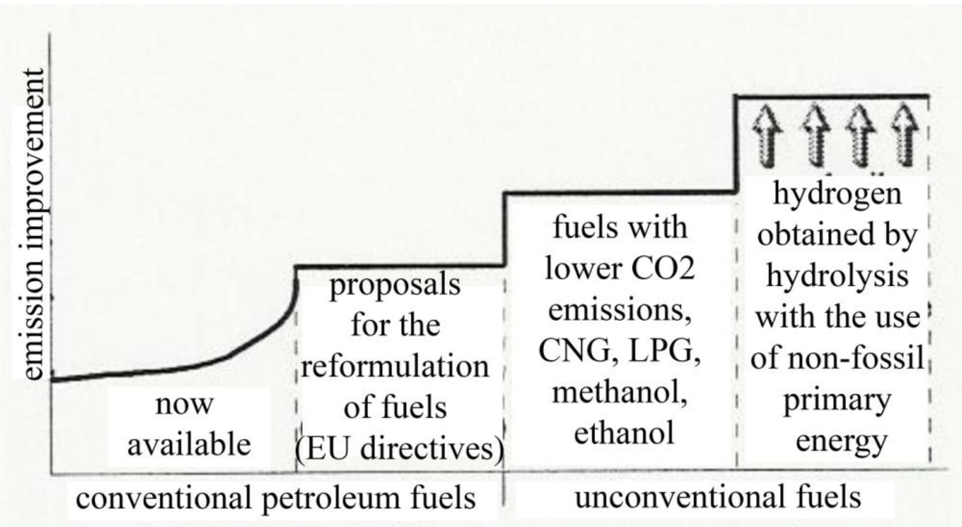

Figure 4. Exhaust emissions in the case of application of conventional fossil and alternative fuels in motor vehicles [3]

It can be concluded that the composition of the fuel burns in an engine has a direct impact on emissions.

ORGANIZATION OF TRANSPORTATION IN URBAN AREAS

Organization of transport in urban areas, and the use of alternative forms of transportation is one of the ways in which it can affect the reduction of pollutant emission. Within the European Union was followed by a number of activities to define and implement appropriate traffic policies through the so-called Green Paper (*Green Paper*), which seeks to solve the most important problems in Europe in the field of air caused by emissions from motor vehicles.

Measures that the state or local and regional governments can take to reduce air pollution arising from usage of motor vehicles are:

- Allocate more funds to improve public transport (tram especially in cities that have it),
- Allocate more funds for the construction of bike paths and promoting their use,
- Use alternative fuels in public transport,
- To invest in the development of railway transport, maritime and inland waterway transport and divert more traffic to these branches,
- Restrict or prohibit the use of motor vehicles in a certain area (the zones of Environmental Protection).

Besides the above mentioned features there are more solutions to reduce the content of harmful components in the exhaust gases resulting from the combustion of fuel in motor vehicles, such as:

- Setting the ramp for a total ban on traffic in the central city areas, except for vehicles used for intervention delivery;
- Provision of funds from the city and the municipal budget to subsidize taxi-drivers;
- Reducing the number of passenger vehicles in the overall traffic flow;
- The introduction of tighter controls on roadworthiness and exhaust emissions;
- Continuous modernization and defects in vehicles of public transportation;
- Continuous promotion of public transport and work to improve the relationship with customers;
- Consistent application of legislation in the field of transport;
- The introduction of electric drive vehicles close in the city center.

CONCLUSION

Exhaust gases emitted by motor vehicles is one of the major air pollutants in urban areas. Presented with requests in the last twenty years, the designers placed the internal combustion engine, manufacturers of conventional fuels and the results of the use of alternative fuels in order to reduce pollutants in the exhaust gases of motor vehicles.

In addition to technical training engines use fuels higher quality level necessary to take appropriate organizational measures at the level of individual settlements in order to reduce emissions from passenger cars, commercial vehicles and public transport vehicles. Traffic in urban areas should be organized in such a way to meet the needs of all interested parties, to be safe and secure, friendly, and efficient economic stimulus, and to exercise a minimal negative impact on the environment.

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INCREASE OF AIR PRESSURE AS A METHOD FOR REDUCING DESTRUCTIVE EFFECTS OF EXPLOSIVE CLOUDS

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ABSTRACT

When the breakdown of the conductive tubes with inflammable gas or liquid happens, a cloud of inflammable explosive particles is being released. In this paper, we analyze the density distribution of such clouds. The model describing such a distribution is presented in this paper. All components are linearly dependent on a single spatial coefficient. The conclusion is that the destructive effects of the explosive clouds can be reduced by increasing the pressure in the room. Considering the fact that the explosion at certain height of the room creates a smaller damage than the explosion at the ground level of the room, by increasing the pressure of the air at the ground it can be obtained that the explosive cloud is lifted to a relatively safe level. Simply, at the moment of the explosion, it is necessary to increase the pressure at the ground level by means of opening pipes (creating high pressure) or a tubes with compressed air, similar to car air bags.

Key words: *inflammable and explosive cloud, diffusion, increasing the air pressure.*

The model which will be presented can be used for the analysis of a clouds of combustible and explosive particles [1-3]. In this paper, a certain density of such clouds and parameters that lead to the minimum thickness.

In theory, the air pollution, we started with equation [4]:

$$\frac{\partial R}{\partial t}=\frac{\partial}{\partial x}\left(S_x\frac{\partial R}{\partial x}\right)+\frac{\partial}{\partial y}\left(S_y\frac{\partial R}{\partial y}\right)+\frac{\partial}{\partial z}\left(S_z\frac{\partial R}{\partial z}\right)-U\frac{\partial R}{\partial x} \tag{1}$$

where R - the density of air pollution, U - wind speed, α, β, γ - the speed of diffusion along the x, y and z axes respectively.
Component diffusion coefficients are: $S_x=\alpha x,\ S_y=\beta x,\ S_z=\gamma x$.

Density we searches in the form:

$$R=F(t)\Psi(x,,y,z) \tag{2}$$

Substituting (2) into (1) we obtain:

$$\Psi\frac{\partial F}{\partial t}=F\left\{\frac{\partial}{\partial x}\left(S_x\frac{\partial \Psi}{\partial x}\right)+\frac{\partial}{\partial y}\left(S_y\frac{\partial \Psi}{\partial y}\right)+\frac{\partial}{\partial z}\left(S_z\frac{\partial \Psi}{\partial z}\right)-U\frac{\partial \Psi}{\partial x}\right\} \tag{3}$$

How do we know that the:

$$\frac{1}{F}\frac{dF}{dt}=-\Omega\text{, we obtain: } F(t)=C_F\,e^{-\Omega t} \tag{4}$$

Then we have: $\alpha\, x \dfrac{\partial^2 \Psi}{\partial x^2} + \alpha \dfrac{\partial \Psi}{\partial x} - U \dfrac{\partial \Psi}{\partial x} + \Omega\, \Psi = -x \left[\beta \dfrac{\partial W}{\partial y} + \gamma \dfrac{\partial \Psi}{\partial z} \right]$

If we take the:

$$\Psi(x,y,z) = \Phi(x) W(y,z) \tag{5}$$

we obtain:

$$W\left[\alpha\, x \frac{d^2\Phi}{dx^2} + (\alpha - U)\,\frac{d\Phi}{dx} + \Omega \Phi\right] = -\,\Phi\, x \left[\beta \frac{\partial W}{\partial y} + \gamma \frac{\partial W}{\partial z}\right] \tag{6}$$

Whence, dividing by - ΦWx, we obtain:

$$\begin{aligned} &\alpha\, x \frac{d^2\Phi}{dx^2} + (\alpha - U)\,\frac{d\Phi}{dx} + \left(\frac{\Omega}{x} - B\right)\Phi = 0 \\ &\beta \frac{\partial^2 W}{\partial y^2} + \gamma \frac{\partial^2 W}{\partial z^2} + BW = 0 \end{aligned} \tag{7}$$

Dividing the first equation of system (7) with α and introduction of sign of $\rho = 1 - (I/\alpha)$, we obtain:

$$\frac{d^2\Phi}{dx^2} + (1 - \frac{U}{\alpha})\,\frac{1}{x}\,\frac{d\Phi}{dx} + \left(-\frac{\Omega}{\alpha\, x} - \frac{B}{\alpha}\right)\Phi = 0 \tag{8}$$

For $\Phi = Aa$, we obtain:

$$\frac{d^2 a}{dx^2} + \left(2\frac{A'}{A} + \frac{\rho}{x}\right)\frac{da}{dx} + \left(\frac{A''}{A} + \frac{\rho}{x}\frac{A'}{A} + \frac{\Omega}{\alpha x} - \frac{\beta}{\alpha}\right) a = 0 \tag{9}$$

How then $\Phi(x) = a\, e^{-\Omega x}$, equation (9) becomes:

$$\frac{d^2 a}{dx^2} + \left(\frac{\rho}{x} - 2\Theta\right)\frac{da}{dx} + \frac{\lambda}{x}\, a = 0\,; \qquad \lambda = \lambda_a = \sqrt{\frac{B}{\alpha}}\,; \quad \lambda = \frac{\Omega}{\alpha} - \rho\Theta \tag{10}$$

If you take that $a = \sum_{\nu=0}^{\infty} F_\nu x^{\nu+k}$ and replace the equation (10), we obtain:

$$\sum_{\nu=0}^{\infty} \left[(\nu + k - 1)(\nu + k) + \rho\,(\nu + k)\right] F_\nu = \sum_{\nu=0}^{\infty} \left[2\Theta\,(\nu + k) - \lambda\right] x^{\nu+k-1}\, F_\nu \tag{11}$$

For $\dfrac{\lambda}{2\Theta} = \dfrac{1}{2}\left(\dfrac{U}{\alpha} - 1\right) + \dfrac{1}{2}\dfrac{\Omega}{\sqrt{\alpha B}} \equiv n\,,$ n – whole number (12)

We obtain:

$$F_{\mu+1} = -\,2\Theta\,\frac{\omega - n}{(\mu+1)\,(\mu+\rho)}\,F_\mu\,, \qquad n = \frac{\omega}{2\Theta} \tag{13}$$

For μ = m and applied Gaussian functions, we obtain:

$$F_m = (-2\Theta)^m \ \Gamma(\omega+1)\,\Gamma(\rho)\,\frac{1}{m!}\,\frac{\Gamma(\rho+m-1)}{\Gamma(\rho)}\,F_0 \tag{14}$$

Speed of diffusion along the x, y and y-axis are related to the total rate of diffusion as:

$\alpha = \nu$, $\beta = \gamma = \nu/50$ then $\lambda_\alpha = \sqrt{\frac{B_n}{2\nu}}; \quad \lambda_\beta = \lambda_\gamma = \sqrt{\frac{50\,B_n}{2\nu}}$.

In order λ from equation (12) was equal to the whole number n, the condition must be satisfied:
$\frac{\Omega}{\sqrt{\nu B_n}} = f(n), \quad f(n) = 2,5,8,11,\ldots$ where the:

$$B_n = \frac{\Omega^2}{\nu}\frac{1}{f(n)^2}, \quad \Theta_n = \sqrt{\frac{B_n}{\nu}} = \frac{\Omega}{\nu}\frac{1}{f(n)}, \quad \lambda_n = \frac{\Omega}{\nu}\frac{\sqrt{25}}{f(n)} \tag{15}$$

So finally is gets that:

$$\Phi_n(x) = \frac{5}{2}\,f(n)\sum_{m=0}^{n}\frac{(-1)^m\,2^{m+1}\,n!\,[f(n)-1]!}{(n-m)!\,[f(n)-2+m]!} . \tag{16}$$

Continue to search solutions for the function Wn (y, z) = Wn (y) Wn (z) where:

$$W_n(y) = b(y) = \int_0^{L_y}\sin\lambda_n dy = \frac{1}{\lambda_n}[1-\cos\lambda_n L_y] \qquad W_n(z) = c(z) = \int_0^{L_z}\sin L_n dz = \frac{1}{\lambda_n}[1-\cos\lambda_n L_z]$$

If we assume that: ν/Ω = 5 i $L_y = L_z$ = 10 m, we get:

$$W_n(y) = W_n(z) = f(n)\left[1-\cos 10\frac{1}{f(n)}\right] \tag{17}$$

Substituting (16) and (17) into (5) and in (3) for the initial state (τ = 0), when the mass or density of the time-dependent, we get $e^{-\Omega t} = 1$, and the final expression for density:

$$R_n = \frac{M}{V} = \frac{M}{\Phi_n W_n^2} \quad [\mathrm{kg/m^3}], \qquad m = 1\ \mathrm{kg} \tag{18}$$

Taking into account the last expression - the formula (18) as a reference [5] made a table which shows the density dependence of air pollution clouds in the initial moment of time and the value of the unit of mass (Table 1) and table diffusion density for different values of masses ejected during the explosion (Table 2):

Table 1: The dependence of density clouds of air pollution

n	$f(n)$	W_n(m)	Φ_n(m)	V_n(m^3)	R_n[kg/m^3]$\cdot 10^{-4}$
0	2	1,4327	10	20,534	0,0488
1	5	7,0807	50	0,251	3,989
2	8	5,4774	160	0,480	2,0832
3	11	4,2409	320,001	0,575	1,7375
10	32	1,5498	2951,304	0,709	1,4107
15	47	1,0598	6450,562	0,724	1,3802
20	62	0,8047	11299,779	0,732	1,3667

Table 2: Densities of diffusion for different values of the mass

n	$M = 1\cdot 10^{-4}$ kg	$M = 2{,}54\cdot 10^{2}$ kg	$M = 1{,}2\cdot 10^{3}$ kg	$M = 4{,}5\cdot 10^{3}$ kg	$M = 1{,}2\cdot 10^{4}$ kg	$M = 1{,}2\cdot 10^{4}$ kg
0	0,487	12,370	58,44	2,1915	584,4	3360,3
1	0,3989	0,101	0,479	1,795	4,787	27,524
2	0,20832	0,0529	0,250	0,937	2,4998	14,374
3	1,7375	0,0441	0,208	0,782	2,085	11,989
10	1,4107	0,0358	0,169	0,635	1,693	9,734
15	1,3802	0,0351	0,1656	0,621	1,565	9,523
20	1,3667	0,0347	0,164	0,615	1,640	9,430

CONCLUSION

In paper is shown that a decline in density over time means a decrease in the value of gas mass ejected in the time. For the initial state ($\tau = 0$) the mass and density does not depend on the time. Increasing the diffusion coefficient increases the volume and decreases density.

This can be achieved by increasing the pressure in the room, inserting at the space of some quantity of gas so as to obtain a mixture which increasing of the diffusion.

There is no absolutely safe concentration of explosive and inflammable particles (explosive - inflammable cloud), but it is certain that you can achieve that it will always be less than the density of air. In this way, explosive and flammable cloud goes to the height and the explosion at a sufficiently great height can cause little destruction and little damage. Denser and heavier-than-air cloud is certainly the most dangerous.

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DISTRIBUTION OF THE CONCENTRATION OF SULPHUR DIOXIDE INTO THE ATMOSPHERE FROM POINT SOURCE

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ABSTRACT

Typical pollutants can include gases which are present in every urban area and near power plants. Among these substances the most common and most harmful to human health is sulphur dioxide. This study analyzes the distribution of the ground concentration of sulphur dioxide from the stationary point sources for different heights of chimneys and different powers of sources in conditions of stable and unstable atmospheric conditions. The distribution of concentration is calculated 24 hours after the release of sulphur dioxide into the atmosphere. The results are compared with the legally permissible concentrations. The distribution of the concentration is determined according to Gaussian mathematical model.

Key words: *sulphur dioxide, air pollution, distribution of concentration, Gaussian mathematical model*.

INTRODUCTION

Clean air is practically not found in nature. It is contaminated by numerous substances caused by human activities. Any change in the composition and condition of the air crossing the border of adaptability of human body, leading to his disease, is called air pollution.
Sources of air pollution can be divided into (Tiwary, 2010):

- Natural sources of pollution
- Anthropogenic sources of pollution

Natural sources of pollution have always been present in biosphere and these include:

- deflation- dispersion of soil and sand (especially increased in the deserts and forest-steppe zones)
- smoke of forest and steppe fires (contains CO, soot, pitch, tar and more)
- volcanoes- with strong eruptions they emit huge amounts of dust, gases of SO2, CO_2 etc.
- mineral and thermal springs- they can emit CO_2, H_2S, methane, etc
- cosmic dust, which is believed to be radioactive
- surface of the ocean can be a source of CO_2, CO, H_2S, chloride etc.
- natural disasters can be accompanied by significant emissions of air pollutants
- storms
- earthquakes

Anthropogenic sources of pollution can be divided into:

- stationary or point sources
- mobile sources

Up to now hundreds of pollution substances have been identified, and we should certainly point out a possibility of creating new ones, so far unknown compounds, under the influence of solar radiation and electric discharges (Jaćimovski, 2012).

Typical pollutants include those gases which occur in every urban area and near thermal power plants. The most common pollutants and sources of pollution are given in the Table 1:

Table 1: Pollution substances and sources of pollution

Pollution substance	Main source of pollution
Sulphur dioxide SO_2	Combustion of coal, oil, heavy and non-ferrous metallurgy
Hydrogen sulfide H_2S	Chemical processes, refinery
Carbon monoxide CO	Combustion, engines SUS
Oxides of nitrogen NO_x	Combustion, engines SUS
C_n H_{n+2}	Evaporation of liquid fluids, exhaust gases
Soot	Combustion
Suspended particles	Technological processes, quarry, cement-works
Volatile organic compounds	Chemical processes, oil process, distribution of petrol

Air pollution can be transported over long distances in relation to the source. Distance depends on the speed of spreading (diffusion) of contaminated air mass and of the speed of sedimentation (deposition) of the contaminated matter.

Changes in air polluted with smoke containing components, in the course of the year depend on various factors, such as:

- meteorological conditions
- size of the urban area
- location of measuring point
- the terrain
- the influence of vegetation, especially forests and
- other physiographical conditions

SULPHURDIOXIDE

It is significant to identify certain kinds of pollutants and their sources. Among these substances the most common and most harmful to human health is sulphur dioxide. A great amount of sulphur dioxide is released from the chimneys of thermal power plants accompanied by other harmful substances.
Sulphur compounds, as a polluting admixtures, emit into the atmosphere:

- natural processes which lead to the emission of sulphur compounds and
- anthropogenic processes which lead to the emission of sulphur compounds.

Out of natural systems (atmosphere, biosphere, ocean systems) comes the emission of the following compounds: H_2S, COS, CS_2, DMS, SO_2, various sulphates and mercaptan.

Oceans and seas are regarded as the main natural emitters of sulphur dioxide (H_2S). The sources of sulphur dioxide (SO_2) are oceans and seas, as a result of the oxidation of the emitted sulpfur dioxide compounds.
Anthropogenic emission of sulphur compounds is at its biggest volume over sulphur dioxide. The most important source of sulphur dioxide, appearing in the atmosphere, are plants for burning fossil fuels, especially coal.

The concentration of sulphur dioxide in the atmosphere of urban and industrial areas is larger than in non-urban area.

All the sulphur emitted into the atmosphere returns again, through sulphuric acid, sulphates and other sulphur compounds, on the earth's surface. The most controlled are emissions of SO_2 of non-cancerous group and soot of cancerous group and complete sedimentary substances. These can be regarded as indicators of air pollution. Sulphur dioxide appears as a product of sulphur combustion in fossil fuels. It is a strong-smelling gas, heavier than air. Its toxicity increases in conditions of increased humidity due to creating sulphuric acid. According to the latest findings, the oxidation products of SO_2 in the air are even more toxic than SO_2 itself. Soot is produced by burning fossil fuels. These are fine, small particles of about 5 microns. They float in the air and act as a gas. They contain toxic and cancerous substances. Sedimentary substances are particles of solid fuel, ash, road dust which fall on the ground due to its weight. Precipitations with the pH value beneath 5,6 are called acid precipitations (“acid rains“).

Sulphor which becomes a part of the fuel (coal,oil) burns forming oxides:

$$S+O_2=SO_2$$

To a lesser extent further oxidation is implemented:

$$SO_2+1/2O_2=SO_3$$

Sulphor dioxide and sulphor trioxide accompanied by the suspended particles and humidity have the most harmful effect on humans, living organisms and material goods. Sulphor dioxide is a colourless gas which does not burn, whose scent feels in the air at the concentration of $0.3-1.0\cdot10^{-6}$, and at the concentration bigger than $3.0\cdot10^{-6}$ sulphor dioxide has a pungent irritating odour. Sulphor dioxide in the mixture with solid particles and sulphuric acid (which has a larger irritating effect than sulphor dioxide) at the average annual concentration of $0.04-0.09\cdot10^{-6}$ and at the smoke concentration of $150-200\ \mu g/m^3$ leads to the symptoms of shortness of breath and lung disease, and at the average daily concentration of $0.2-0.5\cdot10^{-6}$ and smoke concentration of $500-700\ \mu g/m^3$ you can see the sudden growth of the sick and deaths. At the concentration of sulphor dioxide of $0.3-0.5\cdot10^{-6}$ within a few days chronic illness of leaf plants appears (particularly spinach, lettuce, cotton and alfalfa) as well as it appears with needles of conifers.

Sulphur oxides cause acid rains to appear. Chemical reaction that gives rise to acid rains is given as:

$$SO_2 + H_2O = H_2\,SO_3,$$
$$SO_3 + H_2O = H_2\,SO_4.$$

GAUSSIAN MODEL OF DISTRIBUTION OF AIR POLLUTION CONCENTRATION

Scattering particles in the atmosphere is related to atmospheric turbulence and is accomplished by molecular and turbulent diffusion (Берлянд, 1975). In addition, turbulent diffusion has the essential role while the role of molecular diffusion is negligible. Turbulent diffusion has two components, thermal and dynamic. Thermal diffusion is connected to vertical temperature gradient of air and produces so called convective turbulence. Dynamic diffusion accomplishes mechanical turbulence and is produced during the movement of air masses affected by wind. In the lower layers of troposphere1 it increases under the influence of relief and is not connected to the temperature gradient.

Sources of air pollution of business entities are stationary, when the source coordinates do not change over time and non-stationary such as motor transport. Sources of air pollution can be: point, linear and outdoor. Point sources are the ones which are concentrated on one spot such as chimneys, vents etc. Linear sources have distinct length, like highways etc. Outdoor sources are distributed over the surface, such as forest fires.

Depending on the height of the hole (H) through which air pollution is emitted, sources can be divided into four classes (Берлянд, 1985)

High sources ($H \geq 50$ m);

1 Troposphere (up to 11 km) –the lowest layer of atmosphere

Middle sources (H= 10 … 50 m);
Low sources (H =2 … 10 m);
Ground sources (H≤ 2 m).

Major part of pollutants is concentrated in the ground layer of atmosphere up to the height of several meters above the earth's surface.

One of the most used models for calculating air pollution is Gaussian air pollution model that comes from stationary sources. In the basis of this model lies an assumption that the pollutants in the atmosphere are distributed according to Gaussian normal distribution.

Similar calculating method is recommended in the USA by the Environmental protection agency and it has a normative character (Lazaridis, 2011).

Models of this type are suitable for both short-term and long-term forecasts of air pollution. Short-term forecasts are executed by a model which calculates the map of pollution for a period of time during which meteorological conditions are stable. The same models can be used for long-term forecasts if the observed time period can be divided into quasistable meteorological conditions. This kind of approach may demand certain calculation difficulties, especially when you must determine annual average concentration for a large number of sources of air pollution. The distribution of concentration can be found by direct solving of the equation of turbulent diffusion (Tošić, 1982).

According to Gaussian model the concentration of light pollutants is determined according to (Cranck, 1975; Марчук,1982):

$$C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left\{-\frac{y^2}{2\sigma_y^2} - \frac{(z-H)^2}{2\sigma_z^2}\right\} \tag{1}$$

where σ_y^2, σ_z^2. – dispersions that characterize Gaussian distribution of the axes *y* and axes *z*, *Q* – mass flow of pollutants from stationary source (chimney), *u*- wind speed, *H*- effective height of chimney2. According to the concrete calculation, dimensions σ_y, σ_z (for distances from 100 to 10^4 m) are approximated as follows:

Numbers *a, b, c* i *d*, are taken from the following chart (Pasquill, 1983):

Table 2: Calculation parameters

		a	*b*	c	*D*			*a*	*b*	*c*	*d*
Very unstable	(A)	0,527	0,865	0,28	0,90	Neutral	(D)	0,128	0,905	0,20	0,76
Unstable	(B)	0,371	0,866	0,23	0,85	Stable	(E)	0,098	0,902	0,15	0,73
Weakly unstable	(C)	0,209	0,897	0,22	0,80	Very stable	(F)	0,065	0,902	0,12	0,67

Gaussian model is an idealization with the following limitations (Sportisse, 2008):

1) it can be applied only to flat and open surface
2) it is difficult to include the influence of the obstacles which the smoke column encounters
3) meteorological conditions and conditions of the earth's surface are constant on the whole distance through which the cloud goes
4) it is applied only to gases with the density close to the density of air
5) it necessarily presupposes the existence of the wind at the speed of *u* > 1 m/s.

2 Effective height of chimney is the sum of actual height of chimney and maximum height of smoke column above the chimney

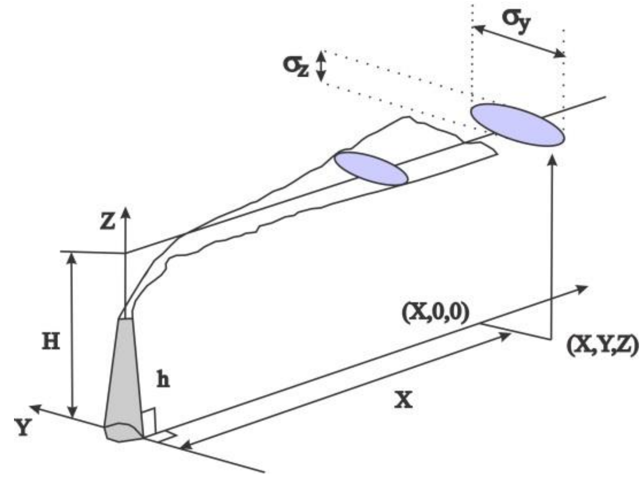

Figure 1. Display of parameters of Gaussian model of pollutants spreading from the source

ILLUSTRATIVE EXAMPLE

As an example of calculation we can take one metallurgical combine which processes 1000 tons of copper-chalcopyrite ore (Tasić, 2007). We shall assume that the atmospheric conditions are neutral and that the wind blows at speed of 3 m/s at the height of 10 m. Using the Gaussian model of spreading air pollution we can calculate the disttribution of the concentration of sulphur dioxide depending on the height of the chimney for neutral weather conditions. Likewise, we can determine the distribution of the concentration depending on the size of the mass flow for neutral weather conditions as well as the distribution of the concentration depending on different weather conditions.

Releasing SO_2 into the atmosphere is a result of technological processing of the ore which is described by the following chemical reaction:

$$4CuFeS_2 + 11O_2 \Rightarrow 4FeO + 2Cu_2O + 10SO_2 \tag{3}$$

ie. every 4 moles of ore take 10 moles of gas, which means that 1 mole of ore takes 2,5 moles of gas . Molar mass of ore is 183,52 g/mole,and molar mass of sulphur dioxide – 64,07 g/mole. Then you can abstract for one day 2,5 x 4,07 x 1000/183,52=872,79 tons or 10101,77 g/s. Concentration *C* of released gas wil be calculated according to the following formula:

$$C(x,0,0) = \frac{Q}{\pi\sigma_y\sigma_z u}\exp\left(-\frac{H^2}{2\sigma_z^2}\right) \tag{4}$$

where we want to know the ground concentration in the direction of the wind blowing, that is the *x* axis. The wind speed *u* is determined by the formula (Степаненко, 2008):

$$u = u_1\frac{H}{z_1} \tag{5}$$

where z_1=10 m, u_1 –wind speed at the height of 10 m.
For neutral atmospheric conditions is $\sigma_y = 0.128x^{0.905}; \quad \sigma_z = \alpha\sigma_y; \quad \alpha = 0.5$.

We want to know the distribution of the ground concentration of SO_2 for different heights of chimneys, maximum concentration, distance at which the maximum concentration can be reached, as well as the area in which the concentration of SO_2 is above the legally permitted (Tiwary, 2010).

The results obtained by applying the Gaussian model to a given example are presented in the table and figures.

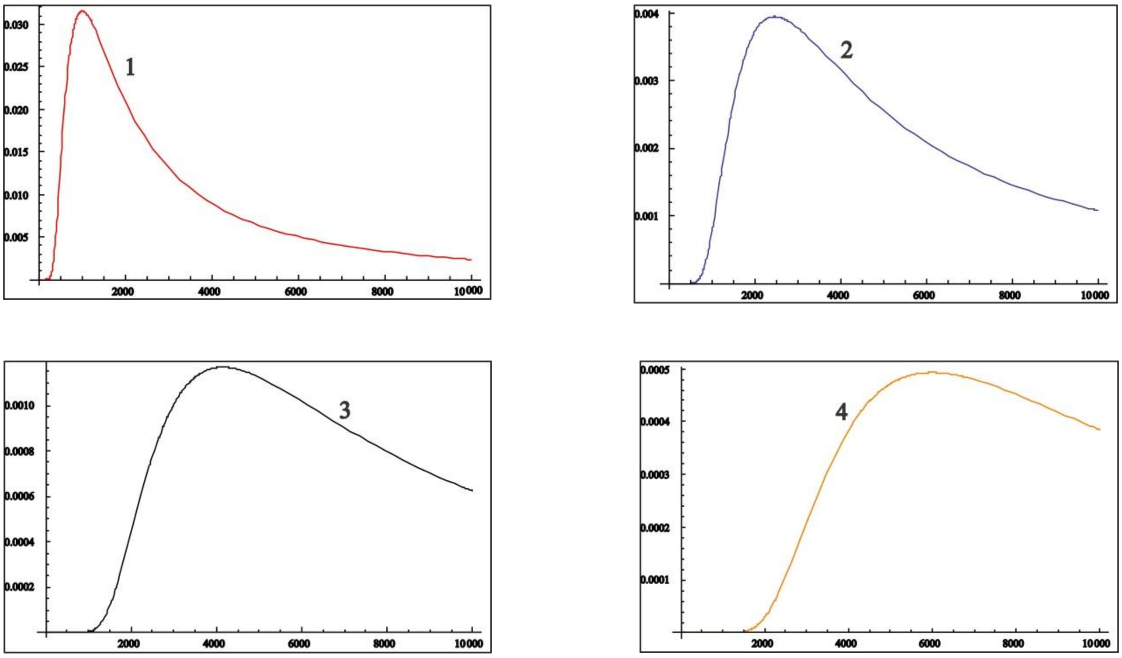

Figure2. Distribution of concentration in the function of distance from the source for different chimney heights: 1) H=50 m;2) H=100 m; 3) H=150 m ; 4) H=200 m

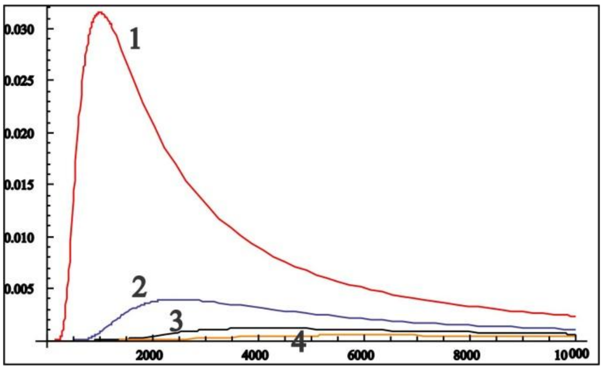

Figure 3. Common display of spreading of concentration for different chimney heights 1) H=50 m;2) H=100 m; 3) H=150 m ; 4) H=200 m

Table 3: Distances of maximum concentrations, limit value of the concentration and the zone in which the concentration is above the limitted one

	x_{max} (m)	C_{max}(g/m^3)	C_{border} (g/m^3)	x_{min}(m)-x_{max}(m)
H=50 m	1012,88	0,032	0,00015	257-59218
H=100 m	2463,17	0,0039	0,00015	775-37672
H=150 m	4142,39	0,0011	0,00015	1563-28397
H=200 m	5990,04	0,00049	0,00015	2723-22470

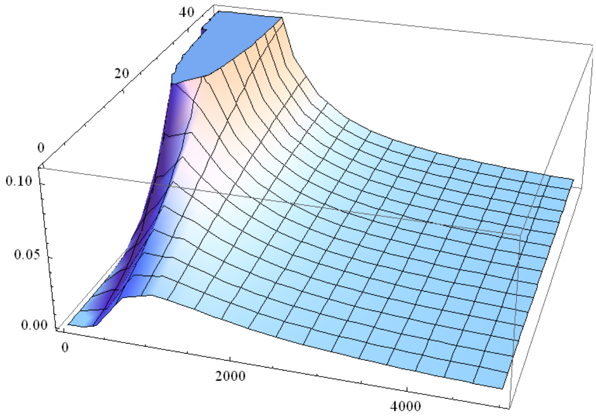

Figure 4. 3D display of functional dependence C(x,0,z)

Also, the analysis of the concentration dependence on the distance for different mass source flows and for different meteorological conditions. Concentration dependence on the distance for different mass source flows is presented in Figure 5.

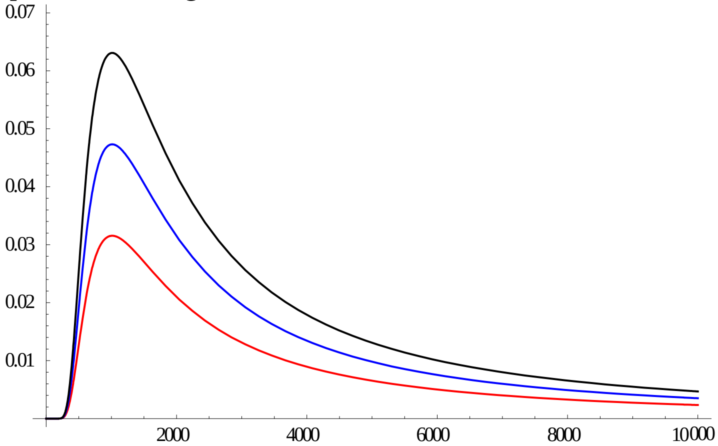

Figure 5. Concentration dependence of SiO2 on the distance for different source flows and the for the same chimney height-blue line corresponds to the source power 1.5 times greater than the basic (red line), and the black line corresponds to the source power 2 times greater than the basic

Dependence of the concentration of the air pollution on the distance of the source for different meteorological conditions is presented in Figure 6.

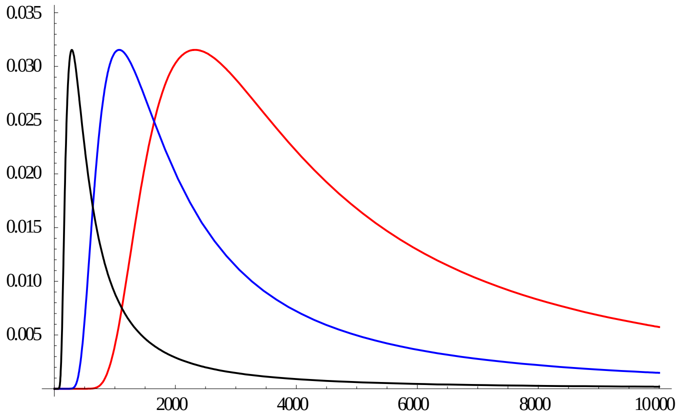

Figure 6. Dependence of concentration of SiO2 on the distance of the source for different weather conditions- black line corresponds to unstable conditions, blue to the neutral and red to the stable ones

All calculations were performed by the software package *Mathematica 9.*

CONCLUSION

This study has analysed one of the most common air pollutants, and that is sulphur dioxide which comes into the atmosphere either by combustion of different fuels or procession of ores in industrial units. Spreading of sulphur dioxide into the atmosphere during the processing of copper-chalcopyrite ore was taken as an example which illustrated the use of Gaussian model for calculating air pollution and finding the ground concentration in the situation of stable weather conditions. Although every model necessarily stands for appropriate simplifications, it is obvious that mathematical moulding of pollutant's spreading into the atmosphere can be calculated relatively fast (up to 24 hours), assessment of spreading and the size of the concentration thereof. Calculations were made for different heights of stationary point source (chimney). Also, it can be estimated at what distance the maximum concentration will be and what its value will be. Besides, you can find a zone in which the concentration is above the legally permitted.
The given example shows that the lower the height of the chimney is, the bigger the ground concentration becomes. Also, the pollutant concentration is above the limitted in the wider area as the height of the chimeny gets lower. With the increase of the chimney height, maximum concentration is shifted to larger distances from the chimneys and at the same time the concentration maximums have a lower value.

Figure 5 shows that the larger the mass source flow gets, the greater the maximum concentration value gets, and concentration maximums are moving away from the source. Figure 6 clearly shows that maximum values of concentration do not depend on weather conditions. Also, for bad weather conditions the concentration maximums are implemented closer to the source of the pollution.

In further research these mathematical models could be implemented into actual systems, and with the data obtained by monitoring the specific area near the source of the pollution and with the use of the Geographic information system, you could get a powerful weapon for prevention and analysis of spreading harmful substances, which would help improve the quality of life in certain areas.

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AIR QUALITY IN URBAN AREAS IN SERBIA: CURRENT STATE AND LEGAL PROTECTION

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ABSTRACT

Satisfactory level of air quality is one of key preconditions for the survival of all living organisms. Due to rapid industrial development, increased traffic and everyday use of toxic substances in industry, agriculture, health care, pharmacy and cosmetics, air pollution, particularly in urban areas, has become a serious global issue. The consequences of this environmental, legal, social, economic and medical problem are long-lasting and devastating. They affect environment as a whole and its integral parts – air, water, soil, living organisms and the entire humankind, including future generations, and represent grave violations of human right of healthy living environment. Annual Reports of Environment Protection Agency show that air quality in the zone of the Republic of Serbia and its agglomerations of Beograd, Bor, Niš and Novi Sad is assessed as "over polluted", which means that tolerable values of one or more air pollutants have been exceeded in these areas, causing serious concern of experts and general public. The authors of this paper provide a brief overview of present state of air quality in Serbia, critically analyze current legislative framework for its protection and explain the mechanism of state reaction to the violation of legal provisions relevant to air protection.

Key words: *Air Quality, Environment, Pollution, Law, Protection.*

INTRODUCTION

Air is one of three mediums of living environment for numerous organisms and appropriate oxygen level makes it the only surrounding where humans can survive. As a climatic, non-biotic ecological factor, air has an exceptional influence on some organisms and populations, as well as on ecosystem as a whole. Air comprises a mechanical mixture of gases, which envelops the Earth creating its atmosphere. It includes circa 4/5 of Nitrogen N_2, 1/5 of Oxygen O_2 and a small quantity of other gasses such as Argon Ar, Carbon-dioxide CO_2, Neon Ne, Methane CH_4, Ozone O_3, water vapor and various impurities (Vig and Gajinov, 2011). In the lower layer of the atmosphere, where life is maintained and various organisms are surviving, the composition of the air is relatively stable. Unchanging chemical and physical characteristics of air are significant for normal functioning of all living organisms and clean air represents a precondition for healthy life of humans and entire ecosystems. But, the troubles appear when the balance of its ingredients is violated (Vig and Gajinov, 2011).

Significant modifications of air's composition in the lower layer are usually of local character and are commonly caused by anthropogenic sources of pollution. However, in the past couple of decades, the modifications of air quality tend to go beyond local borders and obtain global character and importance. Intensive spreading of urban and industrial zones commenced in the times of industrial revolution. Nowadays, the highest concentration of human population can be measured in urban areas. In these artificial ecosystems, regular composition of air is altered because of an increasingly high percentage of air pollutants. These pollutants are launched into the atmosphere from industrial and communal complexes, car engines, cooling devices etc. Due to these sources of pollution, the air is filled with CO_2, CH_4, SO_2, atmospheric oxidants (nitrate oxides NOx, O_3 and secondary photo oxidants), chlorofluorocarbons CFCs (commonly known as freons), hydrogenous halides (HF, HCl, HBr, HI), as well as a large amount of dust and ashes. Increased concentration of these substances in inhabited industrial areas represents one of the signs of anthropogenic pollution of atmosphere.

Various gases and hard substances are mixed together circulating through air masses. Molecules of water keep these substances together, particularly during the winter, in the period of increased air humidity, causing dense layers of fog. These fogs and mists, combined with smoke arising from a multitude of industrial and other funnels represent typical features of large industrial urban centers. Due to sunlight and presence of ultraviolet UV radiation, a stratum of photo-chemical mist is also formed in the atmosphere that is over-polluted with car exhaust gases and smoke from car engines and industrial funnels, such as NOx at first place (Kerr and Seckmeyer, 2002).

Deterioration of forests in the most developed industrial areas of Europe and North America, caused by direct effect of air pollutants and “acid rains” on over-ground parts of plants, particularly on the leaves in the canopy layer of the trees, has been taking place since the times of industrial revolution. Sulfuric compounds, primarily SO_2, lead to these global changes caused by the effect of “acid rains”, that are extremely dangerous for living organisms, water, soil, architectural objects and monuments. Under these artificial atmospheric conditions, constant increase of the concentration of CO_2, CFCs, CH_4 and NOx leads to global planetary warming because it boosts the “greenhouse effect”. The latter may cause the harm of Earth’s thermal balance, melting of snows and glaciers, increase of sea and ocean level and flooding of coastal regions. At the same time, more and more natural habitats are being destroyed and left with scarce vegetation as the consequence of the process of anthropogenic use of plants and “desertification” of landscapes, which all represent burning ecological issues of global importance.

The symptomatology of damages caused by atmospheric pollutants is extremely diverse and nonspecific. A particular pollutant may produce different effects on different organisms, which depends on whether they are resistant or submissive to its influence and the presence of different pollutants may produce equal symptoms. Synergic effects of pollutants and specific climatic conditions of environment are also common (Stevanović and Janković 2001). Polluted air causes extremely severe respiratory disturbance and may lead to the occurrence of bronchitis. The so called “bad” or tropospheric ozone has a particularly harmful impact on human health. According to the data collected by The European Environmental Agency1, nearly 20,000 people per year die in Europe due to the consequences of harmful effects of “bad” ozone. It is estimated that, the damage caused to European agriculture by the “bad” ozone in 2000 was around 2.8 billion of Euros. The concentration of stratospheric or “good” ozone is decreased by NOx and CFCs, disappearance of which produces a multitude of negative consequences. The level of UV radiation in the troposphere is increased (Dahlback, 2008), which affects human health (Norval, et al., 2007) and causes skin cancer, eye lens cataract, weakness of immune system, decrease of bio production, increase of greenhouse effect, damaging of some materials etc.2 Conservation and protection of air i.e. atmosphere contributes to the preservation of climate, which is considered one of fundamental strategic directions on a global level, together with the conservation of biodiversity. Accordingly, air protection is relevant to the conservation of all elements of living environment, which are closely interrelated and depend on each other.

STATE OF AIR QUALITY IN URBAN AREAS IN SERBIA

Data presented in the Report on Air quality in Serbia for 2011, published by Environmental protection Agency in 2012, clearly show that there is reason for concern in this area of environmental protection. According to the findings of this national body in charge of monitoring air quality, total levels of various dangerous pollutants such as SO_2, NO_2 and powder substances have increased in comparison to their values from previous years. Namely, total amount of SOx released on the territory of Serbia was circa 7% bigger in 2011 than in 2010, total amount of released NOx increased for around 15% and an increase in total quantity of powder substances in the air was also detected. Thermal plant “Nikola Tesla A”, electric power plant and mines “Kostolac B”, thermal plant “Nikola Tesla B”,

1See: http://www.eea.europa.eu/themes/air/air-quality/more-about-air-pollutants/ozone-1/impacts/costs-of-ozone-pollution, 22.08.2013.
2 See: http://www.ozonecell.com/viewsection.jsp?lang=0&id=0,165, 22.08.2013.

mines “Bor-Toponica”, copper refinery “Bor”, thermal plant “Kolubara”, thermal plant “Morava” and oil refinery “Pančevo” are identified as the most active polluters since they keep emitting the largest quantities of these hazardous substances in our country.

Exceeding of tolerable or limit annual value of pollutants was noted in 22 cases out of 124. In 12 cases, there was an increase in the level of PM_{10}, in 7 cases in the level of NO_2 and in 3 cases in the level of SO_2.These finding show that suspended particles PM_{10} represent dominant pollutants in Serbia, which means that the concentrations of suspended particles and NOx practically determine the quality of air in the Republic of Serbia. In accordance with the categorization of air into three categories, depending on its purity, which is set by the Law on Air Protection, the quality of air in Serbia, as a whole, can be described as the air of III category, which means over-polluted air. Air of III category or over-polluted air, containing suspended particles PM_{10} was identified in Kosjerić, Smederevo and Pančevo, whereas over-polluted air containing intolerable amounts of other pollutants was found in Beograd, Bor, Niš and Novi Sad. The air of I Category i.e. clean air was identified only at following spots: Kopaonik, Kamenički Vis, Obrenovac-Ashes Deposit, Kostoalc, Smederevo-Customs, Kraljevo, Loznica, Čačak-Institute for Fruit Production, Paraćin, Šabac, Kruševac, Zaječar, Niš-Sveti Sava School, Valjevo and Vranje. However, final assessment of air quality in Serbia, conducted in accordance with relevant rules of estimation, shows that it is over-polluted.3

LEGAL PROTECTION OF AIR QUALITY IN SERBIA – CURRENT LEGAL FRAMEWORK

International documents

The following international documents regulating the issue of global air pollution can be singled out as the most important: 1) The 1979 Geneva Convention on Long-range Transboundary Air Pollution4, ratified by SFRJ in 1986, with additional protocols such as: a) The 1984 Geneva Protocol on Long-term Financing of the Co-operative Program for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), b) The 1991 Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes; c) The 1998 Aarhus Protocol on Persistent Organic Pollutants (Bull, 2003), d) The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone and 2) The Vienna Convention for the Protection of the Ozone Layer5 ratified by the Republic of Serbia in 1990 with the Montreal Protocol on Substances that Deplete the Ozone Layer6, ratified by the Republic of Serbia in 2004 (Vig and Gajinov, 2011; Joldžić, 2006).

The Geneva Convention obliges its member states to promote environmental protection through the protection of air from pollution and gradual decrease and suppression of pollution, to develop policies and strategies for combating release of pollutants in the air, to exchange information relevant to air protection and pollution, to cooperate in the field of research in the area of air quality, to control the state of air quality and establish adequate mechanism for air quality control, to prescribe limit measures that would contribute to the efficiency of air protection, to develop technologies for minimization of release of pollutants and for measurement of their concentration, to participate in the monitoring program etc (Joldžić, 2006). The Vienna Convention obliges its signatories to prevent the pollution of air by the substances that might damage the ozone layer, to prescribe acceptable modalities of use of substances that might deplete the ozone layer, to create a list of these substances,

3 Godišnji izveštaj o stanju kvaliteta vazduha u Republici Srbiji 2011. godine, Beograd: Ministarstvo energetike, razvoja i zaštite životne sredine Republike Srbije, Agencija za zaštitu životne sredine, 2012..

4 Convention on Long-range Transboundary Air Pollution, Geneva, 13 November 1979, UNTS, vol. 1302, p. 217.

5 Multilateral Vienna Convention for the Protection of the Ozone Layer (with annexes and Final Act). Concluded at Vienna on 22 March 1985, registered ex officio on 22 September 1988, UNTS, vol. 1513, No. 26164, p. 293.

6 The Montreal Protocol on Substances that Deplete the Ozone Layer

to determine the modalities of their use, import and export and to keep records of trans-boundary and pollutions that might lead to the depletion of the ozone layer (Joldžić, 2008).

The European Union7 has also dedicated a significant amount of legislative documents to the issue of air quality and air protection (Vig and Gajinov, 2011). Actually, air quality seems to be one of the areas in which the EU has been most active. Since the early 1970s, the EU has been working to improve air quality by controlling emissions of harmful substances into the atmosphere, improving fuel quality, and by integrating environmental protection requirements into the transport and energy sectors8. European air pollution policy has a long history and some notable successes to its name. The most recent wave of policy was launched in 2005 with the Thematic Strategy on Air Pollution designed to make substantial progress towards the long-term EU objective: to achieve levels of air quality that do not result in unacceptable impacts on, and risks to, human health and the environment9. Although the Republic of Serbia is not an EU member state, being familiar with and acting in accordance with the sources of EU law pertinent to environment protection in general, including those regulating air quality and pollution, is a necessary step on the road of our country towards European integrations. Several secondary sources of so called "community law" (Čavoški, 2006) pertinent to air protection have been adopted in the past couple of decades, including the following: 1) Directive 2008/50/EC on ambient air quality and cleaner air for Europe, 2) Directive 96/62/EC on ambient air quality assessment and management, 3) Directive 1999/30/EC relating to limit values for sulfur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air, 4) Directive 2000/69/EC relating to limit values for benzene and carbon monoxide in ambient air, 5) Directive 2002/3/EC relating to ozone in ambient air, 6) Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, 7) Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measurement ambient air pollution within the Member States, 8) Directive 80/779/EEC of 15 July 1980 on air quality limit values and guide values for sulfur dioxide and suspended particulates.

Law on Air Protection

The Republic of Serbia has recently adopted a single legislative document entirely dedicated to the issue of air protection – Law on Air Protection10 of 2009 with the latest amendments and alterations made in 2013. By adopting this law, the Republic of Serbia implemented the entire content of the Directive 2008/50 EC on Ambient Air Quality and Cleaner Air for Europe in its national legislation and fulfilled normative preconditions for harmonization of domestic and EU practice in this field.11 This law arranges the air quality management and establishes the measures, manners of organization and control of the protection and improvement of the quality of air as a natural value of general interest that is under special protection. However, the provisions of the Law on Air Protection are not applied in the cases of pollution caused by radioactive substances, industrial accidents and natural disasters (Art. 1). The fundamental aim of the Law is to achieve air protection through: establishment, maintenance and improvement of a single system of air quality management, preserving and improving air quality through establishing and implementation of protective measures in order to prevent or decrease harmful consequences on health and/or environment, avoiding, preventing and decreasing the pollutions that harm the ozone layer and enhance climate changes, monitoring, collecting and assessing the appropriate data on air quality, providing available data on air quality, completing duties in accordance with ratified international contracts and international cooperation in the field of protecting and improving air quality and ensuring the access of public to these information (Art. 2).

7 In further text, abbreviation EU will be used for European Union
8 See: http://ec.europa.eu/environment/air/index_en.htm, 12.08.2013.
9 Thematic Strategy on Air Pollution, Commission of the European Communities, Brussels, 21.9.2005.
10 Law on Air Protection, Official Gazette of RS, No. 36/09 and 10/13
11 Godišnji izveštaj o stanju kvaliteta vazduha u Republici Srbiji 2011. godine.

Law on Air Protection defines air as the air in troposphere at the open space that does not include air in the closed space (Art. 3). It prescribes essential empowerments (authorizations) and duties pertinent to the protection and improvement of air quality. The protection and improving of the air quality is conducted by the Republic of Serbia, autonomous province, local self-government unit, business associations, entrepreneurs, as well as by other legal or natural persons in accordance with their authorizations. Accordingly, the Law obliges business associations, other legal entities and entrepreneurs that affect or could affect the air quality while performing their activities to provide technical measures for preventing or decreasing the emission into the air, plan the costs of protecting the air against pollution within investment and manufacturing costs, monitor the effect of their activities to air quality and provide other appropriate protective measures. The quality of air and emissions are monitored by competent state administrative bodies and legal persons licence to perform these activities (Art. 4).

According to the pollution level, starting from the prescribed limit and tolerable values and based upon measurement results, the Law distinguishes three categories of air quality. The first is the category of pure or slightly polluted air, where none of the limit values of the pollutants are exceeded. The second comprises moderately polluted air, meaning that limit values of one or more pollutants are exceeded, but tolerable values are not. The third refers to over-polluted air, which means that tolerable values for one or more pollutants are exceeded. It is important to mention that if a tolerable limit has not been prescribed for a pollutant, its limit value shall be treated as the tolerable one. The categories of air quality are established once a year and the list of air quality categories by zones and agglomerations in the territory of the Republic of Serbia is adopted by the government and published in the Official Gazette, via electronic media and on the web site of the Government and the Ministry (Art. 21). The Law prescribes measures designed to contribute to the protection and improvement of air quality. So, in the zone or agglomeration where air quality is assessed as the first category, preventive measures should be implemented with the aim to prevent the emergence of air pollutants that would exceed the limit values. In the zones or agglomerations of the second category of air quality measures for decreasing air pollution are implemented in order to reach limit values or decrease below them. In the zones or agglomerations where air quality is assessed as category three, measures for decreasing air pollution are implemented in order to achieve the tolerable values for short ang long term provision of limit values (Art. 22.).

Law on Air Protection is familiar with several administrative offences (misdemeanors) that represent its violations and provides adequate sanctions for their perpetrators (Jovašević, 2009; Joldžić and Jovašević, 2013). Fine between 500,000 and 1,000,000 RSD will be imposed on a legal person that: 1) fails to develop the Operator's plan for decreasing the stationery sources emission, 2) fails to provide the staff training in accordance with the professional education programme, 3) performs the activities of manufacturing, maintaining and/or repairing the products containing substances that deplete the ozone layer without the Ministry's license, 4) imports and/or exports and sells new products and equipment that use the controlled substances that deplete the ozone layer apart from chlorofluorohydrocarbons, 5) releases substances that deplete the ozone layer and fluorinated greenhouse gases GHGs 6) loads the systems that use fluorinated GHGs with substances that deplete the ozone layer 7) does the wash out with substances that deplete the ozone layer 8) sells and uses tanks for one-off use where the substances that deplete the ozone layer and fluorinated GHGs are stored, 9) retails the substances that deplete the ozone layer and fluorinated greenhouse gases, 10) fails to submit the data on the stationery air pollution source and each its change (reconstruction) to the Ministry, i.e. Agency, competent autonomous province body and competent local self-government unit body, 11) fails to keep records on the exercised measurement with the data on measurement locations, results and frequency, 12) fails to keep records on the type and quality of raw materials, fuel and waste in the combustion process, 13) fails to keep records on the work of machines for preventing or decreasing the pollutants emission, as well as measurement installations for emission measurement, 14) fails to perform the air quality and/or emission measurement in accordance with the Law, 15) starts the measurement before obtaining Ministry's license, 16) fails to perform the air quality and/or emission measurement in accordance with the Law or 17) starts the measurement before getting the agreement by the Ministry. For this misdemeanour a fine can be declared in line with the amount of the harm done, the value of the obligation that has not been fulfilled or the value of goods or other objects that are the subjects of this offense, up to the amount twenty times higher than these values. A responsible person within the legal person may also be found liable for this misdemeanour and can be punished with fine from 25,000 to 50,000 RSD. A legal entity that committed some of the aforementioned misdemeanours can also be imposed a protective measure – ban to perform certain activities for a maximum of three years' period. The responsible person within the legal person may also be imposed a protective measure by which the court forbids him to perform particular tasks for one year (Art. 81).

The Law prescribes fine from 250,000 to 500,000 RSD for the entrepreneur that: 1) fails to develop the Operator's plan for decreasing the stationery sources emission, 2) fails to implement the measures with the aim of decreasing the volatile organic compounds emission 3) fails to provide the staff training in accordance with the professional education programme in accordance with the Law, 4) performs the activities of manufacturing, maintaining and/or repairing the products containing substances that deplete the ozone layer without the Ministry's license , 5) produces substances that deplete the ozone layer, 6) imports or exports substances that deplete the ozone layer, i.e. products and equipment containing them, and which are identified by ratified international contracts from the countries, i.e. into the countries that are not the signing parties of that contract, 7) imports and/or exports and sells the substances that deplete the ozone layer and fluorinated GHGs without license, 8) imports and/or exports and sells new products and equipment that use the controlled substances that deplete the ozone layer apart from chlorofluorohydrocarbons, 9) releases substances that deplete the ozone layer and fluorinated greenhouse gases, 10) loads the systems that use fluorinated GHGs with substances that deplete the ozone layer, 11) does the wash out with substances that deplete the ozone layer, 12) sells and uses tanks for one-off use where the substances that deplete the ozone layer and fluorinated GHGs are stored 13) retails the substances that deplete the ozone layer and fluorinated GHGs, 14) fails to remove defect or disorder, i.e. to adjust the work to the new situation or fails to stop the technological process, in order to bring the emission to the allowed limits as soon as possible,15) fails to take technical-technological measures or to stop the technological process, in order to bring the concentrations of the pollutants to the prescribed limit values, 16) fails to implement the measures that can lead to the odour reduction, although the concentration of the emitted matters in waste gas is below the limit value 17) fails to submit the data on the stationery air pollution source and each its change (reconstruction) to the Ministry, i.e. Agency, competent autonomous province body and competent local self-government unit body, 18) fails to provide the regular emission monitoring and do not keep records on that, 19) fails to enable permanent emission measurement if they are prescribed for specific pollutants and/or pollution sources independently, through automatic machines for permanent measurement, 20) fails to enable control measurement of emission by an authorised legal entity, if emission measurement is exercised independently, 21) fails to provide prescribed occasional emission measurement, by an authorised legal entity, twice a year, unless exercising the permanent emission measurement, 22) fails to enable the air quality monitoring upon the order of the competent inspection body, 23) fails to keep records on measurement and data on its locations, results and frequency 24) fails to keep records on the type and quality of raw materials, fuel and waste in the combustion process, 25) fails to keep records on the work of machines for preventing or decreasing the pollutants emission, as well as measurement installations for emission measurement, 26) starts the measurement before obtaining Ministry's agreement. For this misdemeanour a fine can be declared in line with the amount of the harm done, the value of the obligation that has not been fulfilled or the value of goods or other objects that are the subjects of this offense, up to the amount twenty times higher than these values. Protective measure of forbidding the performance of a specific activity for the period of up to three years may also be imposed (Art. 83).

Criminal Code of the Republic of Serbia

Current Criminal Code of the Republic of Serbia12, which entered into force on 1st January 2006, contains several incrimination of direct or indirect importance for the protection of environment in

12 Criminal Code of RS, Official Gazette of RS, No. 85/05, 88/05, 107/05, 72/09, 111/09 and 121/12

general, including air as one of its elements (Joldžić and Jovašević, 2012). These incriminations are systematized within its Chapter 24 entitled as “Criminal Offences against the Environment” (Stojanović, 2006) and include the following criminal offences: Environmental Pollution (Art. 260), Failure to Undertake Environmental Protection Measures (Art. 260), Illegal Construction and Operation of Facilities and Installations Polluting the Environment (Art. 262), Damaging Environmental Protection Facilities and Installations (Art. 263) and Damaging the Environment (Art. 264). The Code does not explicitly mention the protection of air quality in the titles of these incriminations, but uses a general term “environment”, defined in Law on Environmental Protection13, according to which environment represents a set of natural and man-made values whose complex mutual relations make up environment i.e. area and conditions for life and natural value is natural wealth that comprises air, water, soil, forests, geological resources, plants and animal life (Art. 3). Naturally, all of the offences that are directed against the environment in general at the same time represent attacks on its integral parts, including air and its quality. Criminal offence of Environmental Pollution exists if a person by violating the regulations on protection, preservation and improvement of the environment pollutes air, water or soil to larger extent or over a wider area. The punishment is imprisonment from 6 months up to 5 years and fine. If the offence is committed with negligence, the offender shall be punished by fine or imprisonment up to two years. On the other hand, if the offence results in destruction or damage to animal and plant life to large extent or environmental pollution in such extent that its revitalization requires a longer period of time or great expense, the offender shall be punished by imprisonment of one to eight years and fine. If the offence results in destruction or damage to animal and plant life to large extent or environmental pollution in such extent that revitalization requires longer period of time or great expense, the offender shall be punished by imprisonment of six months to five years and a fine (Art. 260). Criminal offence of Failure to undertake Environmental Protection Measures is committed by an official or responsible person who fails to undertake the stipulated environmental protection measures, or fails to proceed according to orders of competent authority in respect of environmental protection. For the basic form of this criminal offence, imprisonment up to three years or fine may be imposed. If the offence is committed with negligence, the offender may be punished by fine or imprisonment up to one year. However, if the offence resulted in environmental pollution, the offender shall be punished for the offence of Environmental Pollution (Art. 261). Illegal Construction and Operation of Facilities and Installations Polluting the Environment is a criminal offence committed by an official or responsible person who, contrary to regulations on environmental protection, preservation and improvement, allows construction, start-up and operation of facilities and installations or use of technologies that pollute the environment to larger extent and over a wider area. The punishment for this criminal offence is imprisonment of six months to five years. If the offence results in destruction of animal and plant life to high extent or pollution of the environment to such degree that revitalization would require a long period of time or great expense, the offender shall be punished by imprisonment of one to eight years (Art. 262). Damaging Environmental Protection Facilities and Installations exists if a person damages, destroys, removes or otherwise makes inoperable facilities or installations for environmental protection. Imprisonment up to three years may be imposed on the perpetrator of this criminal offence. If the perpetrator acted with negligence, he shall be punished by fine or imprisonment up to one year. If the consequence of the offence was air, water or soil pollution to larger extent or over a wider area, the offender shall be punished by imprisonment of six months to five years and if the pollution of air, water or soil to larger extent or over a wider area, the offender shall be punished by imprisonment up to three years. If the offence resulted in destruction or damage of animal and plant life to high extent or pollution of the environment to such degree that revitalization would require a long period of time or great expense, the offender shall be punished by imprisonment of one to eight years. If more serious forms of this offence result in destruction or damage of animal and plant life to high extent or pollution of the environment to such degree that revitalization would require a long period of time or great expense, the offender shall be punished by imprisonment of six months to five years (Art. 263). Criminal offence of Damaging the Environment is committed if a person causes damage to the environment to large extent or over a wider area by violating regulations, through use of natural resources, construction of buildings, executing works or in any other manner. The punishment

13 Law on Environmental Protection, Official Gazette of RS, No. 135/04, 36/09, 36/09, 72/09 and 43/11

prescribed is imprisonment up to three years. If the perpetrator acted with negligence, he shall be punished by fine or imprisonment up to one year (Art. 264).

The court may pronounce a suspended sentence (Stojanović, 2005; Jovašević, 2006) (Art. 65-69) for each of the aforementioned criminal offences. In such cases, the court may to order the offender to undertake particular measures to correct the detrimental consequences to the environment within a set period of time. In its decision on suspended sentence, the court may also order that previously determined penalty shall be enforced if the convicted person fails to restore material benefit acquired by the commission of criminal offence, fails to compensate the damage he caused by the commission of criminal offence or fails to fulfill other obligations provided by the provisions of criminal legislation. The deadline for the fulfillment of these obligations is set by the court within the specified probationary period (Jovašević and Đurđić, 2006; Jovašević, 2009).

CONCLUSION

Available data show that the quality of air in Serbia is constantly deteriorating. Such state causes justified and reasonable concern of both – experts in the field of ecology, biology, agriculture, medicine, and law as well as of general public and “common” citizens who often suffer health consequences of over-pollution. Although our country adopted the Law on Air Protection, which enabled normative harmonization with the EU standards in this sphere of environmental protection, there are still some practical issues that need to be resolved in order to stop further pollution and, if possible, recover the quality of air in our country. According to Serbia Progress Report for 201214, published annually by the European Commission, certain but rather small progress has been made in the field of environment protection and climate changes. Complete harmonization of Serbian legislation with the Directive on the Assessment of the Effects of Certain Public and Private Projects on the Environment15 has been fully accomplished, but its practical implementation has to be improved, particularly in the sphere of quality of interaction with the public and dialogue with non-governmental organizations. The Law on the Ratification of the Protocol on Heavy Metals16 and the Law on the Ratification of the Protocol on Persistent organic Pollutants17 were adopted in 2012. Keeping up with the data on air quality in Serbia was additionally improved by the fact that National Laboratory for Calibration is in charge for keeping records on air quality, whereas analytical laboratory for air pollutants functions within the auspices of the Environmental Protection Agency (SEPA). However, the capacity and financial resources of SEPA are insufficient for proper performing of all activities pertinent to measurement and maintenance of air quality.

A slight progress has also been achieved in other fields that are directly or indirectly related to air quality, such as waste management, improvement of water quality, implementation of legislation pertinent to industrial pollution and risk and chemicals management as well as in the sphere of nature protection. However, insufficient administrative capacities and the lack of financial resources still represent serious obstacles in all of the aforementioned areas. Unfortunately, no progress has been detected in the field of climate change prevention, as one of the areas that has the most significant

14 Serbia Progress Report for 2012, European Commission, SEC (2012) 333, Brussels, 10.10.2012.

15 See: Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, Directive 97/11/EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, Directive 2009/31/ of 23 April 2009 on the geological storage of carbon dioxide and amending Directive 85/337/EEC, Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 and Directive 2011/92/EU of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.

16 Protocol to the 1979 Convention on Long-Range Trans-boundary Air Pollution on Heavy Metals, Aarhus, 24 June 1998, United Nations, Treaty Series, vol. 2237, p. 4, Document of the Economic and Social Council EB.AIR/1998/1,

17 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants, done at Aarhus (Denmark), 24 June, 1998, Document of the Economic and Social Council, ECE/EB.AIR/60.

impact on air protections. General policy on climate change prevention still needs to be improved and a comprehensive climate strategy must be developed. Namely, the issue of climate changes is an integral part of energetic policy, where only a small progress has been made regarding the field of renewable energy sources and energetic efficiency. Serbia still has not adopted the planned legislative framework on rational use of energy. It is necessary to make great efforts in order to integrate the issue of climate changed within sector policies and strategies. Serbia has not dedicated enough attention to its obligation to minimize its emissions until 2020 and limited progress has been made in the harmonization with the law of the EU regulating the issue of climate. All in all, limited progress has been achieved in harmonization of our legislation with legal heritage of the EU and great efforts need to be made in order to strengthen Serbia's capacities for following, reporting and verification in the area of climate. It is still necessary to raise consciousness an all levels on the importance of environment protection and climate changes and appropriate initiatives should be strengthened. The lack of administrative capacities and *ad hoc* international cooperation postpone the preparation and implementation of climate policy that is in accordance with the EU legislation. Administrative structure in charge for climate changes should be strengthened and support is needed in order to build capacities necessary as a response to requirements in this field.

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MATHEMATICAL MODELS IN THE ANALYSIS OF SPREADING THE AIR POLLUTION

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ABSTRACT

Mathematical modelling is today the universal component of the methodology of research of arbitrary science.It does not deny the classical methods of research,but complements them. It often enables getting the information of the objects and processes which couldn’t be obtained through experiments.Within work,different mathematical models are analyzed(turbulent diffusion,statistical methods,semi-empirical methods...) for studying the spreading of the air pollution from different sources.Using them,the distribution of concentration and the parameters of concentration of air pollution can be determined,depending on the type of the source.Their characteristics are compared,the advantages and disadvantages,as well as the results which are given by different models.

Key words: *mathematical model,air pollution,the concentration of air pollution*.

INTRODUCTION

The condition of the environment greatly affects the life of all living creatures on the planet.The emission of the harmful matters in the atmosphere negatively affects the condition of the atmosphere which represents a vital component of nature.The significant share in these processes is the anthropogenic factor.In order to limit the negative share of this factor on the atmosphere,the normatives of ejection of harmful matters have been determined and automatic monitoring of air quality control has been introduced.Automatic cells measure the concentration of different substances in the air.The degree of pollution is determined by comparison of the measured concentration with maximum allowed concentration,determined by norms,which is acceptable because it doesn’t affect human health.

Regardless the fact that the information obtained by measuring cells maintain the real condition of the atmospheric air within places where the measuring is performed,the causes of air pollution remain unknown.Also,those information show the level of pollution only in some points and cannot give the adequate picture of air condition on the entire wanted teritory.For solving these problems the mathematical modelling of spreading the air pollution is performed,which enables the evaluation of the degree of pollution in the observed point without making the corresponding measurings.Besides,by using the mathematical modelling,the change in the atmospheric air can be predicted on longer terms,different hypothetical situations can be modelled(for example,the construction of the new factory which would represent a potential pollutant) and plan in advance the measures for preventing the air pollution. Modelling demands a complex consideration of many factors,such as the parameters of the source of pollution,current meteorological condition of the atmosphere,the conditions of the scattering of the polluting substances in a certain place,the characteristics of the pollutant substances etc.

TYPES OF MATHEMATICAL MODELS

The air pollution is one of the most complex ecological problems in many industrial places. The increased concentration of impurities is spotted,practically in every industrial place and therefore it is necessary to solve the problem of estimation of the level of pollution and modelling the spreading of air pollution,particularly from the stationary sources with an aim to prevent or reduce its negative effect on the ecosystem. Within the analysis of the process of air pollution the essential difference is whether it comes from the stationary or mobile sources. If the air pollution comes from the mobile source it is,as a rule,of a local character and reaches small heights.With stationary sources (factory chimneys,thermal power plants,boilers,technological facilities...) the air pollution reaches up to 150m and higher,and spreads on large distances. Air impurities form air dispersion systems,and during turbulent motion and other processes remain long in the air (Берлянд, 1985).

Mathematical models which describe the motion of the pollutants in the air under the influence of the wind(transmission) and turbulent motion of the atmosphere (diffusion) are called the models of atmospheric dispersion.They are divided into theoretical,empirical and semi-empirical,as well as stationary and non-stationary. Starting from the methods of mathematical descripton of the process of scattering of the impurities,3 classes of models of analysis of air pollution can be singled out: Lagrange’s, Euler’s and Gaussian.The equasions of those models are gained by different schemes of solving the equasions of turbulent diffusion.

Lagrange’s model

Lagrange’s model describes the transmission of certain air currents over time under the influence of atmospheric fields and spreading of air pollution.It can be shown as (Lazaridis, 2011; Аргучинцев, 2007):

$$< C(\vec{r},t) > \geq \iint p(\vec{r},t \,|\, \vec{r}\,',t')S(\vec{r}\,',t')\,d\vec{r}\,'dt' \tag{1}$$

where $< c(\vec{r},t) >$ is the middle concentration of air pollution in the point $\vec{r}$ and time t; $S(\vec{r}\,',t')$ represents the source of air pollution; $p(\vec{r},t \,|\, \vec{r}\,',t')$ is the function of possibility of transition from place $\vec{r}\,'$ t' in the place $\vec{r}$ and time t. The function of possibility should be determined as the function of total meteorological data in the vicinity of the source.

Euler’s model

Oiler’s model consists of the solution to the semi-empirical equation of turbulent diffusion which can be written as [1](Степаненко, 2008; Берлянд, 1975):

$$\frac{\partial C}{\partial t} = -\vec{u}\cdot\nabla C + \frac{\partial}{\partial x}\left(k_x\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_y\frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial z}\left(k_z\frac{\partial C}{\partial z}\right) \tag{2}$$

where $\vec{u}\cdot\nabla C$ is the adequate component of the equation; k_x, k_y, k_z the components of the coefficient of turbulent diffusion; C middle concentration of the impurities.

When solving specific tasks, this equation can be simplified.For example,with the stationary processes for the spotted source which continually emits impurities,the equation is this form (Crank, 1975):

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial t} = k_x\frac{\partial^2 C}{\partial x^2} + k_y\frac{\partial^2 C}{\partial y^2} + k_z\frac{\partial^2 C}{\partial z^2} \tag{3}$$

where u is the average velocity of the wind in the direction of moving of the impurities.

1 There are different variants of the equation of turbulent diffusion (Марчук, 1982)

This equation reflects the law on maintenance of weight and it is based on the assumption of analogy of the process of molecular and turbulent diffusion.The limit terms for this equation are:

$$C/t \le 0 = 0; \quad C/(x^2+y^2+z^2) \to \infty = 0 \tag{4}$$

For the stationary spotted source with coordinates $(0,0,h)$ with constant coefficient of the turbuent diffusion,this equation has the solution (Эльтерман, 1985):

$$C(x,y,z) = \frac{Q}{4\pi x\sqrt{k_x k_y}} \exp(-\frac{uy^2}{4k_y x})\left\{\exp\left[-\frac{u(z-h)^2}{4k_z x}\right] + \exp\left[-\frac{u(z+h)^2}{4k_z x}\right]\right\} \tag{4}$$

Within the frame of Euler’s model, Ukrainian scolar Марчук analyzed several variants of the equation of turbulent diffusion.
For one-dimensional case Марчук analyzed the equation of the shape (Марчук, 1982):

$$u\frac{dC}{dx} + \sigma C = \mu\frac{d^2C}{dx^2} + Q\delta(x-x_0) \tag{5}$$

(here $\mu \equiv k$ is the coefficient of turbulent diffusion,and σ is the coefficient which has got the unit of reciprocal time and which shows for what time the concentration of the impurities drops *e* times) which solution is:

$$C(x) = \frac{Q}{\sqrt{4\sigma\mu + \mu^2}}\begin{cases}\exp\left\{-\left(\sqrt{\frac{\sigma}{\mu}+\frac{u^2}{4\mu^2}}-\frac{u}{2\mu}\right) \; x - x_0\right\} \\ \exp\left\{-\left(\sqrt{\frac{\sigma}{\mu}+\frac{u^2}{4\mu^2}}-\frac{u}{2\mu}\right) \; x_0 - x\right\}\end{cases} \tag{6}$$

The upper expression stands if $x \ge x_0$, and lower if $x \le x_0$
In the two-dimensional case the equation of the diffusion is of a form (Марчук,1982):

$$u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} - \mu\Delta C = Q\delta(\vec{r} - \vec{r}_0) \tag{7}$$

Which solution can be written as:

$$C = \frac{Q}{2\pi\mu}\exp\left\{\frac{\sqrt{u^2+v^2}x}{2\mu}\right\}K_0\left(\frac{\sqrt{u^2+v^2}x}{2\mu}|\vec{r}|\right) \tag{8}$$

where K_0 is McDonald’s function $K_0(x) = \int_0^\infty e^{-xchy}dy, \quad x > 0$.

During the 1980-s of the previos century,the group of researchers from the science university in Novi Sad, gathered around the scolar B.Tošić, found in several works, for different terms, analytical solutions of the equation of turbulent diffusion in the case of the spotted source of the impurities in 1D, 2D and 3D case (Tošić, 1982; Tošić, 1984; Tošić, 1988; Kapor, 1983; Kapor, 1988). One-dimensional stationary numerical case is later analysed (Jaćimovski, 2012)

It has shown that the results gained from the equation (3) aren’t completely in accordance with the data gained from the experiments. It has shown that the coefficients of the turbulent diffusions aren’t of a constant size and that they depend on the dimensions of the clouds of impurities.Using the assumption that the distribution of the concentration of the impurities in the cloud fits the Gauss’s normal distribution, Seton got the solution for the stationary spotted source of shapes (Эльтерман 1985):

$$C(x,y,z)=\frac{Q}{\pi\, u\, x^{2-n} s_y s_z}\exp\left\{-\left[\frac{y^2}{{s_y}^2\, x^{2-n}}+\frac{z^2}{{s_z}^2\, x^{2-n}}\right]\right\} \tag{9}$$

where s_y , s_z are the virtual coefficients of diffusion,and n is the number of values from 0-1 and it is determined from the profile of the wind. Generally, *n* can have the following values:

- In the case of unstable atmosphere $n<0$
- In stable conditions $n=0-0.5$
- Within the zero gradient $n=0-0.2$
- In the strong inversion $n\geq 0.5$

Seton’s relation is used mostly in case of stable atmospheric conditions.Still,it doesn’t decrease the value of the model,because the unstable terms don’t last long and the concentration of the impurities in unstable conditions is always smaller than in stable conditions due to the great scattering of the impurities.
Berljand has found the solution of the equation (2) for spotty source which is on height *h*. For ground concentration of the impurities it is of the shape:

$$C(x,y,0)=\frac{Q}{(1+m)k_1\varphi_0 x^2\sqrt{2\pi}}\exp\left[-\frac{u_1 h^{1+m}}{k_1(1+m)^2 x}-\frac{y^2}{2\varphi_0 x^2}\right] \tag{10}$$

where k_1, u_1 are the values of the coefficient of turbulent diffusion and speed of the wind on unit height, φ_0 dispersion of the wind direction, $m=n(2-n)$.

With modelling of spreading of the impurities for three dimensional case the analythical or numerical solution is used of the semi-empirical differential equation of turbulent diffusion in Decart’s coordinates. In that case the linearised model of spreading the impurities contains specific chracteristics of the process:the transmission of the impurities in the direction of the flow, turbulent diffusion,convection, space and time inhomogenity of the parameters of scattering,the interaction of impurites with the ground surface and other factors.

Semi-empirical equation of the turbulent diffusion of the most general form is analyzed by Степаненко, Волошин і Типцов and it is of the shape (Степаненко, 2008):

$$\frac{\partial C}{\partial t}+u(t)\frac{\partial C}{\partial x}+v(t)\frac{\partial C}{\partial y}+w(t)\frac{\partial C}{\partial z}=k_x(t)\frac{\partial^2 C}{\partial x^2}+k_y(t)\frac{\partial^2 C}{\partial y^2}+k_z(t)\frac{\partial^2 C}{\partial z^2}- \tag{11}$$
$$-\lambda(t)C(t)+Q(t)\delta(t-t_k)\delta(x-x_s)\delta(y-y_s)\delta(z-z_s)$$

In the upper equation Q represents the mass of impurities which set aside in the moment $t=0$ in coordinate beginning (x_s, y_s, z_s). The impurities are momentarily ejected t_k , the strenght of the source is $Q(t_k)$; $u(t)$, $v(t)$, $w(t)$ are the projections of the speed of wind on adequate coordinate axis, δ Dirak’s delta function, $\lambda(t)$ the speed of the (loss) reduction over time.

The solution of the equation (11) vertically has got certain characteristics since the spreading of impurities vertically depends on thermo dynamic structure of the bordering layer of the atmosphere and interaction of the impurities with its borders.Therefore,the bordering terms for this equation are:

$$k_z\frac{\partial C}{\partial z}+wC+\beta C=0,\qquad z=z_0 \tag{12}$$
$$\lim_{x,y\to\pm\infty} C(t,x,y,z)=0$$

In (12) is β parameter which characterizes the interaction of impurities with the ground surface.The basic dynamic parameter of surface is the relief z_0,that is the zero level from which the logarithm profile of the wind is measured.The position of the lowest border z_0 matches the height of the relief layer. When the impurity which is sedimented or is light,interacts with the surface, they either deduct of it $\beta = 0$ or are absorbed $\beta \to \infty$ .These facts are taken under consideration when vertical profile of concentration of the impurity is determined.

The solution of the equation (11), for stationary case $Q(t) = Q = const$ is of the form:

$$C(x,y,z) = \frac{Qe^{\frac{ux}{2k_x}+\frac{vy}{2k_y}+\frac{w(z-h)}{2k_z}}}{4\pi\sqrt{k_xk_yk_z}} \cdot \left(\frac{e^{-\frac{1}{2}\sqrt{\frac{x^2}{k_x}+\frac{y^2}{k_y}+\frac{(z-h)^2}{k_z}}\sqrt{\frac{u^2}{k_x}+\frac{v^2}{k_y}+\frac{w^2}{k_z}}}}{\sqrt{\frac{x^2}{k_x}+\frac{y^2}{k_y}+\frac{(z-h)^2}{k_z}}} + \frac{e^{-\frac{1}{2}\sqrt{\frac{x^2}{k_x}+\frac{y^2}{k_y}+\frac{(z+h-2z_0)^2}{k_z}}\sqrt{\frac{u^2}{k_x}+\frac{v^2}{k_y}+\frac{w^2}{k_z}}}}{\sqrt{\frac{x^2}{k_x}+\frac{y^2}{k_y}+\frac{(z+h-2z_0)^2}{k_z}}} \right) + \tag{13}$$

$$\frac{w+2\beta}{k_z}\,\frac{Qe^{\frac{ux}{2k_x}+\frac{vy}{2k_y}+\frac{w(z-h)}{2k_z}}}{4\pi\sqrt{k_xk_yk_z}} \int_0^{\infty} \frac{e^{\frac{w+2\beta}{2k_z}\xi}\, e^{-\frac{1}{2}\sqrt{\frac{x^2}{k_x}+\frac{y^2}{k_y}+\frac{(z+h-2z_0-\xi)^2}{k_z}}\sqrt{\frac{u^2}{k_x}+\frac{v^2}{k_y}+\frac{w^2}{k_z}}}}{\sqrt{\frac{x^2}{k_x}+\frac{y^2}{k_y}+\frac{(z+h-2z_0-\xi)^2}{k_z}}}\, d\xi$$

where $\xi = \int_{t_k}^{t} k_x(t)\,dt$.

Gaussian model

The simplest model for the calculation of the ground concentration of pollution is the statistical Gaussian model.It is that,in most of the countries,the models of this type are mostly used in normative documents for practical realization of the quality of air.In the base of that model lies the assumption that the impurities emited by constant spotty source form the smoke column in which the symetrical distribution of concentration of particles to the axes of the smoke column.The basic equation of the statistical Gaussian model consists of two functions of thickness of the possibility of the normal law of distribution and they are of the form (Степананко, 2009; Lazaridis, 2011;):

$$C(x,y,z) = \frac{Q\, f_F\, f_W}{2\pi\sigma_y(x)\sigma_z(x)\bar{u}} \exp\left(-\frac{y^2}{2\sigma_y^2(x)}\right)\left\{ \exp\left[-\frac{(z-h)^2}{2\sigma_z^2(x)}\right] + \exp\left[-\frac{(z+h)^2}{2\sigma_z^2(x)}\right]\right\} \tag{14}$$

where Q –is the mass flow; C–concentration of the impurities in the specfic point in space; $\sigma_y(x), \sigma_z(x)$ dispersion of diffusion in the direction of adequate axis, which depend on meteorological conditions of the distance which the particle crosses from the source to the point with the coordinate x, whereby it is assumed that the direction of the axis $0X$ matches the direction of the wind vector; $\bar{u}$ − average speed of wind on the measuring level; h –effective height of the source; f_F и f_W–the corrections on the reduction of the clouds of impurities due to the dry sedimentation of impurities.

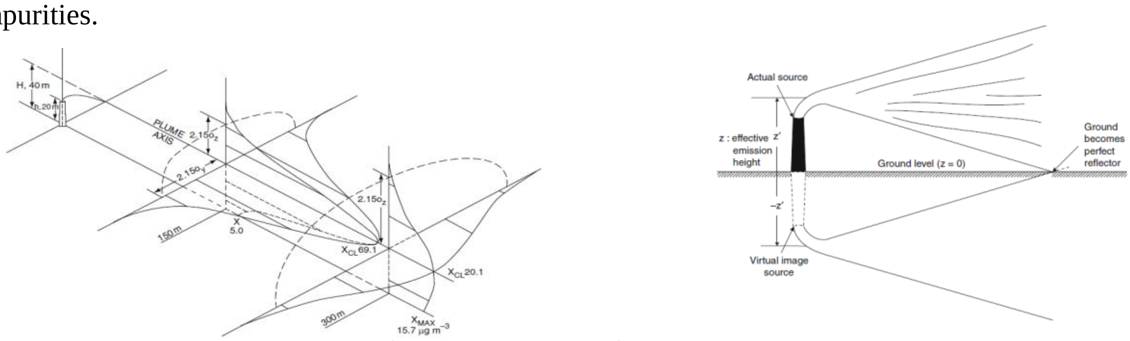

Figure 1. Graphic presentation of the assumptions of spreading the air pollution with the Gaussian model (taken from Lazaridis, 2011)

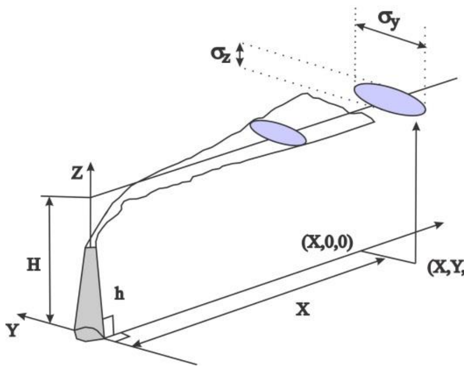

Figure 2. Graphic presentation of dispersion of the smoke column from the source (Jaćimovski, 2013)

In the equation(14) σ_y, σ_z horizontal and vertical dispersion of the distribution of impurities.For the determination of these dispersions,the following relations are used:

$$\sigma_y = Ax^a; \sigma_z = Bx^b$$

where A, a, B, b are the coefficients which depend on the stability of the atmosphere and the relief of the surface and are determined experimentally.

Table 1: The parameters for calculating the dispersion

		A	a	B	b			A	a	B	b
Very unstable	(A)	0,527	0,865	0,28	0,90	Neutral	(D)	0,128	0,905	0,20	0,76
Unstable	(B)	0,371	0,866	0,23	0,85	Stable	(E)	0,098	0,902	0,15	0,73
Weakly unstable	(C)	0,209	0,897	0,22	0,80	Very stable	(F)	0,065	0.902	0 12	0,67

Reference: σ_y is taken for the average time10 min; σ_z for z_0 = 0,1 m i h < 20 m; x, $\sigma_y \sigma_z$ – are given in meters.

In this model,due to getting the most realistic estimations of concentration of air pollution,certain corrections of some sizes are performed.

The correction due to the relief of length z_0

The research of the interaction of air flows with the ground surface isn’t possible without the data about the aero-dynamic characteristics of the surface.Basic dynamic parameter of the surface is the relief z_0 ,that is zero level from which the logarithm profile of the wind is measured.Under that level,the average translatory flow of air equals zero.

The term relief includes wild growth,cultivated growth and buildings.In the table 1. σ_z is given for z_0 = 0,1. The calculations are performed by following formulas $C_{z_0} = (10z_0)^{0,53x^{-0,22}}$; $\sigma_z = C_{z_0} a x^b$

As C_{z_0} depends on x, the simplest will be to recalculate a i b for a given value z_0 in order to calculate the corrected value for σ_z.

The corrections on the dimensions of the source

As the spotted sources are the idealisation,it is necessary for real sources to perform correction due to the dimensions of the source.It is performed by introducing the so called virtual spotty source. (Tiwary, 2010).

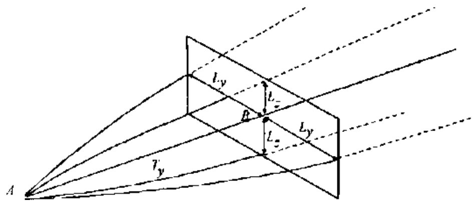

Figure 3. The scheme of use of the virtual source

The chosen point A in which the spotted source is on the distance x_v from the source B in the wind direction.It creates the smoke column which in the point B has a proper width $2L_y$ of the real source. According to the calculation x_v, for the given source n, it must be aprikimed σ_y on the basis of L_y. In those purposes,the following expression is used: $\sigma_y = L_y / 2.15$ The point where the concentration of the impurities drops to 10% from its maximum value is considered the boundary of the source. If the concentration over the source to the certain limit doesn't comply with the Gaussian distribution,and is still homogenous,the next expression can be used: For x_y,in the direction y : $x_{vy} = \left(L_y / 2{,}15aC_{t'}\right)^{1/a}$ Analogously, for z direction: $x_{vz} = \left(L_z / 2.15C_{t''}\right)$ For the distances by which it is σ_z >>L_z the aproximation with h = 0 is satisfactory.

The correction on the average time measuring

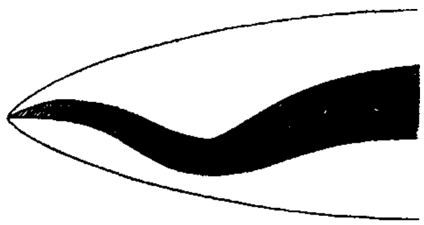

Figure 4. Scheme of the smoke collumn

There is a momentary recording of the smoke collumn on the picture, and a wide contour which represents the smoke column after 10min.The effect of spreading of the smoke column significantly affects the measuring and the ammount of the substance of the smoke column which would be inhaled by a human.If the measuring of the current position of the smoke column is performed for a very short time,then the high concentration is registered.If the average value would be determined in that position for the time of 10 minutes or one hour,the concentration would be significantly lower.All these facts are taken into consideration by introducing the corrective coefficient C_t in the form: $C_{t'} = \left(t' / 600\right)^{0,2}$ time in seconds; $\sigma_y = C_{t'} \cdot ax^b$ Coefficient $C_{t'}$ has the minimum value of around 0,5.

Gaussian model is the idealisation which has the following limitations (Sportisse, 2008):

1) it is applied only on flat and open surface
2) it is difficult to calculate in the influence of the obstacles on which the smoke column comes across
3) meteorological conditions,as well as the conditions of the ground surface are constant on the entire distance which the cloud of gas passes
4) it is applied only on gases which thickness is close to the thickness of air
5) the existence of wind must be assumed,which speed is u > 1 m/s.

Unsolved issues:

1) It is assumed in models that horizontal and vertical turbulent scattering is performed independently one from another.It is just that term which enables to consolidate two functions of the possibility of the normal law of distribution.
2) The coordinate x in which the concentration is calculated,doesn't explicitly enter the formula,but implicitly as an argument in dispersions $\sigma_y(x)\sigma_z(x)$.
3) The components of the vector of the speed of wind aren't used u,v iw , which leads to the trajectory of transmission of the impurity being the flat line.
4) There are dispersions figuring in the model,which characterize the scattering of the clouds of impurities with the distance from the source.In many empirical expressions for $\sigma_y(x)\sigma_z(x)$ it is wrongly considered that the dispersion depends only on the distance of the observed point along the coordinate axis.In reality,the dispersity depends on time for which the cloud of impurities gets to the observed point. Similar mistake leads to the breaking of the law of mass maintenance of the diffusing impurity.
5) According to the formula(13) in the initial moment of time in the point in which the source is,is infinitely big.That fact breaks the condition of material balance and deforms the field of concentration.
6) The formula (13) doesn't allow the calculation of concentration for the small speeds of wind(less than 1 m/s).

THE USE OF INFORMATION TECHNOLOGY IN THE MODELLING OF THE AIR POLLUTION

There are many models today which enable the calculation of the ground concentration of air pollution in the area of industrial facilities and sources of pollution.It is considered that there are over 120 models of the different level of complexity and purpose of which the following should be extracted: ISC (SAD), ADMS (England), AERMOD (Canada, USA), MARS (Greece), DISPERSION21 (Sweden), EURAD (Germany), MERCURE (France), MILORD (Italy), SLP-2D (Spain), OPS (Holland) and other. Some of them are legally regulated as the normatives for certain countries,while others have scientifically researching character.

At the same time,regardless the massiveness of the spent research,up till today there isn't a unique methodics (models) which would enable uniformly calculation of the ground concentration of air pollution. It is linked with the fact that there isn't a unique scientifically research center,in which the specialists of the different countries would work, in which the basic principles and algorithms of the practical models of polluting of the atmosphere would be developed.

The use of GIS in the analysis of air pollution

The calculations done on the base of some model are necessary to be realized in some information system on the base of appropriate meteorological and geographical data.It is also suitable to present those results in the form of ecological chart.Besides that,it is necessary to model some hypothetical situations by setting the virtual sources of polution on the chart,and perform the prognosis of concentration and spreading the same into the atmosphere.Also, it would be desirable that the prognosis via the internet become accessible to the interested ones.Today, for the work with geographical and space data the geographical information system (GIS).This information system contains the possibility of managing the bases of the space data, the resources for presenting the cartographic data and the resources for performing different analythical calculations.One of the components of this information system is ArcGIS. With it,the data entry on the sources of pollution, metheorological and cartographic data and also get the display of the field of concentration of the impurities in the atmosphere and the field of complex index of pollution (KIZ) by using the technology ArcSDE. Besides that,the possibility of ArcGIS can be used in forming the interactive charts on a PC desktop (ArcGISEngine) and on web pages(ArcGISServer), as well as the manipulation the field of concentration of pollution(SpatialAnalyst).

The possible architecture of this information system is presented on the Figure 5. It represents the combination of two architectural-service-oriented architecture for realization of the user interface(work station). The structure of the system is like this (Смирнов 2001):

- ArcGISServer – It contains the space data base,in which are the cartographic,metheorological data,and data on the sources of pollution.The access to the data base is possible over the geo service.
- IIS- it is the web service of the Microsoft company.There is the nucleus of the system on it.The web service and computing modulus.Besides that,there is a web service on it which realizes the interface of the portal visitors.
- The nucleus of the system-it coordinates the work of the system and connects ArcGIS server with the computing modulus.
- Web service- it represents the possibility of connection to the computing modulus through the local net or the internet through a desktop client.
- The computing modulus- is necessary for performing the adequate calculations via some of the mathematical models.
- Desktop application – That is the client who realizes the interface of some programme with which the worker on the work station gets the access to ArcGISServer services and the access to the possibilities of the web service.
- Web application – is a client who realizes the interface to the portal visitors.Through it,a portal visitor has the access to the interactive charts and the results of the calculations.

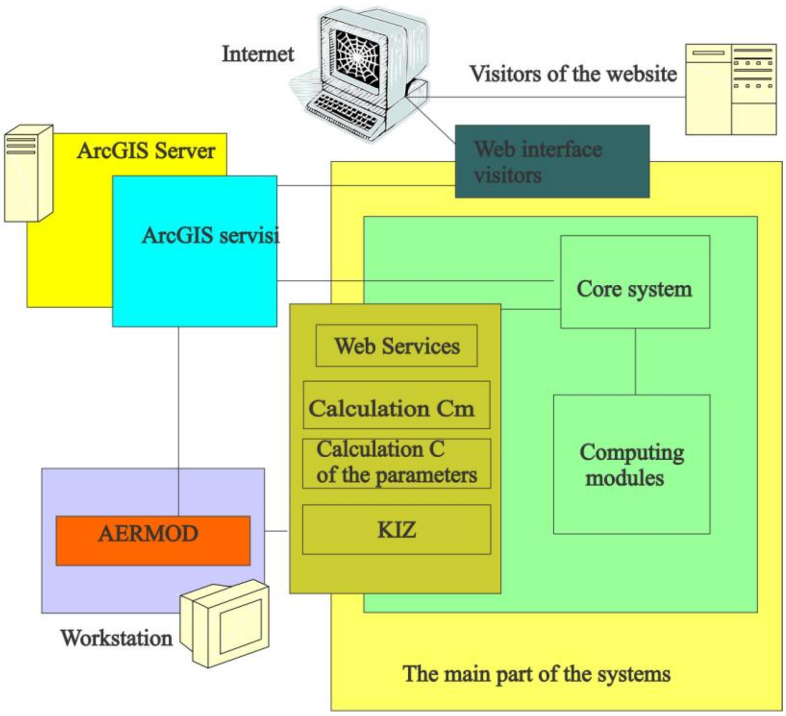

Figure 5. Possible architecture GIS with the air pollution analysis

CONCLUSION

There has been an attempt in the work to perform the classification of the mathematical models of the spreading of air pollution.This is a very complex problem because of the differences of the source of air pollution,as well as many accesses in resolving the same.Also, the use of the model is connected to a number of factors linked to the condition of the atmosphere and geo-morphological characteristics of the terrain on which the impurities are spread.Mostly spotted stationary sources are encompassed, and of models the Lagrange's, Euler's and Gaussian model. Due to the width of the problem,the air pollution from the mobile phones hasn't been analyzed,and neither are the models which are used in case of the breakdowns with the emission of air pollution (for example Paskvil Giford's model). The methods which are used in some countries as the normatives for the air pollution analysis haven't been encompassed either.Of the considered models,most used is the Gaussian (as the simplest) for analysis of the spreading of the impurities to the distance of 50 km from the source. For spreading the impurities to the greater distances,the Euler's and Lagrange's approach is used.The Lagrange's method requires immense calculations,but with the development of the information systems it can be used for practical purposes.

The significance of the use of mathematical models has been emphasized,as well as the contemporary possibility of the information technologies, above all the GIS, which are used worldwide for following and analysis of air pollution of the certain area.

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LASER APPLICATIONS IN SOME ECOLOGICAL PURPOSES (LASER CLEANING AND ISOTOPE SEPARATION) WITH LINEAR AND NONLINEAR PHENOMENA AND LIDAR METHODS

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ABSTRACT

Laser role in up-to-date general applications, especially in ecological problems, include laser interaction (destructive processes) as well as lasers participation in diagnostic systems. Remote laser sensing is especially important for the high risk systems and environment including nuclear, chemical, and other types of possible contamination. On the other hand, laser cleaning processes of various types, laser processing methods in powder production, contribute to development of many new processes, which are not possible with other common non-laser methods. Some analyses of scattering experiments (dynamic and static) are presented with adequate representation of results. Laser cleaning methods considered from chosen point of view, were analyzed in IR and UV ranges (including multi-photon transitions). Laser interaction with material is widely applied in various processing technologies. Powder production methods with various laser types from results in references, are fitted analytically treated and specific distribution parameters were obtained.

Key words: *laser, lidar, ecology, LIS, scattering, photochemistry*.

INTRODUCTION

Wide laser applications in physical, chemical and etc. processes are connected to price of laser sources. If expensive materials of organic or inorganic origins are involved than this reason is not important. Those applications include ecological and other processes, too as is nuclear contamination, isotope selection (enrichment), growth improvements of expensive plants (for medicaments), laser isotope separation (*LIS*), laser *decontamination* of nuclear waste, and other hazardous materials - chemical and poisonous.

Laser application in processing, measuring and diagnostics in mentioned areas is still increasing. In this study paper we will choose some selected applications from our measurements, analyzes and from references. Note that sizes of the material samples have great influence on human health as well as environment - animals and plants.

Chosen laser applications in ecology, concerning linear and nonlinear processes in scattering phenomena are presented in this paper. Generally, they could be the basis for lidar (remote sensing) methods which are possible in various recognition processes because of connection to large measurement data base (data base is constantly adjusted and increased by laboratory performed data as well as from distance measurements - lidar, ladar, dial, colidar, white lidar, Raman lidar, etc). The same methods and methodology are used in fire detection and monitoring as well as in control of volcanic dust, particles propagation, forensics [1-28].

Dynamic and static light scattering depends on scattering area descriptions (scattering centre sizes). Therefore many different measurement devices are developed of modular and closed type. Here are presented laser measurement illustration of uranil salts solution [23].

Laser application for triggering artificial breakdown processes in atmosphere for the purpose of lightning protection belongs to intensive processes which have abundance of nonlinear and multi photon effects. On other hand they could be treated in area of new lidar type development (BELINDA, white light).

The evaluation of error (uncertainty) in measurement belongs to processes of new error interpretation by using developed uncertainty which should be performed for each specific measuring method [24]. It means that uncertainty type "a" and "b" should be calculated for old measurements and accordingly a schedule should be done for new measurements including laser application in material description by scattering, fluorescence or absorption processes.

All atmospheric investigations should be compared to other common methods (i.e. acoustics, electrostatic, etc) of real atmosphere definition with hydrodynamic parameters and depolarization state of scattered light. The use and importance of these measurements spread from every day's life to control of atmosphere's influence on overall human heritage.

Anisotropy (molecular and macroscopic), optical constants by direct and indirect methods, optical constants of plants (canopy), or the objects of human heritage should be studied meticulously. Fluctuation of principal response material functions could be presented trough correlation function of index of refraction, density correlation, concentration correlation and anisotropy correlation. Higher order correlation function has characteristics behavior $\sim n^4$ where n is index of refraction.

MATERIALS AND METHODS

Laser material cleaning

The principal advantage of the laser material cleaning including every day's life as well as arts [17] and pharmaceutical applications, is the possibility to initiate excitation with high selectivity of the unique components of the compound mixture. From this point of view cleaning process could target only material in traces in the bulk of the basic material. There are many laser methods which are capable to achieve those demands. The processes include gaseous, liquid as well as solid state phases.

Excitation in infrared range

Many experiments with selective photo dissociation of organic inclusions (dopants, impurities, etc) were performed. Those processes are possible in first place due to possibility of coherent monochromatic or tuned wavelength of quantum generator or amplifier. Depending on energy difference between excited and ground levels and laser pulse photons energy, single of multi-photon processes are included [25, 26]. Some of them are triggered using pulse CO_2 TEA (Transversal Electric Atmospheric Pressure) laser for removing of organic impurities in $AsCl_3$. CW CO_2 laser was used for cleaning of BCl_3 from $CoCl_2$ residues. Pulse CO_2 lasers triggered dielectric breakdown (DB) in the mixture of SiH_4 and B_2H_6. The analysis of obtained vapors shows selective disappearing of B_2H_6. Some experimental details about quantum efficiency (output) during photochemical removing of AsH_3 and PH_3 from SiH_4 at uvaser irradiation 193 nm are presented in Tab.1 [2].

Table 1: Quantum output during photochemical removing of AsH_3 and PH_3 from SiH_4 during irradiation at 193 nm. (1 Torr=1mmHg=133.32 Pa.)

Pressure AsH_3,[Torr]	Pressure SiH_4, [Torr]	Quantum output
0.050	0.5	0.85
0.050	0.5	0.88
0.050	2.0	0.57
0.050	8.0	0.46
0.050	15.0	0.50
Pressure PH_3, [Torr]	Pressure SiH_4, [Torr]	Quantum output
0.050	0.5	0.61
0.050	2.0	0.40
0.050	8.0	0.34
0.050	15.0	0.25
0.050	15.0	0.30
0.025	7.5	0.27
0.025	12.5	0.25

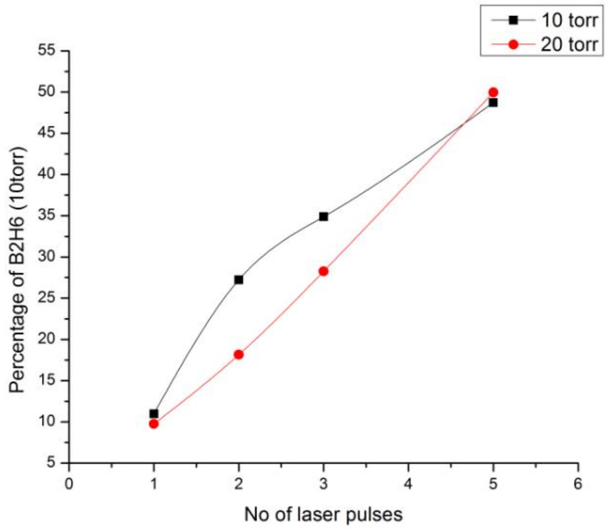

Figure 1. Influence of multi pulse and single pulse CO_2 laser interaction in case of SiH_4 cleaning from B_2H_6 by various SiH_4 pressures (908.5 cm^{-1}). B_2H_6 - 1 torr, SiH_4 - 10 torr and 20 Torr.
■- 10T.torr • - 20 Torr (1 Torr=1 mmHg=133.32 Pa).

Influence of cumulative laser energy (multi pulse interaction) of IR CO_2 lasers to SiH_4 cleaning from B_2H_6 by various pressure of SiH_4 is analyzed (Figure 1.) based on experimental data (Bradley Moore, 1983) [2]. The cases analyzed in Figure 1. used two lines of CO_2 lasers: 908.5 cm^{-1}, (which coincide with SiH_4 vibrations) and 947.7 cm^{-1} (non resonant). DPL - DB experiments include the heating with shock wave excitation, ionization and dissociation processes. Therefore DB methods have some advantages.

UV Laser Photolysis

Application of excimer lasers for removing of H_2S from mixture of CO and H_2 at UV photolysis processes was successful. These kinds of processes are useful as alternative for obtaining carbon-hydrogen compounds from raw oil. The selectivity of the H_2S excitation in the presence of appropriate synthesis gas could be 10^7. Some earlier attitudes were, with 1 ppm content of inclusions, dopants: the common cleaning methods are more optimal than laser methods, but by c<1 ppm laser methods are more appropriate for the H_2S cases (industrial applications are possible). The cases of SiH_4 smudges

(Figure 2) could be solved with uvaser, also. SiH_4 is commonly used for amorphous, mono-crystal and poly-crystal Si. It could be used from solar cells to integrated circuits.

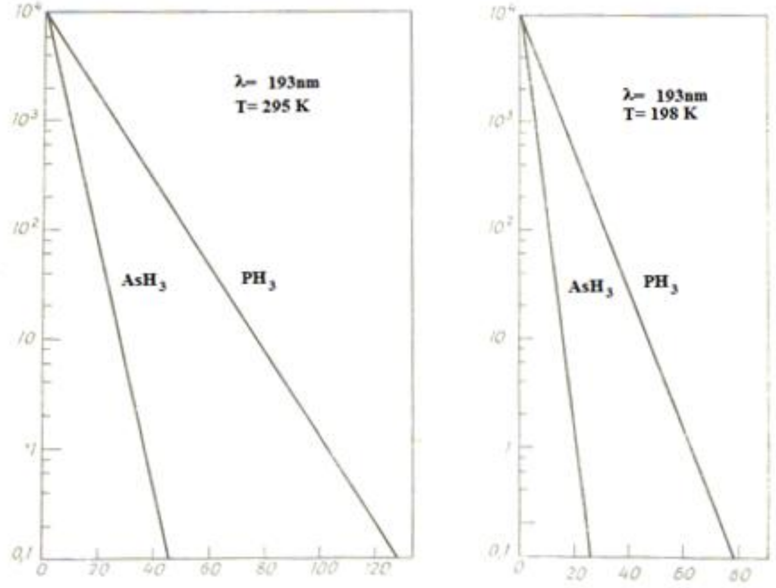

Figure 2. Influence of laser beams to the degree of cleaning of SiH_4 from AsH_3 and PH_3, at 295 K (a), and 198 K (b), according to the equation $n_A \approx n_A{}^o \exp\left(\frac{-\varphi_A \sigma_A \varepsilon}{n_S{}^o \sigma_S}\right)$*, where n is silane molecule concentration, and inclusions A, φ-quantum efficiency of the molecule re-movement, which is the number of the non-exited molecules and absorbed energy, in the units of UV quant- ε and molecular density, σ_S are efficient appropriate cross section.*

Material Hardness

Radiation hardness of the material of various types (nuclear, chemical, ultrasound, laser) is very important material performance which has to be known, especially hazardous environment as are nuclear accidents, earthquakes, volcano eruptions, mining accidents, as well as in the common working conditions, in nuclear plants near reactor, etc. Especially remote control is important and fiber role as a part of laser measuring systems, where fibers are used either as sensors or as telecommunications infrastructure, or part of fiber lasers and amplifiers [10].

Fiber optic sensors based on fiber optic components such are optical fibers, are today inevitable in the science, industry, medicine and mass media (magnetic and electric fields, chemical sensors, biosensors...). The influence of γ- nuclear radiation to optical fiber contributes to develop the environmental monitoring systems. The γ and X irradiations are also of interest, considering the influence of radiation in medical treatment environmental conditions. Some of new optical sensor experiences are related to the development of fiber lasers and fiber amplifiers, followed by the fiber sensors that could be applied for high power nuclear radiation monitoring and detection systems for power control. This is very important for monitoring environmental conditions in the nuclear plants area, as well as in military purposes. The various measurement methods, which could be complementary to the standard methods for optical propagation diagnoses (the OTDR, dispersion measurements, infrared-IR spectroscopy...), could be applied in real time during the monitoring. Based on these techniques, the key parameters of irradiation processes could be precisely monitored and doses were determined by developed administration in nuclear laboratory. That fact leads to achieve monitoring results in real-time, and the dynamics of the processes could be of interest for the fast safety reaction. In general, the interest for study the influence of electromagnetic radiation in the whole electromagnetic spectrum is the topic in large scientific area, beside of nuclear physics, nuclear technique, interactions of nuclear radiations and particles with material, dosimetry and radionuclide applications. That kind of investigation leads to developing the new environmental sensors with very good performances; such are dead zones, reacting times, range of EM radiation, etc. Above mentioned could be explicitly expressed by followed items:

- the consideration of the influence of high energy nuclear radiation to fibers and materials in general in the purpose of measuring and sensing (GeV range energy detection);
- the amelioration of nuclear detector [16] characteristics (particle detection by laser irradiation);
- By the irradiation of optical fiber with different type of radiation (EM and nuclear). Especially the irradiation by the iraser of optical fiber another glass materials during drawing processes ameliorate the mechanical performances;
- projects considering behaviour of material performances after the nuclear explosion past through the simulation and experiments;
- monitoring of working area and ecological problems;
- monitoring of working area in medical facilities;
- Optical supply of sensors.

Particle production and dimensioning by lasers and relationship with potentially hazardous dimensions

Some results from the references and authors are presented in Figures 3 a, b, c, they present particle size distribution in various laser regime applications [25] and they deserve further study as in [21].

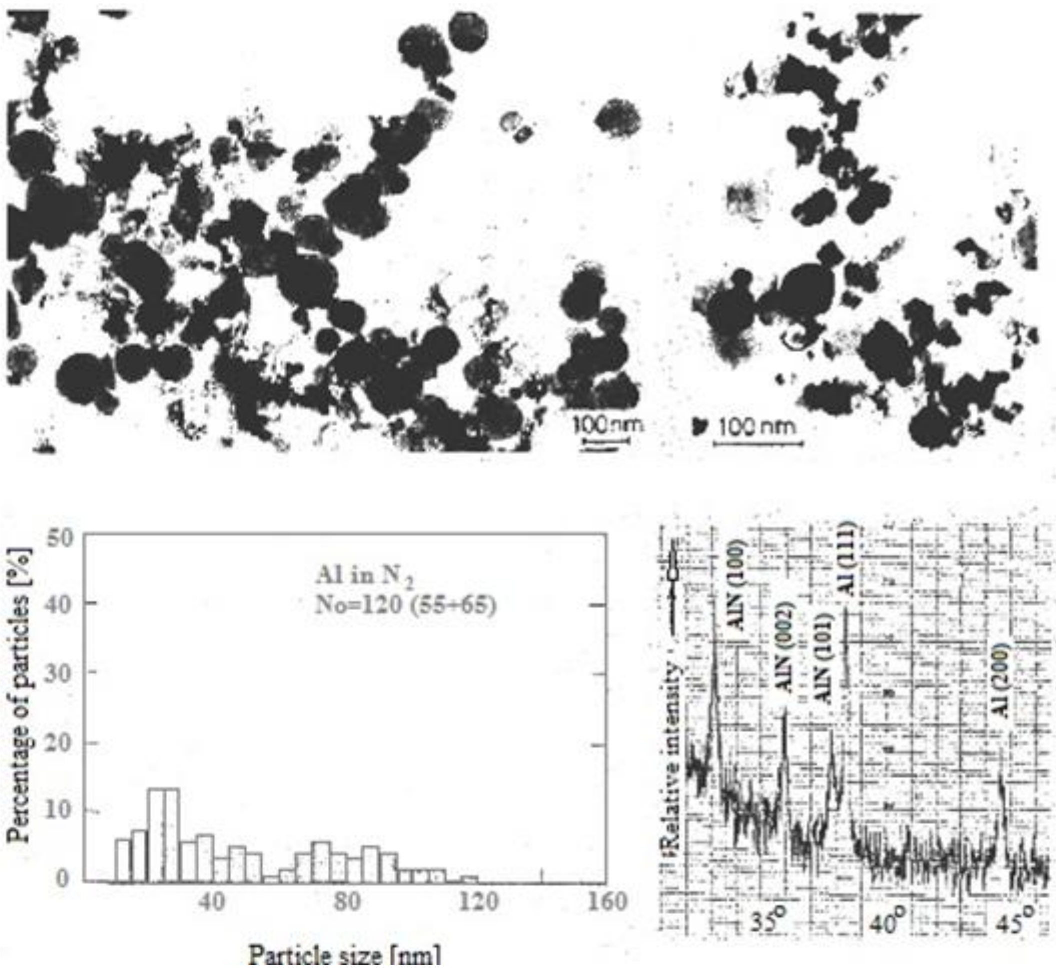

Figure 3a. Particles size distribution - obtaining nano particles from Al in N_2 atmosphere.

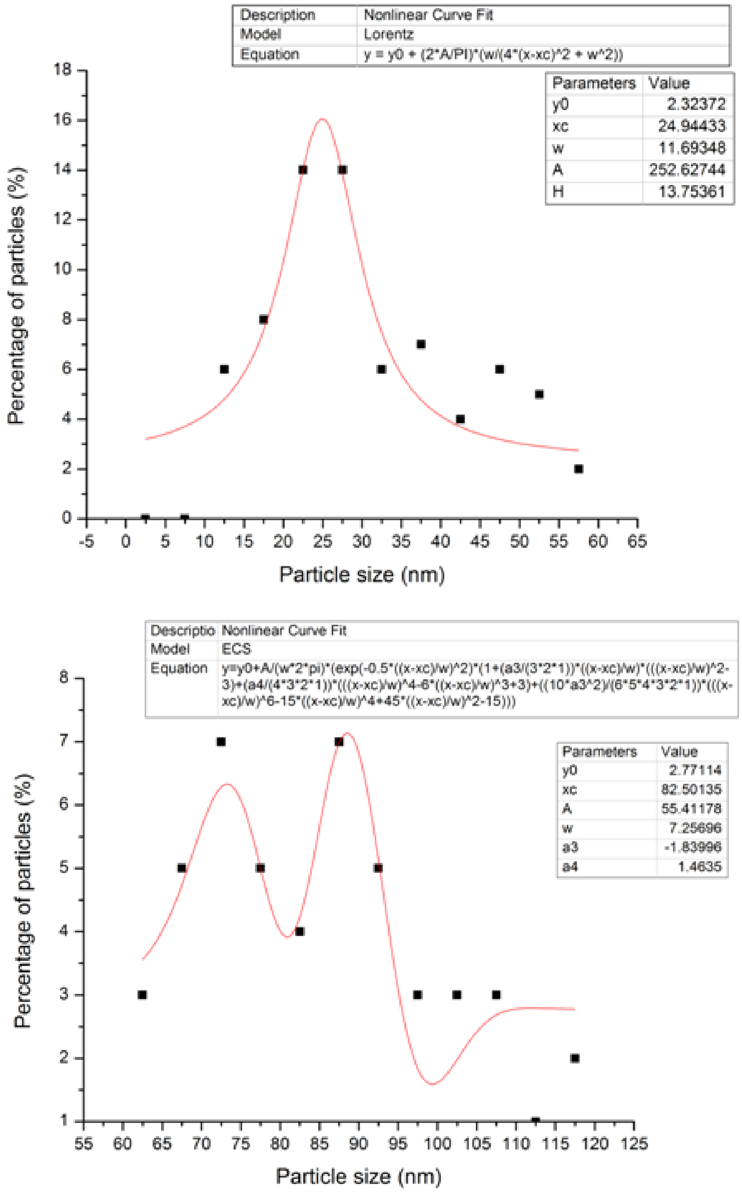

Figure 3b. Fitting of particle size distribution with Lorentzian or ESC. Particles size distribution - obtaining nano particles from Al in N_2 atmosphere

The results from obtaining ultra fine particles from Al in N_2 atmosphere are depicted in Figure 3a. They are common followed by X ray diffractometer, TEM as well as SEM analyses. Figure 3 presents Al and nitride AlN forming. TEM micrographs show both larger spherical and smaller particles. It is in correspondence with two types of particles with dimensional distribution (sizes) in the range 10-60 nm and 60-120 nm. Al-particles are spherical, and smaller particles are spherical. Nitride particles are not formatted from Fe, Ni, etc. sheets.

Up to date are produced nano and other particle sizes from metallic target with laser in various dynamic regimes: cw, Q switch (ns, ps and fs regimes) in different environments (Ar, He, O_2, N_2, etc). Some conclusions about laser role in particle production are:

- Metallic material with high reflectivity, high thermal diffusivity and high boiling temperature are more difficult tasks for laser methods,
- Metal evaporation and nano particle forming follow the rise time of the laser pulses and further during the exposition time,
- Mean size of nano particles (10 - 30 nm) can be obtained from the appropriate metals in Ar or He atmosphere in near atmospheric conditions,

- Particle sizes decrease with pressure decrease,
- Nanoparticles of metal oxides (Fe_2C_3, NiO, Al_2O_3, TiO_2, CrO_2, Cr_2O_3, WO_3, Ta_2O_3, and MoO_3) are obtained in O_2 atmosphere (1 atm~10^5 Pa). Nitride particles (TiN, ZrN and Ta_2N) are obtained in N_2 atmosphere; from Al target mixture of particles Al and AlN are obtained. These general conclusions have to be modified depending on the chosen demand.
- For sensing purposes which include optical fiber with various material (glass or polymer based) include various powder material with different magnetic, piezoelectric or other optomechanics, optoacoustics, performances for broadening fiber sensing applications in wide range of environmental situations [10, 25].

Photochemical Separation of the Elements in Solutions

Photochemical process investigation of separation in liquid phase had the spectral resolution lower than in gas or solid state. Metallic materials (elements) which could be subdued to photochemical transformation in order to change its pH degree (within regular solvents) are recognized in references. In Table 2, some elements where photo red-ox processes are accomplished as well as potential elements for those processes are supposed.

Table 2:

Photoredox processes	Elements
Photoredox processes are performed	*Transient metals D* V, Cr, Mn, Fe, Co, Cu, Nb, Mo, Ru, Rh, Pd, Ag, W, Ir, Pt, Au, Hg *Transient metals F* *Lanthanides* - C, Sm, Eu, Yb *Actinides* - U, Np, Pu,
Photoredox processes are supposed	*Lanthanides* - Tm *Actinides* - Am, Bk, Md, No

Laser dynamic and static scattering in object dimensioning (molecules solution molecular interaction optical purity). ***Static and dynamic laser scattering measurements and interpretations***

In Figures 4a and 4b are presented integral measurement for phytol i.e. angular distribution and in Fig.5 dynamical laser scattering data obtained by appropriate devices. The first data are scattering intensities for polarization components (Fig.4) and from Figure 5 it could be evaluated needed spectral linewidth for measuring the scattering on uranil salt molecules in water solution. Here we fitted obtained linewidth using Lorentzian in chosen working conditions.

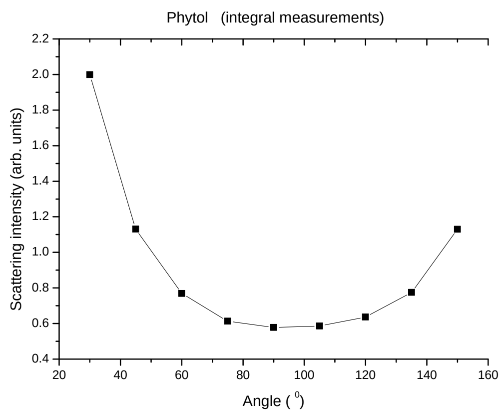

Figure 4a. Static- integral scattering intensity of phytol ,

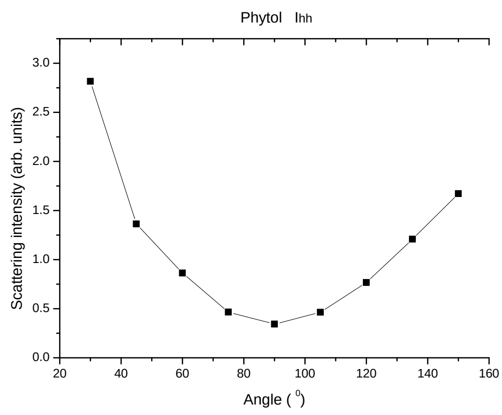

Figure 4b. Static- integral scattering intensity of phytol

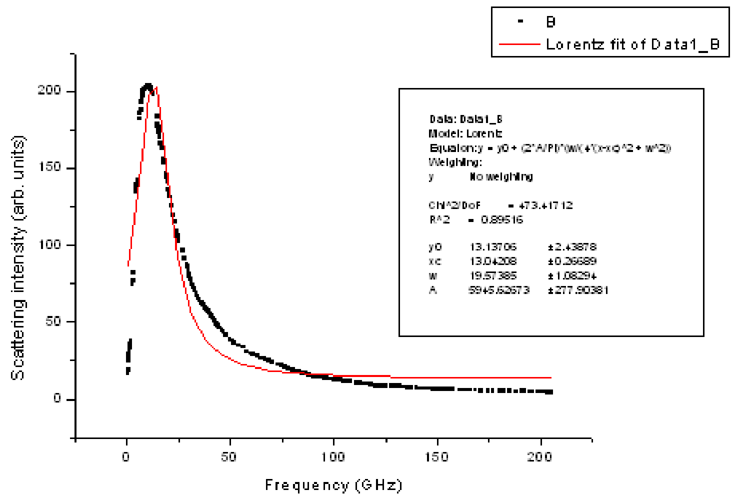

Figure 5. Dynamic LASER beam scattering on the solution of uranil salt [23].under θ=8^0 and coherence with Lorentzian, Γ=1.26 Hz (HHLW).(Technical detail - *Scattering angle θ_2=8_{app},U_{PM}=0.75kV; filtre 0.3Hz – 3000Hz*

White light lidar

High-power laser pulses propagating in transparent media undergo a number of nonlinear effects. Non linear self-action leads to strong evolutions of the spatial (self-focusing, self-guiding, self-reflection), spectral (four-wave mixing, self-phase modulation) as well as temporal (self-stepening, pulse splitting) characteristics of the pulses. The propagation medium is affected, as it is partially ionized by the propagating intensive beam. *New phenomena* have been found and extensively studied since the 1970s, from the theoretical and the experimental point of view. The development of the chirped-pulse amplification -CPA technique permitted ultra-fast laser pulses producing (1985). High power laser make possible to observe highly nonlinear propagation in slightly non linear media (atmosphere). We will focus here on nonlinear propagation in air and on processes related to coherent white-light generation and filamentation [11, 26].

White-Light Generation and Self-Phase Modulation (SPM)

The spectral content of the emitted light is of principal importance for laser distance methods in atmosphere -environmental descriptions and measurement of atmospheric parameters and processes. Nonlinear propagation of high-intensity laser pulses provides self-guiding but also an extraordinarily broad continuum from the UV to the IR ranges. The formatted super continuum is generated by self-phase modulation as nonlinear effects. Electro optics and electromagnetic effects (here Kerr effect) lead, due to the spatial intensity gradient, leads to laser beam self-focusing. The intensity varies with time, and the instantaneous air refraction index is modified according to:

$$n(t) = n_0 + n_2 \cdot I(t), \quad d\Phi = -n_2 + n_2 \cdot I(t) \cdot \frac{\omega_0 z}{z} \tag{1}$$

There from follow time-dependent phase shift. Note that ω is the carrier frequency, generates new frequencies

$$\omega = \omega_o + \frac{d\Phi}{dt} \tag{2}$$

The smooth temporal envelope of the pulse induces a strong spectral broadening of the pulse about ω. The spectra, emitted by filaments were created by the propagation of a 2 TW pulse in the laboratory. The super continuum extends from 4 μm to 400 nm. Measurements in air have shown an extraordinary

UV extension to 230 nm due to efficient third-harmonic generation (THG) and frequency mixing. It thus covers absorption bands of many trace gases in the atmosphere: methane, volatile organic compo unds (VOCs), aromatics, CO, NO_2, H_2O, SO, and ozone. It enables new, multi spectral lidar measurements of many beside mentioned. Filamentation studies have shown that white light was generated in the filamentary structure, and due to coupling with the plasma, leaking into the forward direction as a narrow cone. “Conical emission” with the longer wave lengths in the center to the shorter wavelengths at the edge, extends over a typical half-angle of 0.12◦. A more important aspect for lidar applications is the angular distribution of the white light continuum in the near-backward direction. In the first fs lidar experiments, a pronounced backscattering component of the emitted white light was found. The angular resolved scattering experiments are needed. The emission close to the backward direction of the super continuum from light filaments was significantly enhanced as compared to linear Rayleigh – Mie scattering R-M S. Fig. 6 shows a comparison of the linearly backscattered R-M S from a weak laser beam with the nonlinear emission from a filament, for both s (left part) and p (right part) polarizations. At 179 degrees the backward enhancement amounts to an order of magnitude.

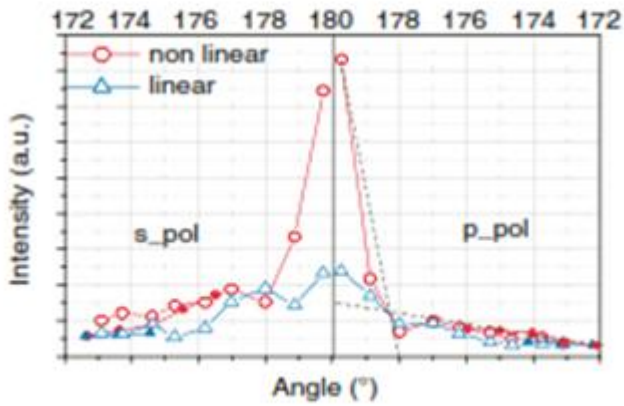

Figure 6. Angular dependence of the white light intensity by a filament. A strong backwards enhance ment is observed for s(left) and polarization (right). Circles present nonlinear emission, triangles scattering from, low-energy beam in the wavelength regions (400-450 nm). 180; experiments are close to the technical possibilities. [26]

Nano-particles and Human Health

Wide references exist now days concerning the benefits of nano-particles. We will only remain that the benefits should be carefully considered, due to no effects not so known which are reported sometime. Those are the elements of toxicity and the need for dosimeter point of view should be admitted in all applications not only nano, but the other kind of materials. In spite that materials as from chemically point of view are not hazardous, they should be *dangerous* for health if the sizes are smaller than some critical size. It is found in many cases. In the case of nano-material, nano-toxicology exists as science and its development is steel increasing. It could be under titles: cellular toxicity, metal based nano-particles and toxicity, toxicity of silver nano-particles, ingested nano-particles toxicity, new technique control of sizes of nano-particles, clusters for environmental, health and safety, nano-particles in sunscreens etc. Silver nano-particles, is a germicide, because their capability to suppress the growth of harmful organisms, but the further route should pay attention. But there also investigations that ingestion of commonly nano-particles at typical environment levels is unlikely to provoke over toxicity [18-20].

In the study of those problems, the diagnostics of nano-particles and measuring methods should be considered [27], including LDA methods and distance measurements of volcanic processes, and generally lidar methods in concentrations measurements and centers of scattering sizing.

CONCLUSION AND DISSCUSION

Some of the results are presented, which should show the real descriptions of material with could be the objects of further analysis and interpretations as well as the links with other physical performances which are indirectly link with the optical performances. Some simulations and fittings of the results enable to evaluate the possibilities of obtained measuring results. Specific parameters and distribution shapes could be used for sample and method recognition. Especially, the tasks with laser dissymmetry should be fulfilled with inclusion the other dosimetries developed for spontaneous radiations in the same spectral ranges. From the presented results measurements of some uranil salts are shown the possible order of magnitude of line-width which determine measuring complex-systems, as well as the intensity of static components measured on phytol in cylindrical angular disposition. Some nonlinear phenomena are considered from the point of view now (but successfully developed lidar systems) in atmosphere descriptions and obtaining real parameters. They belong also to the propagations of laser pulses in long distances and can be a part of solutions generalized Space problems considering space waste and defense using the chosen techniques as well as laser applications in isotope selections, measurements of low concentrations of material of different influence, as are military poisons etc. Nonlinear propagation of TW laser pulses exhibits several unique properties for multi-spectral lidar measurements extremely broadband coherent light emission (“white light laser”) confined in a self-guided beam and back-reflected to the emitter as the laser pulse propagates.

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AIR QUALITY MONITORING IN ZRENJANIN

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ABSTRACT

Air quality monitoring is not only a moral but also a legal obligation. Therefore, only laboratories that are accredited by the Accreditation Body of Serbia (ATS) can perform air quality monitoring. This paper gives a brief overview of the basics of air quality monitoring, legislation, as well as the current state of air quality monitoring in Serbia. In addition, inter-laboratory measurement of air quality for the purpose of accreditation of two laboratories is presented, as well as the measuring equipment and measurement results. Laboratories used the measuring device Recordum Airpointer, and measured the concentrations of carbon monoxide, nitrogen oxides and particulate matter.

Key words: *air quality monitoring, Recordum Airpointer, carbon monoxide, nitrogen oxides, PM.*

INTRODUCTION

Man can live for days without food and hours without water, but only minutes without air. An average adult inhales a total volume of approximately 15 cubic meters of air per day. Although the air is essential to life, exposure to polluted air can lead to significant health problems. Pollutants present in the air inevitably affect the human respiratory system and subsequently human health, because the entire amount of air a person breathes is filtered through the alveoli in the lungs. Because of that, air quality is of vital importance to human kind, and knowing the level of polutants in air is of great significance.

Monitoring of air pollution (air quality monitoring) is a measurement of imission, or in other words, determination of concentrations of harmful substances in the sorrounding air. Monitorimg can be divided into two categories (Nathanson, 2000):

1. Outdoor air monitoring - which means the measurement of the concentration of pollutants in the air in the open areas,
2. Indoor air monitoring - which means the measurement of air pollution in rooms where people live and work.

In this paper only outdoor air monitoring will be presented.

SOURCES OF POLLUTION

Sources of ambient air pollution are mainly of anthropogenic origin (which means that they are the product of human labour) and they can be classified into two groups (Pavlovic, 2011):

1. Stationary sources of pollution include:
    - pollution sources in rural areas related to agricultural activities, mining and quarrys,
    - sources of pollution related to industry and industrial areas (chemical industry, metal industry, electricity generation)**,**
    - sources of pollution in the communal areas, such as heating, waste incineration, and others.
2. Mobile sources of pollution include:
    - any form of vehicle with internal combustion engines (cars, motor boats, planes)

The level of air pollution has been changing with years. Today, the most influential parameters, which are measured in order to verify and monitor the condition of air pollution are:

- Carbon dioxide - CO_2
- Nitrogen oxides - NO_x
- Volatile organic compounds - VOC
- Particulate Matter - PM_{10}, $PM_{2,5}$
- Ozone - O_3
- Sulfur oxides - SO_x

AIR QUALITY MONITORING IN SERBIA

Serbia has its own network for air quality monitoring. Authority over the national network is delegated to the Agency for Environmental Protection. National network consists of automated monitoring stations, that work with reference methods. There are 40 stations in total, of which 28 stations were donated, and 12 stations were acquired with the help of the Fund for Environmental Protection of the Republic of Serbia, and some major operators (e.g. RTB Bor, CIS association). Locations of the monitoring stations is shown in the figure 1.

Figure 1. Locations of automatic stations

DESCRIPTION OF AIR QUALITY IN THE REGION OF BANAT

Air quality is monitored by automatic measuring stations that are set at the measuring points, as defined by law. Zrenjanin (figure 2), is the largest city in the Banat region, located on the western edge of the loess plateau of Banat, at the point where the channeled Bega river flow into the former bed of the river Tisa. Municipal area is extremely flat area. The city lies at 20° 23' east longitude and 45° 23' north latitude. Elevation of Zrenjanin municipality is 80 meters, and ranging from 77 to 97 meters in the city.

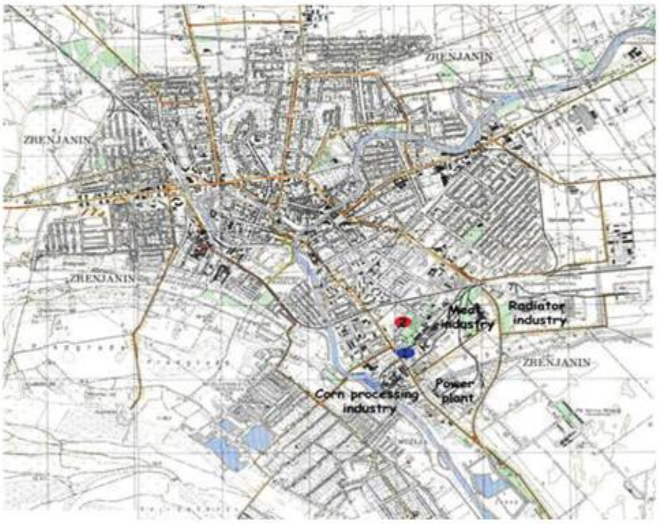

Figure 2. Map of Zrenjanin

LEGAL REGULATIONS ABOUT AIR MONITORING

Governing law that addresses the air quality and monitoring is the "Law on Air Protection". It consists of 13 chapters, which are:

1. General provisions,
2. Air quality control,
3. Requirements for air quality,
4. Strategies, plans and programs,
5. Measures for improvement of air quality,
6. Measuring the emission and level of pollutants,
7. Informing and reporting,
8. Information system,
9. Financing the protection and air quality improvement,
10. Supervision,
11. Authority on resolving the appeals,
12. Penalties,
13. Transitional and final provisions.

This law is followed by the "Regulation on the conditions and requirements for air quality monitoring". It consists of 23 articles and 14 annexes that supplement this regulation. These annexes contain the upper limit values of pollutants that may be present in the ambient air, procedures for determination of measuring spots, required number of measurements during one year, reference methods, etc. These laws also define the requirements that firms must fulfil to be eligible to do air quality monitoring. The main condition is that laboratories are accredited by the Accreditation Body of Serbia (ATS).

In our measurements we have used these laws and regulations, which helped us to determine the air pollution in Zrenjanin.

EQUIPMENT FOR THE MEASUREMENT

For our measurements, we used automatic portable measuring station Recordum Airpointer. We measured five components: carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter (TSP, PM_{10} and $PM_{2.5}$) and ozone. Each component is registered by separate module (figure 3.)

Figure 3. Recordum Airpointer

Measuring principle for CO – Non-dispersive infrared (EN 14626)

In the most basic terms, this component uses a high energy heated element to generate a beam of broad-band IR light with a known intensity at 4.6 μm wavelength. This beam is directed through multi-pass cell filled with sample gas. The sample cell uses mirrors at each end to reflect the IR beam back and forth through the sample gas to generate a long absorption path (figure 4). The length was chosen to give the analyzer maximum sensitivity to fluctuations in CO density. Upon exiting the sample cell, the beam shines through a narrow band-pass interference filter that allows only light at a wavelength of 4.6 μm to pass. Finally, the beam strikes a infrared detector that converts the light signal into a modulated voltage signal representing the attenuated intensity of the beam.

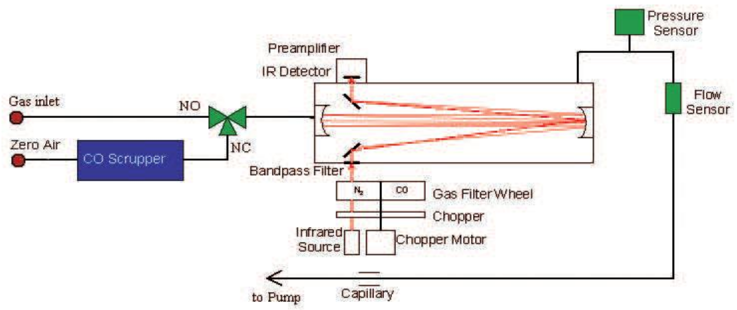

Figure 4. CO Sensor

Measuring principle for O_3 - Ultraviolet photometry (EN 14625)

Measuring principle is shown in the figure 5. From a high energy UV lamp a beam goes alternately through two tubes, which are filled with the sample gas, alternately with the ozone sample and with a sample where the ozone is filtered. The decrease of the light's density, resulting from the presence of ozone, is measured with two detectors at the end of the tubes. Two-path design ensures correction of possible changes in light intensity.

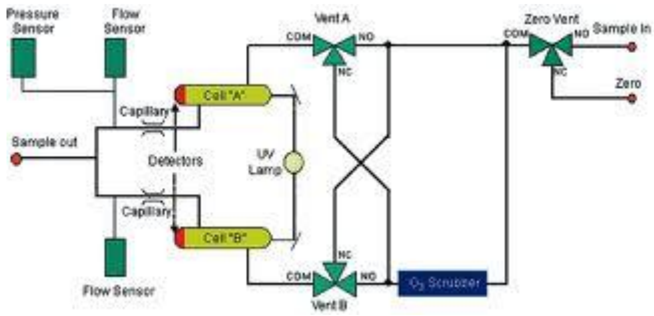

Figure 5. Ozone Sensor

Measuring principle for SO_2 – Ultraviolet fluorescence (EN 14212)

The SO_2 module of the Airpointer measures the amount of sulphur dioxide in a sample. This is done by exciting the SO_2 molecules by ultraviolet light with a wavelength of 214 nm and then measuring their fluorescence (figure 6). The sample gas is lighted with an UV lamp, which causes the sulfur dioxide part of the gas to absorb energy. The absorbed energy is emitted as a light pulse (photon) shortly afterwards, which is measured with a photo multiplier tube.

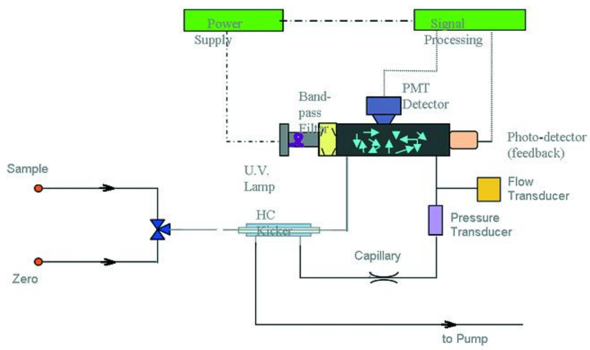

Figure 6. Sulfur Dioxide Senzor

Measuring principle for NOx – Chemiluminescence (EN14211)

The device measures the concentration of NO and NO_X in a gas sample and is able to calculate the concentration of NO_2. In this case the analyzer measures the chemiluminescence of nitrogen monoxide when it reacts with ozone. Nitric Oxides in the sample gas react with ozone and this reaction results in electrically excited molecules. These molecules release their excess energy by emitting photons, which are measured by a photomultiplier tube. The Airpointer NOx module is equipped with a delay loop to allow NO and NO2 results from the identical sample.

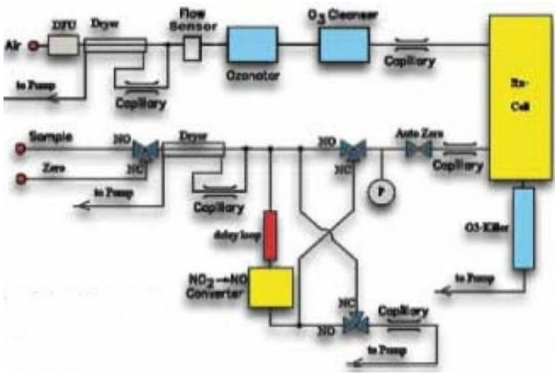

Figure 7. Nitrogen oxide Sensor

Measuring principle for Particulate Matters (TPM, PM_{10} and $PM_{2,5}$)

The Airpointer PM module uses a well proven optical method, the nephelometry. A sample heater minimizes humidity effects. It uses a light-scattering photometer with a near-IR LED, a silicon detector hybrid preamplifier and a source reference detector. The light scattered is proportional to the particle concentration. This is the fastest particle concentration measurement with high precision and very low detection limit. There might be a dependency on particle properties for the calculation of the mass concentration. The Airpointer PM module is equipped with a TSP head. To switch to PM10 or PM2.5 measurements the operator simply has to change to size selective sample inlets, which are optionally available.

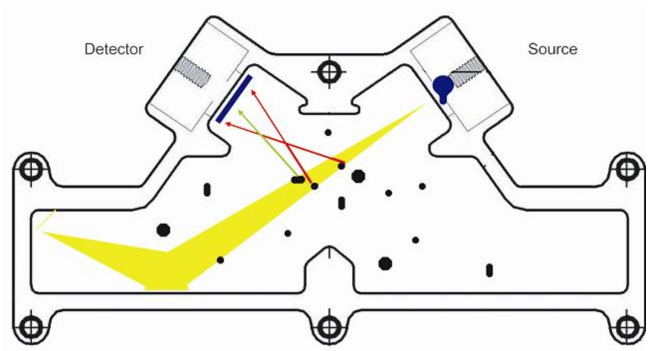

Figure 8. Airpointer Nephelometer Module

MEASUREMENT RESULTS

Purpose of this measurement was preparation of Laboratory for environmental protection and energy efficiency (which belongs to the Technical Faculty “Mihajlo Pupin” Zrenjanin) for the accreditation procedure. Measurement was conducted in the backyard of the “Gerontoloski centar Zrenjanin”. Measurement of air pollution was done on Airpointer, which was set in 4 p.m. and put into operation. It began to measure after half an hour because it had to reach its working temperature, which was at 4:30 p.m. All parameters were measured for 20 hours, except the suspended particles which were measured on three occasions: total suspended particulates from 4:30 p.m. to 9:30 p.m, PM_{10} from 9:30 p.m. to 08:30 a.m, $PM_{2,5}$ from 08:30 a.m. to 12:30p.m. In order to measure these three parameters, we had to manually change the modules that are on top of the Airpointer. Results of measurement are presented in table 1. Our measured values are averaged on 20 hours.

Table 1: Table of measured and limit values

Parameters	Measurements [μg/m^3]	Daily limit values [μg/m^3]
NO	4.79	
NO_2	14.43	85
NO_x	22.04	
CO	0.98	5
O_3	43.12	120
SO_2	29.22	125
TSP	104.48	
PM_{10}	68.60	50
$PM_{2.5}$	60.99	25

Obtained results can’t be strictly compared with the limit values given in "Regulation on the conditions and requirements for air quality monitoring", because we measured for less than 24 hours. Nevertheless, it can be seen that all results are far below their respective limit values. Only exception is particulate matter. There could be few reasons for that. Firstly, and most probably, the backyard is used as a parking lot for medical vans, and secondly whole gerontology center is very near to the busy road and “Dijamant” factory. For the definitive answer, more measurements are needed.

CONCLUSION

Air quality is vital to a human health. Hence, it is evident that air quality monitoring is an important activity, and that it must be preformed constantly. Republic of Serbia has its own network of 40 measuring stations, but they are stationed and sometimes not very well serviced. Because of that, there are private firms and Public Health Institutes that have accredited laboratories with adequate measuring equipment.

Technical Faculty “Mihajlo Pupin” from Zrenjanin possesses the Laboratory for environmental protection and energy efficiency, which is currently in the process of accreditation. This measurement of air pollutants served as a good practice for the researchers, and showed that measuring equipment is in the excellent working condition.

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A REAL TIME AIR POLLUTION DISPERSION MODELLING OF PC NUCLEAR FACILITIES OF SERBIA

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ABSTRACT

This paper presents a system for mathematical modeling dispersion of air pollutants in the boundary layer of atmosphere in real time. The basis of this system is straightforward Gaussian plume model. Input for the model are meteorological data which provides an automatic meteorological station, then emission and the other set of data like 3D topography, physical and chemical properties of the pollutants through the input files. One such system has been developed earlier to control the environment of nuclear facilities in NI "Vinca", today in PC nuclear facilities of Serbia (PC NFS) at Vinca.

INTRODUCTION

Industry and its products are now considered to be the most important man-made sources of pollution atmosphere. Chimneys, ventilation outlets, disposal and storage of waste and other harmful substances, exhaust systems of transport vehicles, sprayers for plant protection in agriculture are some typical artificial sources of atmospheric pollutants. Beside the systematic pollution of atmosphere, Besides systematically pollute atmosphere in the routine work of these sources, in accidental situations, these sources can additionally and uncontrollably to spoil of the air quality in the boundary layer of the atmosphere in which occurs most human activities.

When pollutants get into the atmosphere they feel the wind transport, atmospheric diffusion, dry and wet deposition (deposition), raising the soil after deposition (resuspension) and chemical transformations. Consequence of the emission of pollutants into the atmosphere and the processes of propagation through the atmosphere is their presence in larger or smaller concentrations.

These concentrations can in principle obtain measurements in the monitoring points or mathematical modeling. These concentrations can be obtained by measuring with a monitoring network or by using mathematical modeling.

Measuring the concentration of pollutants using monitoring network is still in principle technically complex and expensive procedure, whether it is about systems that provide real-time information, whether the information obtained by subsequent analyzes of air samples in the laboratory. With an increase in the number of measuring points the problem is increased.

Monitoring the distribution of pollutants in the atmosphere, can also be performed by applying mathematical dispersion models, which calculate their fields concentration. Mathematical models in addition to providing information on the concentrations of pollutants in the entire computational domain in the form of field concentration, have the convenience of having a relatively low-cost tools. Disadvantages of mathematical models, in terms of their practical application in the analysis of air quality in real time or for subsequent analysis, is mainly due to inadequate input data.

Gaussian straight line plume model

After an accident at a nuclear reactor at Windscale, Cumbria, 1957. The British Meteorological Office was to provide procedures for the calculation of the concentration of windborne pollutants. The problem was divided into two questions-solving formulation of relations that are related to the dispersion of the conditions in the boundary layer of the atmosphere and their presentation on the basis of available meteorological data.

The British Meteorological Office issued a decision in the first of these problems in the form of technical note in 1961, (Pasquill, 1961) in the form of work that is to link the standard deviation of wind direction fluctuations in the horizontal and vertical directions with concentrations of pollutants in the air.

This research and the recommendations of British meteorological service have led to work Pasquill (1961), in which he suggests a method to estimate diffusion. Pasquill’s method, spreading plume of pollutants in the vertical and horizontal direction, expressed by the standard meteorological measurements and observations wind speed, insolation, cloudiness. Based on this, he ordered the six classes of stability.

Curves of vertical and horizontal lateral spreading plume, depending on the distance from the source of the wind are given for these classes of "stability."

Gifford (1961) was converted Pasquill angular spread of smoke plumes, expressed by the standard deviation of wind direction fluctuations in the horizontal and vertical directions, to the standard deviation of the fluctuations in the concentration of pollutants in the plume σ_y i σ_z, now known as Pasquill-Gifford (PG) family of sigma curves, Hanna S.R. (1980).

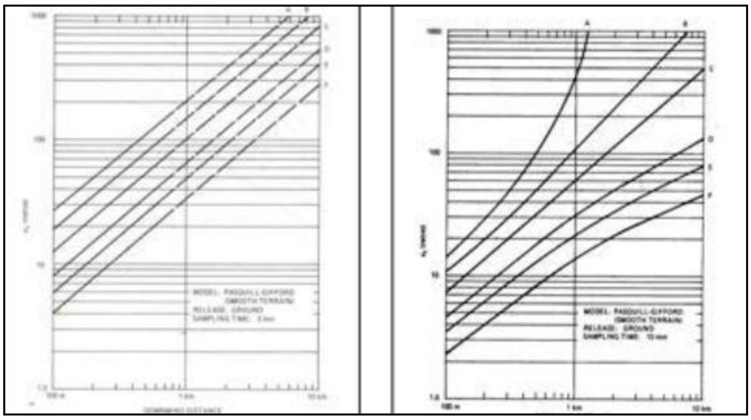

Figure 1. Graphical presentation of σ curves

To determine the PG class of "stability" as the input meteorological data using a standard hourly meteorological measurements. The main drawback of this approach is a subjective assessment of sunshine and clouds. For example, the strong insolation Pasquill gives a definition: "It's insolation that occurs mid-day, mid-summer in England ....."

The next important step in the development of the concept of problem solving dispersion of pollutants in the boundary layer of the atmosphere was quantification Pasquill scheme done by Turner defining a strong, moderate, low and poor insolation at the height of the Sun above the ground, cloudiness and amount of prevailing type of clouds , which overcome uncertainty in Pasquill classification scheme, Turner (1964).

Presented concept of stability class led to a mathematical model, whose main input data wind speed, stability class and the data on the source of pollutants, the strength of the source and its height.

This model is well-known equation of Gaussian straight line plume IAEA (1980), Nieuwstadt F.T.M. (1982):

$$C(x, y, z) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left(-\frac{1}{2}\frac{y^2}{\sigma_y^2}\right)\left\{\exp\left[-\frac{1}{2}\frac{(z-H)^2}{\sigma_z^2}\right]+\exp\left[-\frac{1}{2}\frac{(z+H)^2}{\sigma_z^2}\right]\right\} \quad (1)$$

Where:

C (x, y, z)	the concentration of pollutants at the point (x, y, z)	
Q	strength source (emission rate) (kg / h, Bq / h ...)	
σ_z	standard deviation of the Gaussian cloud in the direction of z axis, which define its dimensions in terms of time *t* or distance downwind	x =*u t*, (m)
σ_y	standard deviation of the Gaussian plume in the direction of y-axis	(m)
H	the effective source height	

With the increasing use of personal computers in their daily work eighties, there has been increasing use of mathematical models for air quality in the area of industrial and municipal sources of pollutants.

At the same time the market began to offer models of various levels of complexity, which however, were hardly applicable in each particular case, as delivered in the executive form, without the option that users can access the code and to make some changes according to their requirements.

Commercial names of some models that can be purchased on the market or over the internet, are for example RIMPUFF, AERMOD, CALPUFF, ISC3……. A particular problem in applying a commercial model, is the provision of the necessary input data. In order to promptly respond to the increased concentration of pollutants in the atmosphere, particular in accidental situations it is necessary that mathematical diffusion models are integral parts of software automated measuring systems, which are installed in the zone of influence of sources of pollutants, and as output can provide concentration fields in real time.

Preparation of input (meteorological) data in the PC NFS

As it was mentioned in the previous chapter, one of the main problems in the application of mathematical models to solve the problem of propagation of pollutants in the boundary layer of the atmosphere is the provision of meteorological input data for the location of the source of pollutants.

In R. Serbia only a small number of industries has its own meteorological program appropriate to start the mathematical models of atmospheric dispersion, Mikkelsen T.(1980).

National network of weather stations and automatic weather stations of the national automatic air quality monitoring can not be used for this purpose, because the first of them were primarily in a function of various meteorological program Hidrometeorological Institute of Serbia and they are only rarely placed in representative locations of sources of pollutants. National automatic air quality monitoring network at its stations have automatic weather stations too, but they do not follow all the meteorological parameters that are required to start the mathematical model of air dispersion Nieuwstadt F.T.M. (1982), Rajkovic (2002).

In PC NFS we have established meteorological program which is subordinate to the requirements of computer codes that we have developed for modelling dispersion of pollutants in the boundary layer of atmosphere and it is primarily based on measurements with automatic meteorological station on the meteorological tower 40 m tall, Grsic Z. (2001), Grsic Z. (2004).

For the Computer code for routine work, which is based on the Gaussian model of atmospheric diffusion and Pasquill original theory, also was established a program of classical measurements and observations, Gifford F.A. (1961).

This program provides the input data: cloudiness in total and by type, height of the base of prevailing cloud, wind speed and direction at a height of 10m above the ground and precipitation, at each hour term of meteorological measurements and observations.

Insolation in each hourly term and the beginning of the day and night (sunrise and sunset for any location sources) are determined by the computer code that we developed based on spherical trigonometry equations that define the relationship of the sun between horizon and equatorial coordinate astronomical system Grsic Z. (2011).

Classic program of meteorological measurements and observations in PC NFS serves as a reserve and used when the automatic weather station is out of service.

Basic meteorological program based on measurements of automatic meteorological station, among other benefits, allow direct determination of stability class at Turner's scheme in practically real-time and access to the same rate and to the values of σ_z and σ_y, Turner D.B. (1964).

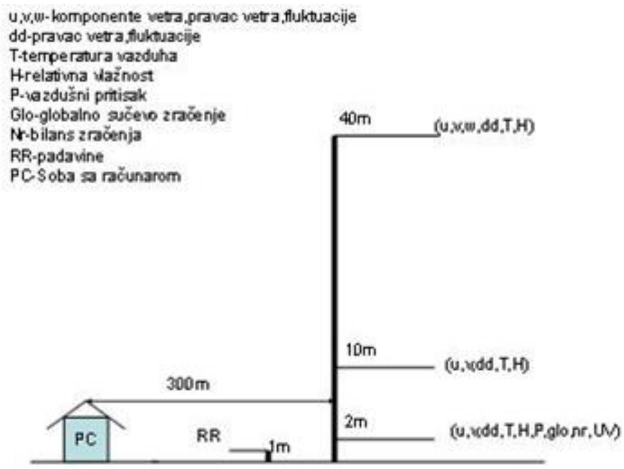

Figure 2. Schematic representation of automatic meteorological station in PC NFS

Data from these stations, which figure as input meteorological data of model are recorded in a minute (for accident emission) or ten-minute (for routine emission) in a file that is automatically created for each new minute or ten-minute data set, the format is as in the example below:

1211080835 15.5 95.5 734 321 7.3 313 3.1 22.1 10.1 323 24.9 15.4 343 1.5 -1.2345E-06 4
Date, month, year, hour, minute (two digits)
1211080835
T_Temperature at 2m
15.5
H_ Humidity at 2m
95.5
glo_Global Sun Insolation
734
nr_Net radiation
321
v_Wind speed at 2m
7.3
dd_Wind direction at 2m
313
RR_Precipitation
3.1
T_Temperature at 10m
22.1
v_ Wind speed at 10m
10.1
dd_ Wind direction at 10m
323
T_Temperature at 40m
24.9
v_Wind speed at 40m
15.4
dd_Wind direction
343
w_Vertical wind component at 40m
1.5
MO_Monin Obukhov length
-1.2345E-06
SC_Stability class
4

Figure 3. Automatic meteorological station in PC NFS

Preparation of other input data for the mathematical model of atmospheric dispersion

Source characteristics

Point sources, for example (high chimneys), in the file with the input data on the sources, are presented with their intensity (speed emission), with its coordinates on the computational domain, then with physical height, with exit diameter, with a temperature of exit gases and with their vertical speed. Line, surface and volume sources are displayed as a number of point sources, which are described with previously mentioned data for point sources.

Number of sources is practically unlimited and depends only on the capacity of the computer and its ability to follow the dispersion process in real time.

Physico-chemical characteristics of the pollutants

Basic set of these parameters provides information about the density of pollutant, if particles are concerned their particle diameter and speed of dry deposition and leaching coefficient for wet deposition, Pendergast M.M. (1984).

Thickness of the mixing layer

This parameter is taken as a parameter based on a variety of literature, depending on the stability classes according with Pasquill scheme Yamada T. (1975).

Relief-3D maps of the terrain around Vinca

Although these models have been developed for flat terrain, but due to a number of good qualities, they are adapted for use on uneven ground, the theory of Witek(1975).

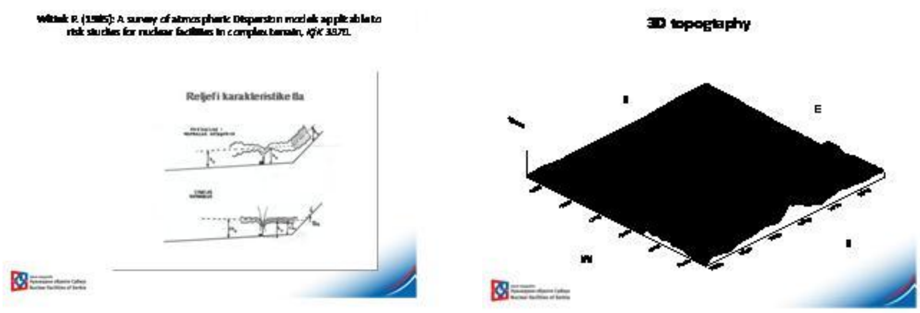

Figure 4. Topography in the mathematical model of PC NFS

For any territory, 3D orography of the terrain can be downloaded from Google Maps.

Practical application of the model PC NFS

The concept of a mathematical model that was developed for the purposes of environmental control PC NFS, had its practical application in several projects, and here are illustrations of some application in the next figures:

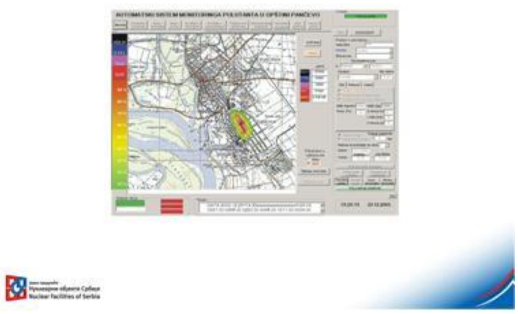

Figure 5. Industrial zone of Pancevo Grsic(2004)

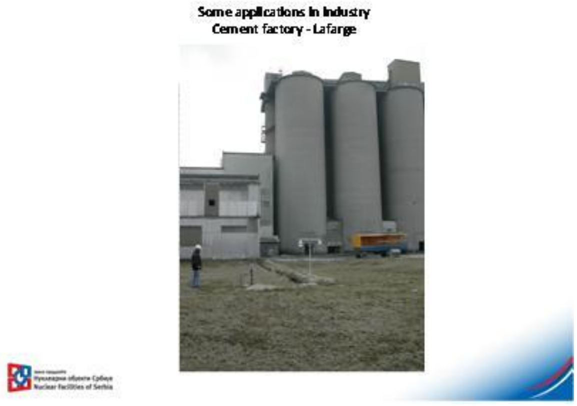

Figure 6. Cement factory Lafarge Grsic (2002)

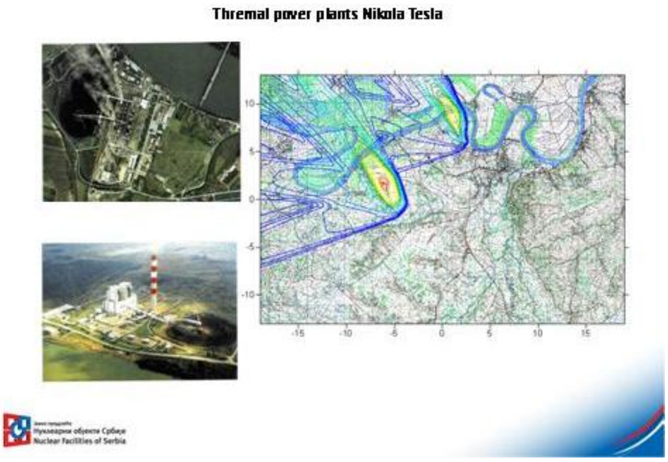

Figure 7. Thermal Power Plant Nikola Tesla of Obrenovac, Grsic (2010)

CONCLUSION

Straight line Gaussian plume model is one of the most commonly used mathematical models in the world, which is used to estimate the distribution of pollutants through the boundary layer of atmosphere. Commercial "models"- software packages, whose base is previously described Gaussian model of atmospheric diffusion, that are offered for free over the Internet or in a favorable commercial form, have the disadvantage that they are available to users as a executive software, whereby users can not access the code and adapt it to their specific requirements. A particular problem is the preparation of input data. Meteorological data are a problem, because industrial and the air pollution sources- users, usually have no meteorological programs in their locations. The application of the model for commercial purposes in addition to these general issues is of particular, relating to the listing of the sources according to their type, such as line, surface or volume sources, or input 3D terrain topography on the selected computational domain. Harder way to overcome this problem, is for users to develop their own codes of models, but at least in our country, it is not so easy because the laws regarding the control environment does not give importance to this approach to solving problems in the way as it is done in developed countries. In the PC NFS, we have developed our own codes, based on the air diffusion models recommended by all relevant world organizations WMO, IAEA, EPA, ..., on them are also based licensed "models" such as RIMPUFF, AERMOD, CALPUFF, ISC3 ....,by WMO(1982), IAEA (1980), EPA(2013) etc. Because we have developed our own codes for atmospheric dispersion, we have managed to solve different problems in the assessment of environmental impacts of various industrial facilities, and the experience during the bombing has confirmed that with this approach we are able to answer to the demands of environmental control using mathematical models even in the most complex accidental situations Grsic (2007).

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EXPOSURE ASSESSMENT FOR THE CHARACTERIZATION OF HEALTH RISK FROM AIR POLLUTION

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ABSTRACT

Risk characterization involves collection of data on the toxicity of a chemical agent to which a given group of human population is exposed, as well as collection of data on the exposure characteristics. The collected data are presented both qualitatively and quantitatively for the purpose of establishing the risk level for agents with a potential carcinogenic or non-carcinogenic effect. This paper presents a methodology of quantifying exposure to air pollutants, which is a function of their concentration and their effect duration. Thus, it is possible to quantify health risk – by using physical equations – for the territory of the City of Niš from 2001 to 2011, in relation to SO_2*, CO,* NO_2*, and soot concentrations in ambient air.*

Key words: *health risk, uptake dose, air pollution, hazard quotient, total cancer risk.*

INTRODUCTION

Health risk is defined as the probability of unwanted effects on human health, which are a function of exposure to pollutants, their concentration, and their effect duration in environmental mediums (air, water, and soil) under real conditions.

Health risk assessment can be qualitative and quantitative, and it is performed by means of appropriate scientific methods. When assessing health risk, it is necessary to include the following stages: hazard identification, determination of the dose-response relationship (toxicity assessment), exposure assessment, risk characterization, and risk presentation. Thus, risk assessment can be presented as a process that determines hazard, exposure, and risk (Figure 1).

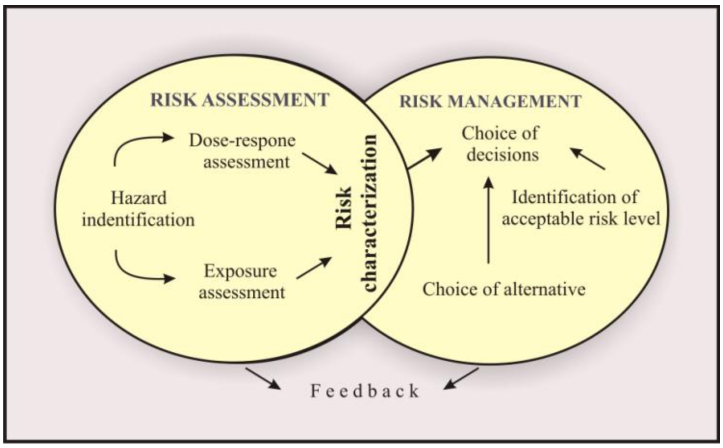

Figure 1. Relation between risk assessment and risk management procedures

The health risk characterization stage is the most important stage in risk assessment and it results in a qualitative and quantitative assessment of health risk. Scientifically-based health risk assessment is of great national importance. Errors in health risk assessment can have multiple negative effects from the health, social, and economic perspective. Health risk assessment and health risk management are inter-dependent and objectively connected in space, time, and development. Health risk assessment is followed by risk management decisions.

EXPOSURE ASSESSMENT

During health risk assessment, determination of the level of exposure follows after identification of the chemical agent that has been confirmed to potentially cause detrimental health effects.
The magnitude of exposure is a function of the chemical agent exposure concentration and the time interval of its effect, and it is expressed with the following equation (Figure 2):

$$E = \int_{t_1}^{t_2} C\ t\ \ dt\ , \qquad (1)$$

where: E – magnitude of exposure [mg/m^3/duration]; $C(t)$ – concentration of agent as a function of time [mg/m^3]; and t_2 - t_1 – exposure duration [ED]. ED is a continuous period of exposure (e.g. a day, a week, a year, etc.).

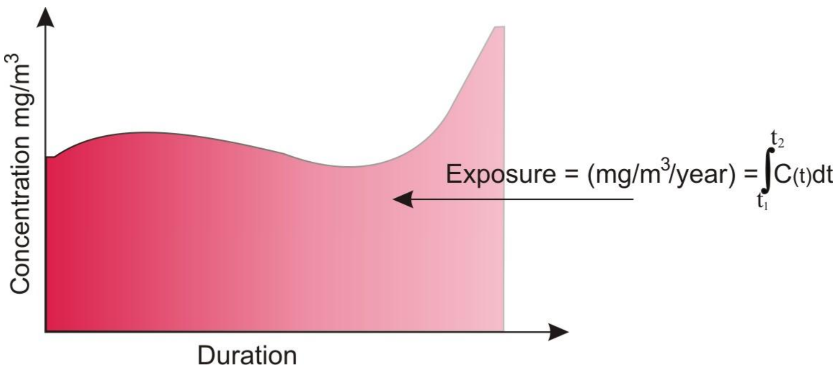

Figure 2. Functional dependence of exposure on concentration and effect time

Exposure concentration of the agent C(t) can be equal to zero during an interval of the exposure time. The total exposure is calculated for a given individual, for a specific chemical agent, and for the corresponding exposure dose for the given period of time.

Exposure assessment is most often based on the actual maximum exposure (AME), which is defined as the maximum exposure present in the designated area. AME is assessed for each identified exposure pathway. In case the population becomes exposed to the same chemical agent through different exposure pathways, the AME has to reflect the actual impact of multiple exposure pathways.
Exposure pathways are determined based on the types and locations of pollution sources, the manner of pollutant emission, physicochemical and chemical transformations of pollutants, as well as the living conditions of the observed subgroups in the exposed population.

Exposure quantification includes determination of the size, frequency, and duration of each identified exposure pathway. Exposure quantification is conducted by assessment of concentrations and calculation of toxic agent uptake.

Assessment of concentrations involves determination of concentrations of the identified chemical agents in an environmental medium, to which an individual of a given subgroup (children, healthy adults, unhealthy adults, senior citizens, etc.) is exposed during a certain period of time. Concentration of chemical agents in a given environmental medium is established by use of standardized measuring methods; if measuring is not possible, the adequate mathematical models for concentration prediction can be used.

Uptake calculation involves calculation of the quantity of chemical agent coming into contact with the exposed person’s body per unit body weight per unit time (expressed as mg/kg/day), according to the defined uptake pathway [1]:

$$\text{Uptake dose} = \mathrm{C}_{\mathrm{i,x}} \left(\frac{IR_y}{BW_y} \right) \left(\frac{ED_i \cdot ET_i \cdot EF_i}{AT_x} \right) [mg/kg/day] \tag{2}$$

where: Ci,x – concentration of pollutant x in environment i [mg/m^3]; IRy – individual respiratory rate at rest per unit time for a representative individual in subgroup y in environment i [m^3/day]; ETi – exposure time of the representative individual in environment i [days/years]; BWy – body weight of the representative individual in the observed subgroup, represented as y [kg]; EDi – exposure duration for the representative individual in environment i [year]; and ATx – average time of effect duration of pollutant x [days].

Inhalation rate, distribution, and resorption of the inhaled air pollutant vary according to the features of individuals in a subgroup. Accordingly, the average uptake of air pollutants is assessed through parameters for a representative individual in a subgroup. Exposure in relation to average uptake of airborne pollutant x and in relation to the representative individual with average anatomical and physiological features in their subgroup, in environment i, is calculated with the following physical equation:

$$E_{\mathrm{i,x,y}} = 0{,}001 \cdot \mathrm{C}_{\mathrm{i,x}} \left(\frac{IR_y}{BW_y} \right) \left(\frac{ED_i \cdot ET_i \cdot EF_i}{AT_x} \right), \tag{3}$$

where: Ei,x,y – exposure, or the average uptake of pollutant x as a function of time, for the representative individual y in the observed subgroup in environment i [mg/kg per day].

For the assessment of potential carcinogenic effects in Eq. 3, Ci,x is the arithmetic mean of annual measured concentrations of pollutants to which an individual in a subgroup is exposed during one or more years.

RISK CHARACTERIZATION FOR POTENTIAL CARCINOGENIC EFFECTS

For the assessment of carcinogenic effects due to long-term exposure to pollutants, the potentially higher risk of carcinogenic diseases can be determined as the product of exposure and carcinogenic coefficient, established for every carcinogenic pollutant. The potentially higher risk of an individual in subgroup y developing cancer due to exposure to pollutant x is:

$$ICR_{i,x,y} = E_{i,x,y} \cdot SF_x \quad , \tag{4}$$

where: $ICRi,x,y$ – probability of individual cancer risk for individual y exposed to pollutant x in environment i, SFx – carcinogenic coefficient of pollutant x [mg/kg/day].

To determine the total risk of carcinogenic disease development for the population represented by individual y, due to exposure to agent n in environment i, the individual risks are summarized as follows:

$$CR_{i,y} = \sum_{x=1}^{n} ICR_{i,x,y} \quad . \tag{5}$$

Use of this equation implies that exposure to different carcinogenic substances produces additional health effects. If the available data on the toxicity of those substances does not indicate any additional effects, the equation may be modified by eliminating smaller risks caused by non-carcinogenic pollutants. For instance, if a pollutant in a pollutant mixture doe not produce carcinogenic effects in the exposed population, the total risk of cancer is equal to the risk caused by the pollutant with the highest $ICRi,x,y$ (individual cancer risk) value.

RISK CHARACTERIZATION FOR NON-CARCINOGENIC EFFECTS

The US EPA recommendation presupposes that non-carcinogenic effects occur only if the exposure threshold of a chemical agent's reference dose (RfD) has been exceeded. For air pollutant exposure, the EPA established a reference concentration (RfC), which represents the exposure concentration threshold below which, even with continuous inhalation, there are no detrimental health effects, including the highly-sensitive population. RfC can be equated with RfD by multiplying the RfC with the individual respiratory rate of individual y (IRy) and dividing it with the individual's body weight (BWy). When assessing the probability of non-carcinogenic diseases, the risk of non-carcinogenic diseases can be assessed as the ratio of exposure and the corresponding RfD for a given pollutant. It is worth noting that the Ei,x,y for the calculation of carcinogenic effects differs from the Ei,x,y for non-carcinogenic effects. The increased probability of health risk in individual y exposed to non-carcinogenic pollutant x in a given subgroup in environment i can be obtained by calculating the health risk hazard quotient (HQ):

$$HQ_{i,x,y} = \frac{E_{i,x,y}}{RfD} , \tag{6}$$

where: $HQ_{i,x,y}$ – health risk hazard quotient for non-carcinogenic substances (dimensionless quantity).

Health risk HQ for non-carcinogenic substances implies the existence of an RfD below which there is low probability of any detrimental health effects on the exposed population, even on the highly-sensitive population (e.g. children). If the exposure level exceeds this limit, i.e. if the E/RfD ratio exceeds 1, there is a possibility of negative non-carcinogenic effects. Table 1 shows the relationship between the HQ and health risk categories.

Table 1: Relationship between HQ values and health risk categories

Health risk hazard quotient (*HQ*)	Health risk category
$1 < HQ \leq 1,6$	Low
$1,7 < HQ \leq 2,3$	Moderate
$2,4 < HQ \leq 4$	High
$4 < HQ$	Very high

The bigger the E/RfD ratio, the bigger is the possibility of detrimental effects. However, during exposure to a mixture containing up to 10 substances, in case of their addition, health risk assessment is performed for each substance based on their HQ value. According to the US **Agency for Toxic Substances and Disease Registry** (ATSDR US) recommendation from 2001, the value 0.1 is used as the acceptable HQ value, i.e. the value for which there is no increased health risk from non-carcinogenic substances interacting in the mixture.

To establish the sum non-carcinogenic effect of exposure to a non-carcinogenic chemical mixture, the health risk HQ values are summed, resulting in the *Hazard Index* (HI):

$$HI = \sum_{x=1}^{n} HQ_{i,x,y} \quad . \tag{7}$$

For pollutants that do not produce additional non-carcinogenic effects, the HI value should be equal to the maximum pollutant HQ value (or the maximum aggregate value of pollutants that produce additional effects). Therefore, negative health effects are to be expected only when exposure dose exceeds the *RfD*. *HI* value does not represent risk probability in the same manner the *ICR* obtained by carcinogenicity analysis does. For instance, *HI* value 2 does not represent risk duplication but only implies an increased level of non-carcinogenic risk.

RISK FROM EXPOSURE TO STANDARD AIR POLLUTANTS ON THE TERRITORY OF NIŠ

Table 2 provides an overview of *HQ* values and *ICR* probability for the territory of Niš from 2001 to 2011. To determine the *HQ* values, we started from the assumption that the population over 18 years of age and under 10 years of age was exposed to an air pollutant for four hours a day. *HQ* and *ICR* values were then determined for annual exposure.

For the territory of Niš, the exposure values required for determining *HQ* and IRC were taken based on the measured air pollutant concentrations monitored within the existing monitoring network and based on the predicted concentrations in areas where no measurements had been performed. Prediction of soot particulate concentration was made by means of the Radial Basis Function (RBF) neural network (Table 3).

Table 2: Health risk hazard quotients (HQ) and probability of individual cancer risk (ICR) from exposure to air pollutants on the territory of Niš from 2001 to 2011

Year	Substance	*HQ* for persons over 18 and health risk	*HQ* for persons under 10 and health risk	*ICR*
2001	Soot			$3.56 \cdot 10^{-6}$- $1.90 \cdot 10^{-5}$
2002	Soot			$3.71 \cdot 10^{-6}$- $1.78 \cdot 10^{-5}$
	CO	1.1-2.38; low risk to moderate risk	3.08-6.26 high risk to very high risk	
2003	SO_2	1.14-1.42; low risk	3.2 – 3.96; high risk	
	Soot			$3.71 \cdot 10^{-6}$- $1.78 \cdot 10^{-5}$
	CO	1.1-2.33; low risk to moderate risk	3.08-6.51 high risk to very high risk	
2004-07*				
2008	SO_2	1.14-2.1; low risk to moderate risk	3.2-5.86; high risk to very high risk	
	Soot			$3.71 \cdot 10^{-6}$- $1.78 \cdot 10^{-5}$
	CO	1.1-2.42; low risk to moderate risk	3.08-6.76; high risk to very high risk	
	NO_2	1.1-1.93; low risk to moderate risk	3.07 – 5.41; high risk to very high risk	
2009	Soot			$3,56 \cdot 10^{-6}$ - $3,17 \cdot 10^{-5}$
	CO	1.1 – 1.63; low risk	2.62 - 4.67; high risk to very high risk	
2010	Soot			$3,56 \cdot 10^{-6}$ - $3,17 \cdot 10^{-5}$
	CO	1.1 – 1.9; low risk to moderate risk	2.62 - 5.44; high risk to very high risk	
2011	Soot			$3,57 \cdot 10^{-6}$-$2,19 \cdot 10^{-5}$
	CO	1.1 – 2.3; low risk to moderate risk	2.62 - 6.61; high risk to very high risk	
	NO_2	1.1 – 2.2; low risk	3.07 – 3.42; high risk	

*In 2004, 2005, 2006, and 2007, concentrations of CO and NO_2 were not measured, and the number of SO_2 and soot measuring points in the monitoring network was insufficient for any relevant conclusions.

Table 3: Maximum predicted annual exposure concentrations of health-risk causing air pollutants in ambient air in the City of Niš from 2001 to 2011

Year	Exposure concentrations of pollutants			
	Soot [μg/m^3]	SO_2 [μg/m^3]	CO [mg/m^3]	NO_2 [μg/m^3]
2001.	80.0	/	/	/
2002.	77.77	/	7.53	/
2003.	77.77	63.61	7.77	/
2008.	77.77	92.78	8.25	112.66
2009.	105.0	/	4.51	
2010.	77.78	/	5.35	
2011.	72.0	/	7.77	69.31

Based on exposure concentrations of air pollutants on the territory of Niš, given in table 3, we can conclude that, for the analyzed period, the pollutant that exceeds the immission limit value (*ILV*) the most is carbon monoxide (CO) (*ILV* = 3 mg/m^3). High CO exposure concentrations caused the highest *HQ* values, which ranged from 1.1 to 2.38 in the exposed over-18 population and from 2.62 to 6.61 in the exposed under-10 population. Likewise, based on the data given in tables 2 and 3, we ascertain that the health risk caused by exposure to non-carcinogenic substances SO_2 and NO_2 for the observed period was discontinuous and that it ranged from low to high level, except for SO_2 in 2008, when the health risk level for the under-10 population was very high.

CONCLUSION

Pollutants in ambient air indirectly affect the health risk level in the exposed population. This indirect dependency is realized through detrimental health effects, which are directly dependent on exposure and which originate from the interaction of pollutants and molecules – receptors – in the human body.

Health risk level in the exposed population is quantified (presented as a health risk assessment) by means of equations in order to grade risk or to determine the probability of cancer.

In order to quantify the magnitude of health risk, the magnitude of exposure needs to be quantified first. The magnitude of exposure is a function of concentration, i.e. dose per unit time of inhalation (uptake time).

For the entire analyzed period (2001-2011) on the territory of Niš, we observed high CO exposure concentrations and estimated the health risk level as ranging from low to very high. The health risk due to exposure concentrations of other analyzed pollutants is less prominent on the territory of Niš. The causality between ambient air quality and health risk on the territory of Niš needs to be studied separately through CO exposure in the air.

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IMPACT OF THERMAL POWER PLANTS "NIKOLA TESLA" ON SULPHUR DIOXIDE AIR POLLUTION IN BELGRADE

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ABSTRACT

In order to evaluate impacts of two major Serbian coal thermal power plants "Nikola Tesla A" (TENT A) and "Nikola Tesla B" (TENT B) on concentration of sulphur dioxide (SO_2) in Belgrade, the AERMOD modeling package is used. The main sources of SO_2 emissions in the city of Belgrade are traffic, heating power plants and individual fireboxes. TENT A and TENT B are the one of the largest coal thermal power plants in Serbia and in the Southeast Europe, and since the work without flue gas desulfurization (FGD) system, their influence on air quality in Belgrade is considerable. Two scenarios are analyzed in this study: Scenario 1(present situation without FGD) and Scenario 2 (future situation after installation of FGD). Results are presented on annual means [$\mu g\ m^{-3}$] plots. Estimated annual means concentrations of SO_2 in 2010, shows that contributions of examined power plants, depending on the part of the city, are 7.73 to 13.24[$\mu g\ m^{-3}$] for Scenario 1, and 1.36 to 2.34[$\mu g\ m^{-3}$] for Scenario 2. Considering that annual mean concentration of SO_2 in 2010 for city of Belgrade is 23[$\mu g\ m^{-3}$], it can be concluded that examined power plants have great influence on SO_2 concentration in Belgrade, and that installation of FGD will significantly contribute to better air quality in the city of Belgrade.

Key words: *thermal power plant, SO_2, AERMOD, modeling, FGD.*

INTRODUCTION

The air quality in the Republic of Serbia is mainly determined by the emissions of SO_2, NOx, CO, particulate matter and other pollutants which originate from thermal power plants (use of lignite and poor precipitation) and industrial plants. Air quality is especially aggravated during the weather conditions without wind and during the heating season.

Electricity in the Republic of Serbia is generated within the PE Electric Power Industry of Serbia.

Belgrade (population 1.6 million) is situated at the crossing of the communication paths between eastern and western Europe, on the Balkan Peninsula. It has grown around the banks of rives, the Sava and the Danube, at their confluence, and has average elevation of 116.75 m, with characteristics of hilly city. The Belgrade metropolitan area combines two different natural settings: the Pannonian Plain to the north and the hilly Šumadija to the south.

The climate is moderate continental, with four seasons; the average annual temperature is 11.9 C, January is the coldest month (average 0.4 C) and July the hottest (average 21.7 C); an annual average of 139 days with precipitation (annual average 667.9 mm). [3]

The SO_2 concentration in the city of Belgrade show very regular variability, with high concentration in winter (October-March), the cold season, and a gradual decrease to minimum values in summer. The analyses shown in [3] indicate that the maximum concentration of SO_2 in winter months is concentrated around the area with several poorly filtered large heating systems near the center of the city. In summer, the maximum is shifted more to the Industrial area near the Danube riverbank. The data show that the SO_2 values exceed the limit value only during the winter season, almost exclusively in the central city zones.

Since total estimated emissions of SO_2 from the plants of the PE Electric Power Industry of Serbia are 360,440 t/year, out of 81,707 t/year from TENT A and 50,110 t/year from TENT B [1], in this paper, we focus on influence of two coal fired power plants in the vicinity of Belgrade (Thermal Power Plant “Nikola Tesla A” and Thermal Power Plant “Nikola Tesla B”) on SO_2 concentration in this city. Since they use lignite as a fuel, those two power plants present major sources of SO_2 emission in this part of Serbia, as well. We evaluate present situation (Scenario 1) when plants operate without a system for flue gas desulfurization (FGD) and future situation (Scenario 2), according plans of PE Electric Power Industry of Serbia, when all existing units work with installed FGD, plus new additional unit B3 (744 MW) in Thermal Power Plant “Nikola Tesla B”.

SOURCE CHARACTERISTICS AND EMISSIONS

Scenario 1

Installed output of the thermal power plants (net output) is 5171 MW or 61.9% of total installed capacities of PE Electric Power Industry of Serbia. [1] The Thermal Power Plant “Nikola Tesla A” (TENT A) is the biggest in Serbia and in the Balkans, with six units totaling 1,690 MW of power. It is located in Obrenovac, a town of 70,000 inhabitans on the banks of Sava, about 30 km from Belgrade, and surrounded by Kolubara and Tamnava rivers. It is the biggest producer of electricity in the electric energy system of Serbia, with an average production of more than eight bilion kWh a year delivered to the consumers through a 400/220 KW transformer station. The Thermal Power Plant “Nikola Tesla B” (TENT B) is located on the right bank of the Sava River, 50 kilometers west from Belgrade and 17 kilometers upstream from TENT A complex. It has two largest power units in Serbia, with power of 620 megawatts each. [2] Units and stacks parameters of those power plants are shown in Table 1.

Table 1: Units and stacks parameters of TENT A and TENT B (Scenario 1) [4]

Plant	Unit	Capacity (MW)	Stack height (m)	Stack inner diameter (m)	Exit temp (□C)	Exit velocity (m/s)	SO_2 emission rate* (g/s)
TENT A	A1-A3	725	150	10.4	175	24.20	6328
	A4	308.5	220	6.3	175	33.24	3148
	A5	308.5	220	6.3	175	33.24	3148
	A6	348.37	220	6.3	175	33.24	3148
TENT B	B1	620	280	8	180	37.00	1870
	B2	620	280	8	180	37.00	1870

* Emissions rates are measured by authorized organization.

Scenario 2

In order to bring sulphur oxide emission in compliance with the requirements of the local and EU regulations PE Electric Power Industry of Serbia has prepared projects for installation of flue gas desulphurization plants in TENT A (excepting units A1 and A2) and TENTB. The technological-technical design for flue gas desulphurization, considered in the design, is based on the newest achievements in the area of wet FGD systems, which imply the use of limestone as a sorbent and generation of gypsum as a by-product. In accordance with the stipulations of the EU Directive 2001/80/EC, the FGD plants have been designed so as to fulfill the requirements related to the emission limit values for sulphur dioxide, being 400 mg/Nm3, which requires a process efficiency of 94%. [1]

Wet FGD (WFGD) technology, using limestone as a reagent, a wet scrubbing process, is the FGD technology most frequently selected for sulphur dioxide reduction from coal-fired utility boilers. The

Wet FGD process is considered a commercially mature technology and is offered by a number of suppliers.

The absorbers are situated after the TPP's electrostatic precipitators (EPS). The raw flue gas, coming from the boiler and ESP's, passes through the induce draft fans and booster fans before entering the absorbers for scrubbing. The scrubbed saturated gas is discharged to atmosphere through a new wet stacks. The WFGD System removes SO_2 by scrubbing the flue gas with limestone slurry. Flue gas is treated in an absorber by passing the flue gas stream through a limestone slurry spray. In absorber design, the gas flows upward through the absorber countercurrent to the spray liquor (limestone slurry) flowing downward through the absorber.

In a wet limestone scrubbing system, a complex series of kinetic and equilibrium controlled reactions occur in the gas, liquid and solid phases. These reactions may be expressed in this overall equation:

$$CaCO_3 + SO_2 + 2H_2O + \tfrac{1}{2}O_2 \rightarrow CaSO_4 \cdot 2H_2O + CO_2 \qquad (1)$$

Characteristics of the flue gas after desulphurisation process are significantly changed compared to the state before treatment at this system. In addition to the required reduction of sulphur oxide content, the flue gas is saturated with moisture, contains a certain amount of droplets (depending on the efficiency of mist eliminators), has a much lower temperature, and the reduced amount of fly ash particles and slightly higher concentration of carbon dioxide. [4]

Besides FGD systems, in order to as closely as possible evaluate a future impact of those power plants, in this study we consider emissions from future unit of TENT B (unit B3) as well.
Units and stacks parameters for Scenario 2 are shown in Table 2.

Table 2: Unit and stack parameters of TENT A and TENT B (Scenario 2) [4]

Plant	Unit	Capacity (MW)	Stack height (m)	Stack inner diameter (m)	Exit temp (°C)	Exit velocity (m/s)	SO_2 emission rate* (g/s)
TENT A	A1-A2	420	150	10.4	68	12.00	1816
	A3-A4	613.5	140	12.4	68	14.45	175
	A5-A6	656.87	140	12.4	68	14.45	175
TENT B	B1	620	230	10.5	68	17.42	157
	B2	620	230	10.5	68	17.42	157
	B3	744	210	9.5	68	18.05	144

* Emissions rates are measured by authorized organization.

DOMAIN AND MODELING APPROACH

The AERMOD modeling system was used to model the air quality impact of power plant emission. AERMOD is a steady-state plume model which calculates atmospheric dispersion based on the planetary boundary layer turbulence structure and on some scaling concepts, and can account for both surface and elevated sources. Moreover, it can be used in either simple (flat) or complex terrain scenarios. In the stable boundary layer, the dispersion is assumed to be Gaussian in both the vertical and the horizontal directions. In the convective boundary layer, the horizontal distribution is assumed to be Gaussian whereas the vertical distribution is described by a bi-Gaussian probability density function. AERMOD uses surface and profile meteorological data obtained from a single meteorological station. Alternatively, the extended version of its meteorological preprocessor, AERMET VIEW, can estimate the wind profile from the surface data. AERMOD incorporates a new approach to account for airflow and dispersion in complex terrain. Namely, where appropriate, the plume is modeled as either impacting on or following smoothly the terrain. This approach is physically realistic and simple to implement, and avoids the need to distinguish among simple, intermediate and complex terrain, as currently required in regulatory guidelines. Hence, the new version of AERMOD saves the need of defining complex terrain regimes, since the terrain in the study area is handled in a consistent and continuous manner. AERMOD’s terrain preprocessor, AERMAP, uses gridded elevation data to calculate a representative terrain-influence height, also referred to as the terrain height scale. The terrain height scale, which is uniquely defined for each receptor location, is used to calculate the dividing streamline height. The gridded data needed by AERMAP is obtained from a Digital Elevation Model (DEM), and the elevation of each specified receptor is automatically assigned through AERMAP. Specifically, for each receptor, AERMAP passes the following information to AERMOD: the receptor’s location, its height above the sea level, and the receptor specific terrain height scale. [5]

Procedure of modeling included the following procedures: 1. Preparation of facilities plan, including sources and facilities; 2. Defining the domain of model and the locations of the receptors; 3. Developing inventories of all observed sources; 4. Characterization of the types of sources; 5. Processing of required meteorological data; 7. The processing of the terrain data; 8. Modeling and analysis of results. Based on the input parameters of sources, emissions and meteorological data, modeling is obtained by the spatial distribution of ground level concentrations of selected pollutants.

Modeling for the present study included model domain of 50 km x 50 km, with TENT A in its center, Fig. 2, or an area of 2500 km^2. Cartesian coordinate system with the distance of 400m between adjacent points (receptors) is used, which means that the models processed 15876 points (receptors). To obtain necessary terrain data, we have used SRTM3 - Shuttle Radar Topography Mission data (resolution: ~ 90m, 3 arc-sec).

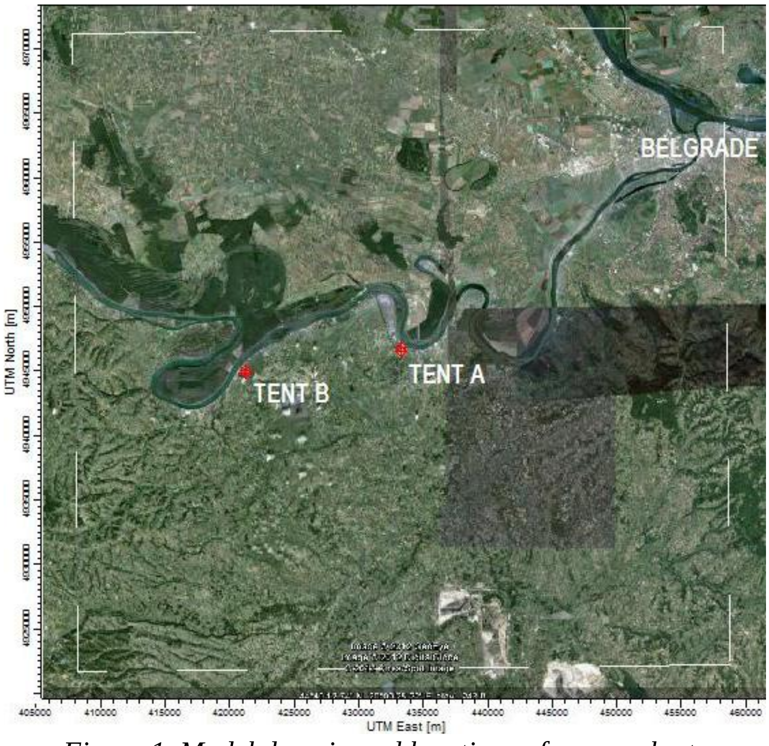


Figure 1. Model domain and locations of power plants

AERMET, a meteorological preprocessor, prepares hourly surface data and upper air data for use in AERMOD. The surface data are hourly observations of surface level parameters such as wind speed, temperature, and cloud cover that are used by AERMET to generate a surface file for use in AERMOD. The upper air data file provides information on the vertical structure of the atmosphere. This includes the height, pressure, dry bulb temperature, and relative humidity. Meteorological data that we used for the preparation of model include hourly values of: wind speed, wind direction, ambient temperature, relative humidity, atmospheric pressure, cloud cover-opaque. Since upper air data was not available, AERMET Upper Air Estimator is used. Meteorological data for the year 2010 were obtained from the Serbian Environmental Protection Agency (SEPA). The closest meteorological station to the power plants are *Obrenovac-Deponija pepela*. Fig. 2 demonstrates wind rose and frequency analysis, based on meteorological data from *Obrenovac - Deponija pepela* for 2010.

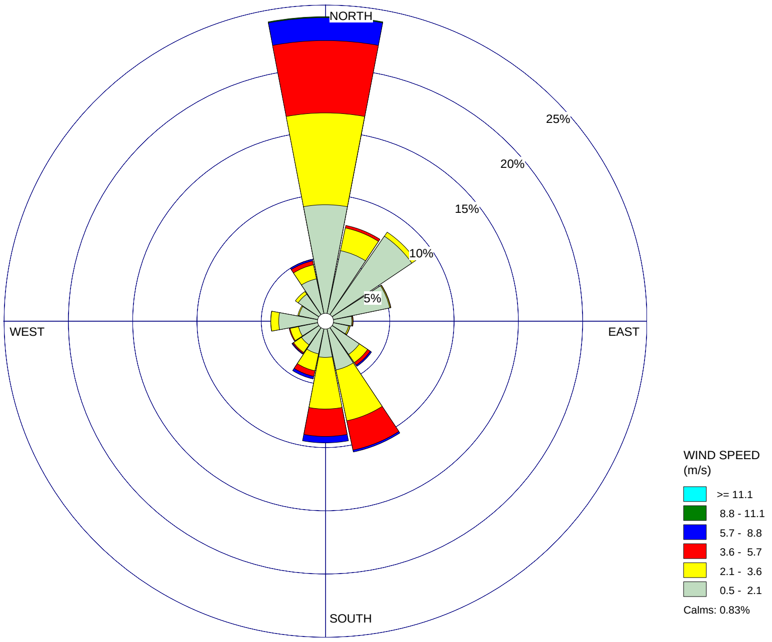
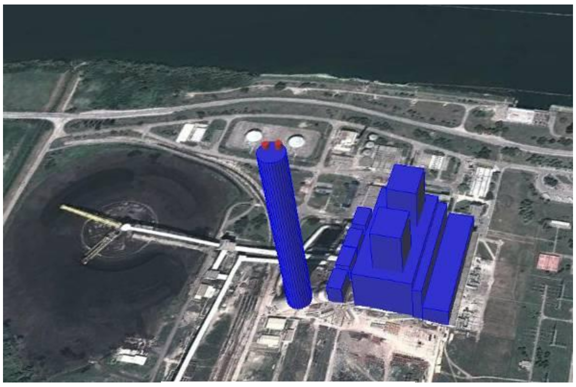
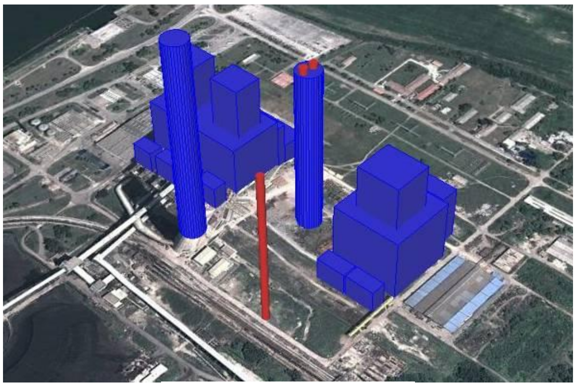
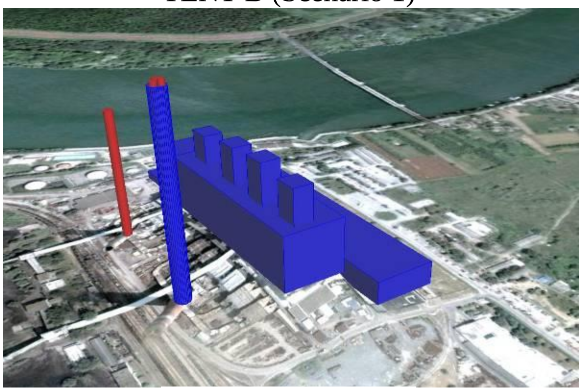


Figure 2. Wind rose and frequency analysis, based on meteorological data from Obrenovac - Deponija pepela for 2010

As buildings could radically influence the dispersion of pollutants there is need for building downwash analysis. Fig. 3. shows 3D models of TENT A and TENT B with all sources (red stacks) for Scenario 1 and Scenario 2.


TENT B (Scenario 1)


TENT B (Scenario 2)


TENT A (Scenario 1)

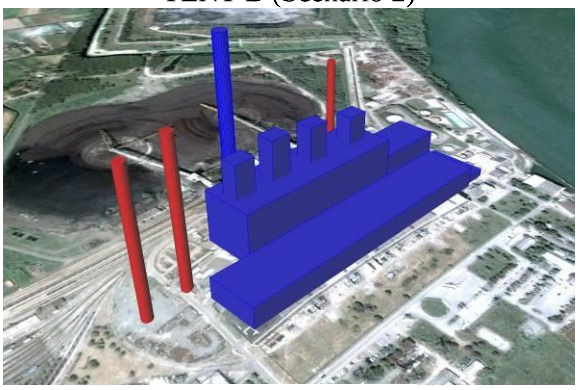

TENT A (Scenario 2)

Figure 3. 3D models of TENT A and TENT B with all sources (red stacks)

RESULTS AND DISCUSSION

Considering that these models are not taken into account background pollution, presented average annual plots do not represent air quality (SO_2 concentration) in the models domain area, but only the contribution of the power plants to overall air quality in Belgrade. It is very important to note that these models represent the worst case scenarios, consider that all pollutant sources emit maximum emission rate 24 hours a day, 365 days a year, which is certainly not the case.

Since the annual mean concentration of SO_2 in 2010 for Belgrade is 23 μg m^{-3} [6], results for Scenario 1 (Fig. 4.) show that TENT A and TENT B have high influence on SO_2 concentration in the city. Depending on the part of the city, that contribution goes from 13.24 to 7.73 μg m^{-3}. West parts of Belgrade are more exposed to the SO_2 emissions from power plants sources, and there, according presented plots could be observed the highest concentrations of SO_2. Clear decreasing trend of SO_2 concentrations could be observed from western to eastern parts of the city.

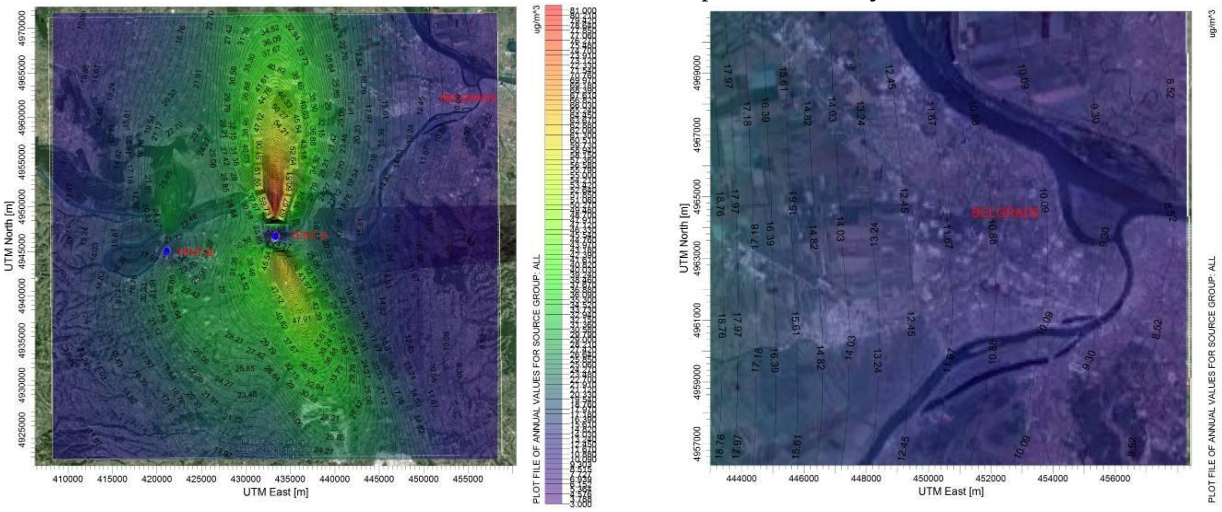


Figure 4. Annual mean concentration of SO_2 in 2010 (Scenario 1)

According the data presented in Table 1. and Table 2., overall emissions for Scenario 2 presented only 13.5% of total emissions from Scenario 1, although Scenario 2 includes additional unit B3. That high difference in emissions and difference in source characteristics is reflected on spatial distribution. Annual mean concentration of SO_2 in 2010 for Scenario 2 is presented on Fig.5. Decreasing SO_2 emission from TENT A and TENT B, as a result of installed FGD technology, brings almost 6 times less contribution of SO_2 pollution in Belgrade. The similar way of distribution and decreasing trend of SO_2 could be observed for Scenario 2 as well as for Scenario 1. In this case, again depending on the part of the city, contribution goes from 1.36 to 2.34 μg m^{-3}. Decreasing trend follows west - east direction.

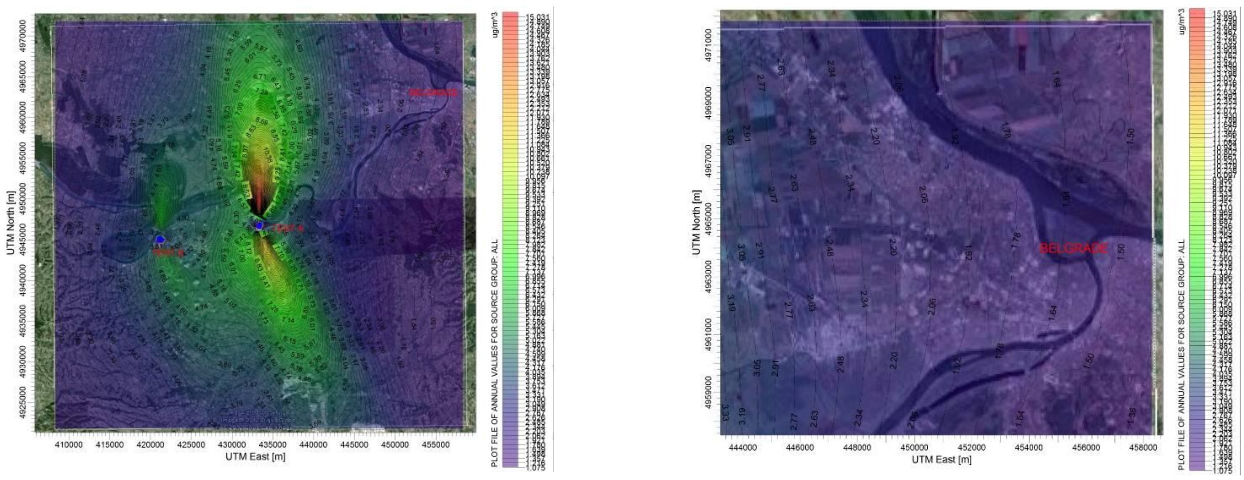


Figure 4. Annual mean concentration of SO_2 in 2010 (Scenario 2)

CONCLUSION

This study shows the evaluated impact of two major Serbian coal thermal power plants “Nikola Tesla A” (TENT A) and “Nikola Tesla B” (TENT B) on concentration of sulphur dioxide (SO_2) in Belgrade. AERMOD modeling package is used to estimate the contribution of this influence. Through two scenarios, this study presented presence influence, and most possible future influence which take into account installation of FGD system and new unit B3 (744 MW). Estimated annual means concentrations of SO_2 in 2010, shows that contributions of examined power plants, depending on the part of the city, are from 7.73 to 13.24 µg m^{-3} for Scenario 1, and from 1.36 to 2.34 µg m^{-3} for Scenario 2. Considering that annual mean concentration of SO_2 in 2010 for city of Belgrade is 23 µg m^{-3}, it can be concluded that examined power plants have great influence on SO_2 concentration in Belgrade, for present situation. Installation of FGD technology will not only bring compliance with the requirements of the local and EU regulations, but it will significantly contribute to better air quality in the city of Belgrade.

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MANAGEMENT OF SOLID URBAN WASTE

III International Conference
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WASTE MANAGEMENT IN THE EU AND SLOVAKIA

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ABSTRACT

Within the context of expansive technological development, the wealth of European society is growing steadily. This has resulted in the production of more and more waste. Every year people in the European Union throw away about 3 billion tons of waste. Therefore, the EU must pay due attention to this problem. This contribution was created within the Leonardo da Vinci international project Wastre for which the Faculty of Mechanical Engineering is a coordinator. The aim of the contribution is to present the current situation of waste legislation systems and waste management in the EU and the Slovak Republic. Waste recovery in the Slovak Republic is also discussed with examples of best practice in waste recovery given.

Key words: *waste, EU waste legislation, Slovak waste legislation, waste management, waste recovery*.

INTRODUCTION

Europe is using more and more materials, and except for the short-term fluctuations due to economic recessions, this trend has continued for several decades. In general, the greater the use of resources, the higher the amount of emissions and the more waste is generated. Therefore, producers have to solve the problems connected with treating, disposing or recycling wastes from production process, either from waste generated during the production process or waste generated after the end of the product's useful life span.

In the response to the need for education in the field of waste management and waste legislation, the project "*Wastre: On-line Learning Modules for Waste Treatment, Waste Disposal and Waste Recycling*" was created. The consortium of the project consists of 8 partners from 5 countries: Multimedia SunShine as innovation donator, 3 leading Central-European technical universities (TU Vienna, CVUT Prague, STU Bratislava), and 3 organizations active in vocational training (Technical and vocational secondary school Tlmace, CHEWCON Humenne, Union of Chambers of Craftsmen and Tradesmen of ESKISEHIR) and the Recycling fund as a body organizing waste treatment and recycling in Slovakia). (O'Callaghan et al., 2011).

WASTE LEGISLATION

Eu Waste Legislation

EU legislation has equal force with national law, and forms an integral part of each Member State's legal system. Every action taken by the EU is founded on treaties which have been approved by all EU member counties.

Actual EU legislation is disseminated under 32 thematic areas corresponding to the activities of the EU. The themes, which also include environment, reflect comprehensive coverage of EU legislation. One of the most important aspects of environmental issues is waste management.

EU waste legislation has a long history. Since the adoption of the first Directive on Waste, 75/442/EEC in 1975, EU waste legislation has undergone significant expansion. At present, there is an extensive body of legislation including the revised Waste Framework Directive, and a lot of other rules. The timeline of the EU waste legislation development is illustrated in *Figure 9*.

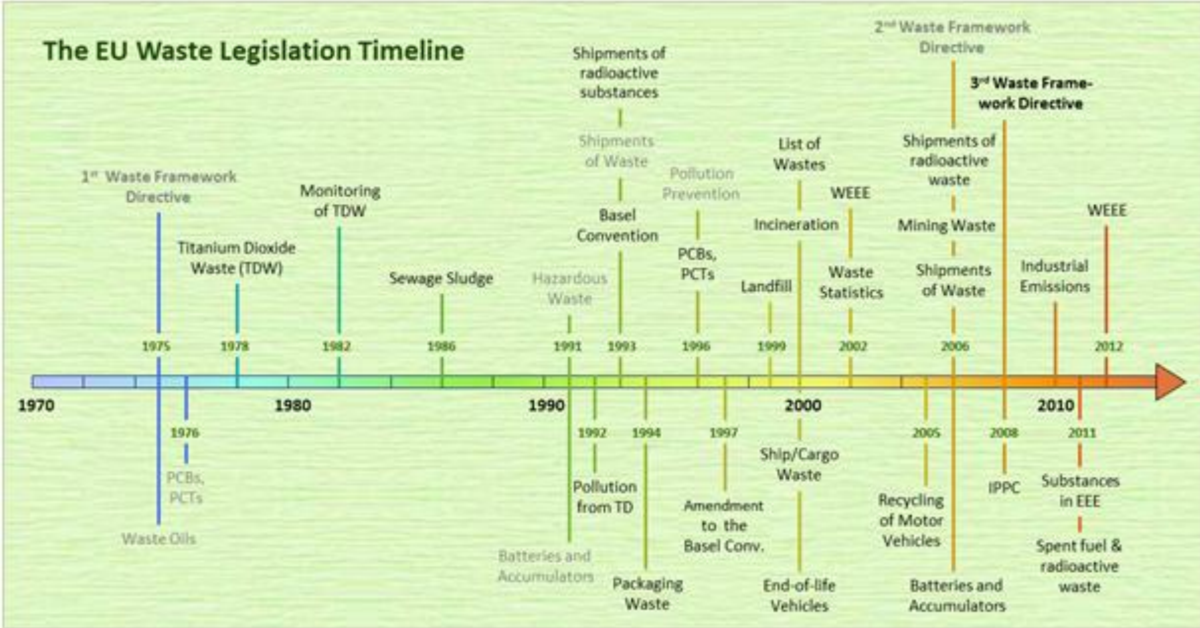

Figure 9. The EU waste legislation timeline (black label – the law is valid, grey label – the law was replaced by one of the laws in black)

Current EU waste legislation is built as a three-stage system of legal acts (Figure 10). The top level represents *framework legislation* that sets out basic principles, fundamental definitions and overall strategic aims. The second level regulates *waste treatment operations* concerning waste incineration and landfilling. The final level contains a number of other directives regulating specific *waste streams*.

Figure 10. Three-stage system of EU waste legislation

The EU’s Sixth Environment Action Programme (2002-2012) identified waste prevention and management as one of four top priorities. Its primary objective is to ensure that economic growth does not lead to more and more waste. This led to the development of a long-term strategy on waste. The 2005 Thematic Strategy on Waste Prevention and Recycling resulted in the revision of the Waste Framework Directive, the cornerstone of EU waste policy. The revision brings a modernised approach to waste management, marking a shift away from thinking about waste as an unwanted burden to seeing it as a valued resource. The Directive introduces a five-step waste hierarchy where prevention is the best option. EU waste legislation aims to move waste management up the waste hierarchy (Figure 11). (European Union, 2010)

The Waste Framework Directive, as well as some waste stream specific directives of the European Union, includes specific targets on recovery, recycling and re-use. An overview of the targets, the objectives and the respective years when the targets have to be achieved is provided in *Figure 11*. (European Comission, 2012).

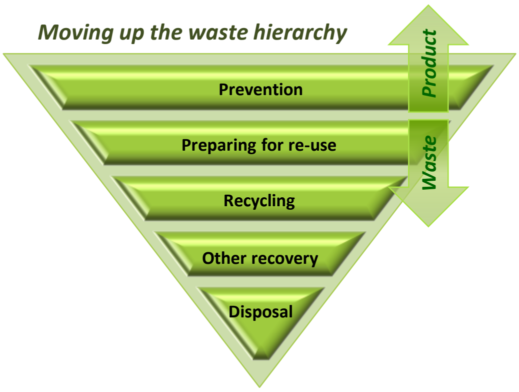

Figure 11. Waste management hierarchy

Table 2: Targets in EU waste legislation (European Comission, 2012)

category	*year*	*min. recovery*	*min. recycling*	*collection rate*
Packaging	2008	60 %	55 %	
Cars	2015	95 %	85 %	100 %
Electronics	2006	70 %	50 %	min 4 kg per inhabitant per year
Batteries	2011		50 % to 70 % (efficiency)	
	2012			25 %
	2016			45 %
Tyres	2006	0 landfill of tyres		
Biowaste diverted from landfills	2006	reduction to 75 % of the 1995 level		
	2009	reduction to 50 % of the 1995 level		
	2016	reduction to 35 % of the 1995 level		
Municipal waste	2015	separate collection: at least paper/metal/plastic/glass		
	2020	50 % recycling of municipal waste		
Construction & demolition waste	2020	70 % recycling/material recovery (including reuse)		

Waste Legislation in the SR

National legislation related to waste comes under the responsibility of several departments, of which the Ministry of Environment of the Slovak Republic (ME SR) is the most important department. The hierarchy of departments responsible for environmental law is illustrated in Figure 12. The Slovak Environmental Inspectorate is the Ministry's specialist organization for looking after the environment and the countryside in accordance with the principles of sustainable development. The Agency also provides expert advice.

Figure 12. System of waste management in the SR

The Slovak Republic is obliged to implement EU waste legislation and achieve the targets required by EU law. Effective achievement of these targets requires several supporting tools. One amongst many problems posed in waste management is the correct waste collection and sorting. For more clear and effective waste flow monitoring in collecting systems, a new integrated information system can be helpful. A proposed structure for an *Integrated information system of waste management in the SR* (displayed in Figure 13) would include a publicly accessible list of waste treatment equipment.

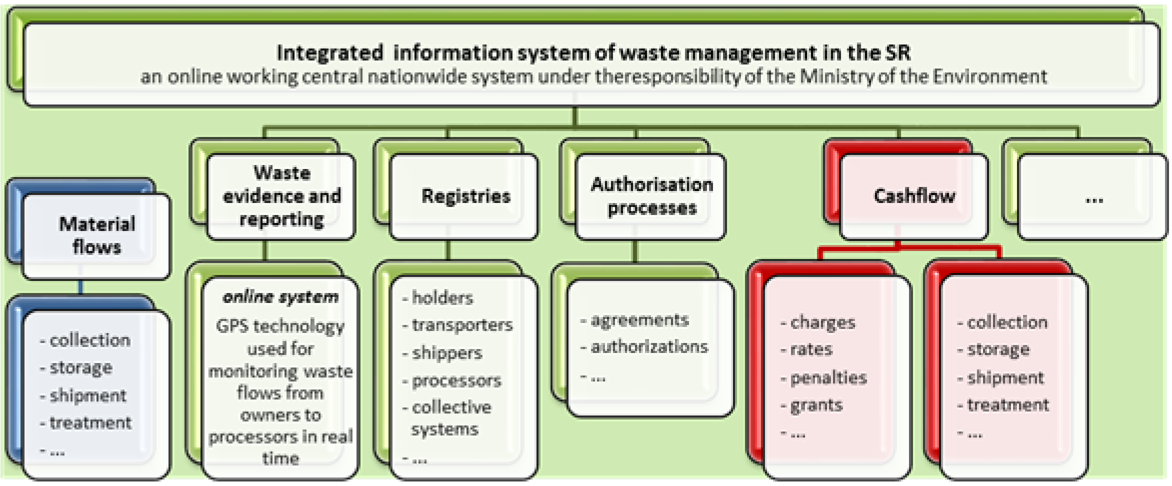

Figure 13. Integrated information system of waste management in the SR

WASTE MANAGEMENT

Waste Management in the EU

The use of materials is intimately connected with economic growth. Average annual use of materials in the EU amounts to under 15 tons per person (Figure 14). While the bulk of this ends up as materials accumulated in the economy – so-called additions to stock, such as buildings, infrastructure, accumulated goods – a significant amount is converted into emissions or waste. On average, over 5 tons of waste per person are generated each year in the EU (Eurostat data centre on waste, 2010).

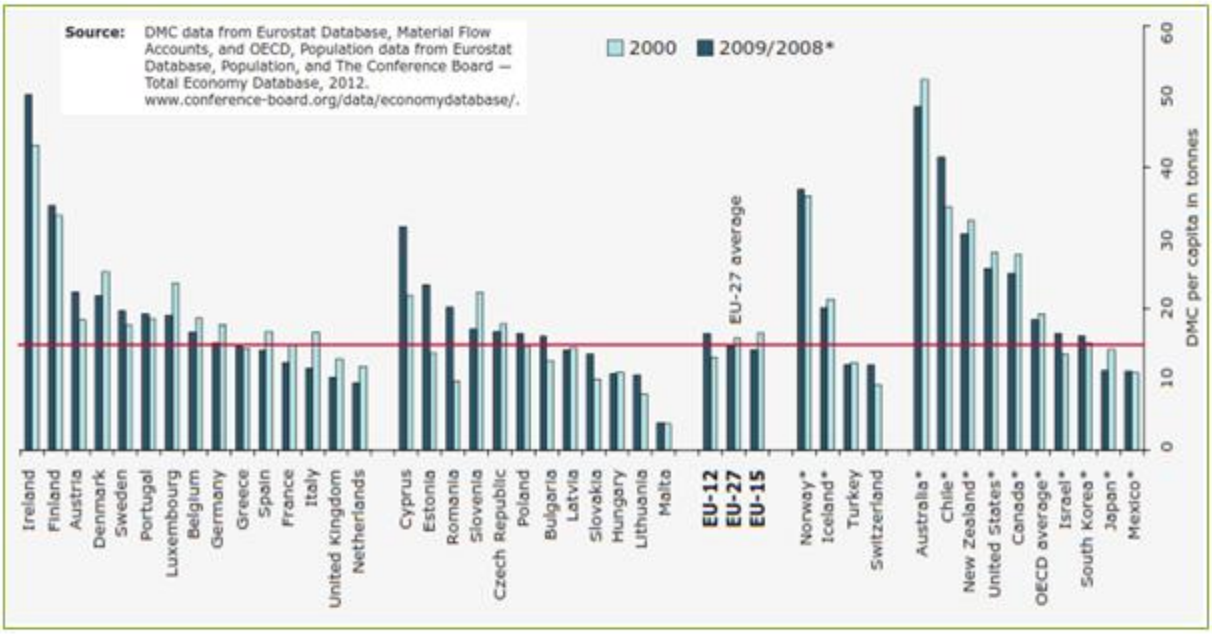

Figure 14. Use of resources per person by country, 2000 and 2009

Consumption of resources is also imbalanced. The average European citizen consumes about four times as many resources as one in Africa, and three times as many as one in Asia. The EU-27 use on average fewer resources per capita than many industrialized countries – about half that of Australia, Canada or USA, but there are large differences between individual countries within the EU (Figure 14). (EEA, 2012)

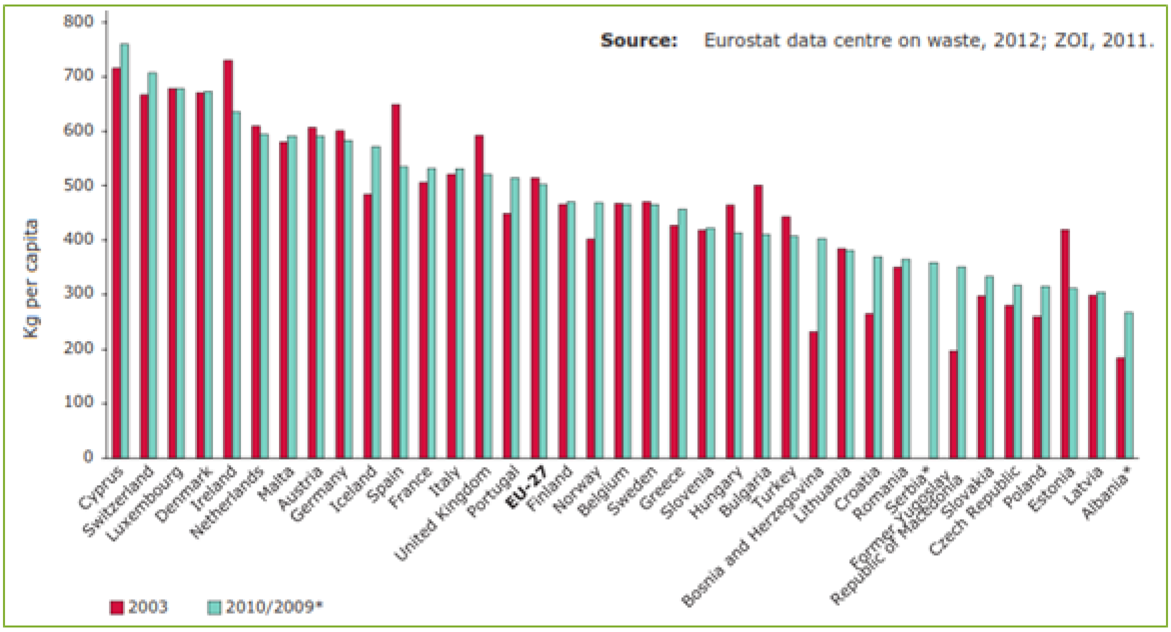

Figure 15. Trend in generation of municipal waste in the EU, EFTA countries, Turkey and Western Balkan countries, 2003 and 2010

The EU-27 Member States plus Croatia, Norway and Turkey in total generated some 2.6 billion tons of waste in 2008, or roughly 5.4 tons per person, of which around 3.7 % is hazardous (Eurostat data centre on waste, 2011; data reported according to the Waste Statistics Regulation). In general, 32 % of the waste generated in the EEA countries is from construction and demolition activities, 27 % from mining and quarrying, and the rest from manufacturing, households and other activities. Almost two thirds of the total is mineral waste, mainly from mining, quarrying, construction and demolition.
The annual generation of municipal waste, mainly from households but including similar wastes from sources such as commerce, offices and public institutions in the EU-27 has reached 502 kg per person in 2010 (Figure 15).

Waste Management in the Slovak Republic

Balance of waste generation: When compared with 2009, the growth in waste introduced to the market has reached approx. 21 %. Furthermore, when compared with the 10.9 million tons of waste produced in 2005, its generation fell by 1.7 %.

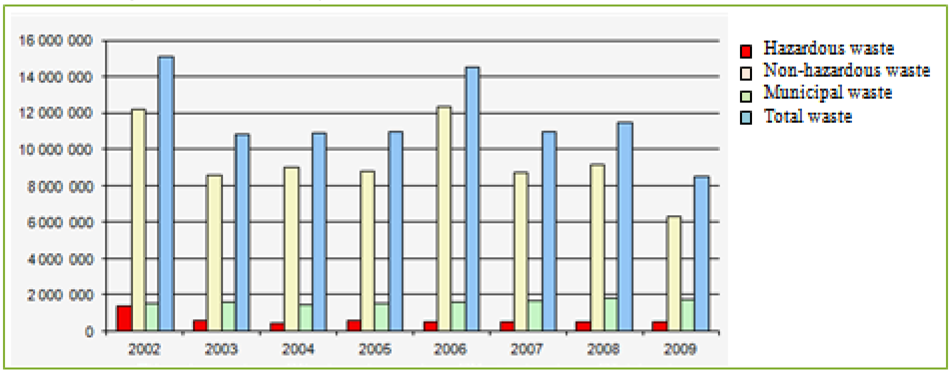

Figure 16. The amounts of waste generated in Slovakia (in tons)

In 2010, waste originators submitted to waste handling authorities slightly lower volumes of hazardous and municipal waste for recovery and disposal than in 2009. However, other waste showed a major growth in its position in the market, which, compared to 2009, represents an increase in the category of other waste of approx. 26 %. (ME SR, 2010)

Compared to 2009, the annual growth of waste in the market is about 21 %. There was a reduction in hazardous waste generation by 1.5 % compared to the previous year**Error! Reference source not found.**. (State of the Environment Report – SR 2010)

In 2011, the industry as a whole produced 5,445,970 tons of waste, of which 297,210 tons was hazardous waste and 5,148,761 tons were other wastes. However, the percentage of waste generated by industry by total volume of waste generated increased from 41.5 % in 2000 to 60.1 % in 2011. (Klinda et al., 2011)

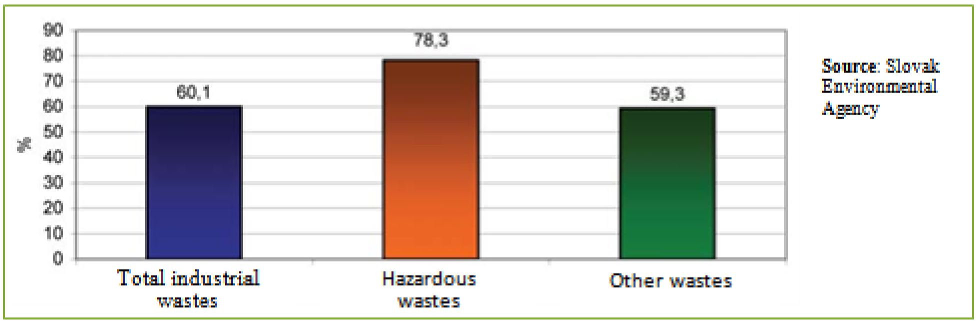

Figure 17. The share of waste categories in total waste generation in 2011 (in percentages) (Klinda et al., 2011)

WASTE RECOVERY IN THE SLOVAK REPUBLIC

When the prevention of waste production is not very effective, then waste recovery is given priority in waste management. Because of better control of waste recovery, wastes can be divided into 3 main categories – *separated wastes*, *technical wastes* and *general wastes* as illustrated in Figure 18.

In Slovakia in 2011, 4,731,712.37 tons of waste (excluding municipal waste) was recovered, which represents around 52 % of total waste (excluding municipal waste). (Klinda et al., 2011)

Figure 18. Three main groups of wastes

Examples of *best practice* in waste recovery carried out by the Institute of Manufacturing Systems, Environmental Technology and Quality Management of the Mechanical Engineering Faculty of the Slovak Technical University in Bratislava (hereinafter *Institute*):

1. Waste plastics recovery

A project for recycling polyethylene bottles for motor oils was developed. It dealt with the design of manufacturing plastic bottles in different combinations of primary granulate and re-granulate (obtained from recycled bottles and packaging material). The project embraces the philosophy of bottle collection, primary and secondary processing, economics, and the strength and pressure tests of the bottles manufactured under different conditions.

2. Waste paper recovery

The Institute has undertaken a project of briquetting of banknotes from the National Bank of Slovakia (*Figure 19*). Banknotes were shredded and compacted into briquettes for subsequent use as a fuel source.

Figure 19. Compacted banknotes from Czechoslovakia

3. Construction waste

The Institute has solved the problem of construction waste recovery for the Czech company SETRA, Ltd. The project was aimed at developing the construction of a plant for dealing with wooden construction waste. A piece of mobile equipment which is placed on a truck trailer was designed. The system comprises a crushing system, a metal separator, a crushed material separator (by size) and a source of energy. The result is a mobile waste handling system in which wood waste wanders round and round until it achieves the required size (sawdust, dust and split,) and is cleaned of metallic particles. The separated sawdust is then used for briquetting.

CONCLUSION

Problems related with waste management are and will always be actual. It is necessary to monitor the situation continually, and proposes and adopt measures to ensure a sustainable development This contribution provides a short overview of the EU and Slovak waste legislation. Also some statistics of waste management are presented to show the current situation in this field. In this way the authors of the Wastre project also want to highlight the results of their project.

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COST ANALYSISOF FACILITY FOR TREATMENT INFECTIOUS MEDICAL WASTEIN THE BIJELJINA REGION

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ABSTRACT

Generated amount of infectious medical waste in health care institutions in the region Bijeljina is necessary to be reduced to anon-hazardous waste using the appropriate device for the destruction in the function of reducing the risks to human health and environmental quality.In this study was evaluated data on business costs and results of the test-survey on the amount and category of medical waste generated in health care facilities in the region Bijeljina and in the towns of Bijeljina, Ugljevik, Lopare, Brcko and Zvornik in order to define the frame work of financial requirements. The construction of facility for treatment of infectious medical waste in the General Hospital Bijeljina can under certain conditions, to achieve positive economic and financial results, keep national material resources, create the basis for new skills and jobs, and improve business and aesthetic conditions of life.

Keywords: *Medical waste, treatment of infectious medical waste, treatment facility, and financial analysis.*

INTRODUCTION

Medical waste is generated as a consequence of human activities in health care institutions, research institutions and laboratories. The World Health Organization (WHO) has classified medical waste in clinical and non-clinical, and further partition toinert (non-hazardous) and hazardous waste. The total amount of medical waste generated in health care institutions of Bosnia and Herzegovina/Republic of Srpska (hospitals, health centers, dental clinics, departments of public health, clinics and institutes etc.) is about 32,500tonnes per annum and has a tendency to increase.

The analysis includes the investment in the construction of plant for the treatment of infectious medical waste in order to improve the level of local and regional social development and improve the protection of the environment. Data on the quantity, composition and origin of medical waste was collected through the test survey, which was carried out on the territory of the Bijeljina region.

Construction of the plant for treatment of infectious medical waste has no socio-economic impact, if was first implemented sorting and classification of medical waste, and then transported from the neighbouring towns in General Hospital Bijeljina, as well as the central place of the treatment.

The refore, it is necessary comprehensiveness of the project on entire territory of Bijeljina region with the total amount of medical waste generated.

RESEARCH METHODOLOGY

The research is based on the collection of data through surveys in the territory of Bijeljina region, where is concentrated around 450,000 population and 42 health care institutions (taken into account the greater generating sources), which are arranged on the primary and secondary health care level.

Category, volume and quantity of medical waste generated varies depending on the type of health care facilities. The following types of hazardous waste is identified: pathological and infectious waste, sharps, pharmaceutical products, pressure vessels, chemical waste and inert(general) waste. Table 1.summarizes the average total amount of medical waste per month, which is generated by a variety of medical facilities in the territory of Bijeljina region.

Table 1: Overview the average amount of medical waste generated gathered by surveying on the territory of the Bijeljina region

Type of health facility	Estimated total amount of medical waste (t/ month)
Health centers	56,9
Dialysis centers	71,4
Polyclinics	132,1
Hospitals	155,1
Ambulance	24,5
Total	440,0

According to the World Health Organization (WHO), we can assume that the total amount of medical waste generated by 440 tons per month, reduce it to80% inert (non-hazardous) waste and 20% of hazardous waste (pathological and infectious waste 15%, chemical and pharmaceutical waste 3%, blades 1% and special hazardous waste 1%), which in our study amounted to 352 tons of non-hazardous and 88 tons of hazardous waste per month.Figure 1.

Infectious medical waste US EPA considers the following medical waste:
• equipment for seeding and cultivation of microorganisms,
• blood, blood derivatives and blood products,
• needles, syringes, pipettes, test tubes and Laboratory Glass,
• wastes from surgery and autopsy room,
• human tissue, organs, excreta and secretions that contain pathogenic micro-organisms,
• waste generated in hemodialysis and blood transfusions
• waste from the production of vaccines and sera,
• tissues and organs of laboratory animals used for experiments with pathogenic microorganisms[9].

The average structure of medical waste in a health care facility is given in Figure 1.

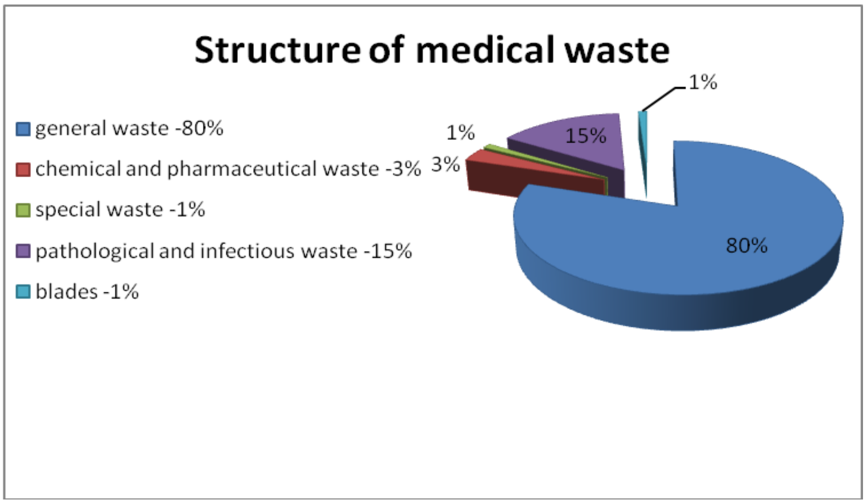

Figure 1. The structure of medical waste based on WHO

From a technical point of view survey is related to the total amount of medical waste generated in health care facilities based on the analysis.

Plant for treatment of infectious medical waste sterilized/disinfected process, using a combination of saturated vapour and microwave radiation for low-temperature waste treatment. The project should be conducted at the General Hospital Bijeljina, and for the entire region of Bijeljina.

Relevant technical information on the system are:

- The plant should cover an urban area with around 450,000 inhabitants on which there are 42 health facilities. Capacity of the treatment plant is 80 tons of infectious medical waste. The plant will occupy existing buildings in the General Hospital Bijeljina.
- Production facilities will be implemented as a public-private partnership (PPP) with a life span of 20 years during which the private partner should apply the model DBFOOT, ie. design-build-financing – Own -operate-transfer, which means that the private sector designs, develops, builds, finances the project, manage the provision of services and benefits the public good, which is his property for 20 years. Upon the expiration of the agreed period, the owner ship of the goods are transferred to the public partner-General Hospital Bijeljina.
- Landfills are currently in use can not be used for disposal of infectious medical waste, and the opportunities for expansion are very limited. Therefore, the alternative "do nothing" and expansion of existing landfill complex excluded.
- After a detailed contextual analysis and options, as the only feasible solution is identified, the treatment plant of infectious medical waste sterilization and disinfection procedures, and has the following operating data:
  - -The combination of saturated steam and microwaves, which guarantees the safe treatment of all types of infectious waste.
  - -Disinfection -temperature of 121° C,1 bar over pressure.
  - -Sterilization -temperature of 134° C,2 bar over pressure.
  - - Appropriate capacity volume of waste.
  - -The absence of hazardous chemicals.
  - -The optimal cycle time of destruction-20 minutes disinfection, 40 minutes sterilization.
  - - The average electricity consumption of 1.5 kW, approximately 10liters of water per cycle.
  - -Features automatic printing of reports on the status of destruction.
  - -Manipulation of the waste is minimal and no special transport or disposal of hazardous infectious waste.
  - -Waste treatment after the volume has been reduced by 75%, unrecognizable and it is impossible to abuse.
  - -Easy operation and absolute safety for personnel and the environment, after a day training.
  - -Provided prompt service and the ability to replace the device.
  - -It is applied in the EU and our inner environment.

COST ANALYSIS

Commercial expenses resulting in health care facilities in the treatment of infectious medical waste destruction device, can be divided in to investment (capital) and regular (current) costs.

Investment(capital) costs include all annual expenses on the means by which the life of longer than one year, such as facilities, equipment, specialized vehicles for transportation, cart with wheels, buckets and containers for transfer of medical waste and the like and are covered by the private partner ships. In the table 2is given a rough estimate of capital costs by the unit price, quantity and duration., which relate to the treatment of infectious medical waste in autoclave device. Differences in the estimation of capital costs are possible in the case of the flexible use of staff and the use of bags and boxes of blades to appropriate procedures when they occur lower costs. Increase in costs is possible in case the activity of the waste handling organizations in dependent of other service providers.

A rough estimate of operating costs is based on data on current prices and additional market research.

Table 2: Assessment of investment(capital) cost per year

Item	Cost per unit (US$)	Quantity (piece)	Life time (year)	Cost (US$)
Container-metal 5 m3	100,00	30	2	3.000,00
Protective equipment	75,00	8	1	600,00
Cartson wheels	50,00	20	2	1.000,00
Autoclave “Sintion”	72.000,00	1	15	72.000,00
Crusher “Shreder Tion 5.5”	30.000,00	1	15	30.000,00
Transport Box-50 l	20,00	300	2	6.000,00
Yellow container for transport -240 l	60,00	100	4	6.000,00
Training of employees	140,00	10 sessions	2	1.400,00
Proper waste collection vehicle	15.000,00	2	7	30.000,00
Total investment costs				150.000,00

Regular (ongoing) costs related to supplies (bags and boxes), as well as the cost of water, energy and employee benefits, which is carried out due process of treatment of infectious medical waste. A rough estimate of current costs for collection, transportation and treatment of medical waste per month are shown in Table 3.based on the average number of cycles per day, estimates of the quantities of waste per cycle in the autoclave, and the number of workers.

Table 3: Estimation of the total cost of regular service on a monthly basis

Item	Cost per unit (US$)	Quantity	Cost (US$)
Boxes for sharp items 3l	2,00	200 pieces	400,00
Boxes for sharp items 1l	1,00	200 pieces	200,00
Yellow plastic bags 250x400x0,04	0,20	1.000 pieces	200,00
Special bags-thermostable	0,91	1.000 pieces	910,00
Black plastic bags 500x900x0,04	0,40	5.000 pieces	2.000,00
Cost of electricity consumption (on average)	0,17	15.000 kW	2.550,00
Cost of water consumption (on average)	1,70	200 m^3	340,00
Transport costs	1,40	1.000 liters	1.400,00
Salary of manager (gross)	1.500,00	1 person	1.500,00
Salary of operator (gross)	800,00	2 persons	1.600,00
Salary of support employees (gross)	500,00	4 persons	2.000,00
Salary of driver (gross)	750,00	2 persons	1.500,00
Cleaners and disinfectants	200,00	1	200,00
Total regular cost			14.800,00

Estimation of the total cost of regular treatment of infectious medical waste per year is U.S.$177,600,00.

The total sum of investment (capital) cost of U.S.$150,000,00 and regular (on going) maintenance costs in the amount of U.S.$177.600,00 we get the total operating expenses in the amount of U.S.$327.600,00 plants for the treatment of infectious medical waste.

Estimates are based on data on the prices applicable at the time of assessment and additional market research.

DISCUSSION

The organized destruction are implemented over the infectious medical waste (type of hazardous medical wastes), as here, involves treatment device for sterilization/disinfection and crushing and a good basis for the
development and up grading of thermal treatment, thus:

- Hazardous medical waste turned into non-hazardous, which is deposited as house hold waste.
- Aligns with EU practice and regulations in the field of hazardous waste management.
- Reduce the total volume of medical waste and the potential for abuse.
- Prevent contamination of certain elements of the ecosystem.
- Achieve a higher level of safety for personnel.

Absolutely is necessary implementation process of separation and identification of medical waste generated at the site (for hazardous and non-hazardous waste) in the appropriate container at the appropriate color-coded (bags, bins and containers) according to the recommendations of the World Health Organization, as an important element in the treatment of waste, due to following positive economic effects and reduction of environmental pollution:

- Reduce the amount of non-hazardous medical waste going to landfill.
- Reduced level of load on natural resources and reduce environmental pollution in accordance with
  EU Directives relating to waste management.
- Create basic requirements for job creation, which allows reducing poverty and increasing living standards.

Separation of the total amount of medical waste generated at the site is environmentally friendly solution would be used as a pre treatment, followed by a hazardous medical waste can be transported, treated appropriately and remaining harmless crush disposed of in landfill complex. Certainly, this proposal represents an interim solution, which fits well into the future final solution - the construction of incineration.

Investment funds in the present, to the revenues and benefits over the years in the future, thereby reducing the high level of uncertainty and have the expected socio-economic performance of these investments.

CONCLUSION

On the basis of this study it can be concluded that there is a possibility of increase in medical waste generated in the region is Bijeljina, due to the lack of recycling activities.

It is essential that the management of health care institutions make decision approaches to education of staff in order to increase the degree of separation and selection of medical waste at the source. Proportion of potentially hazardous medical waste, which represents 20% of the total amount of medical waste, can be further reduced by 1-5% with the application of due process of separation at source.

From the point of view of investment, funds are justified if the total social benefit and the benefit of higher investment.

Since the general hospital is one of the biggest sources of medical waste generated in the region Bijeljina, it is necessary to employed staff made a serious effort to reduce the bulk and increase the degree of separation and segregation of medical waste.

Based on the data presented in this work in this field in accordance with the capabilities and the needs of sustainable development of the municipality of Bijeljina, this work opens up new directions in research of medical waste management in the Republic of Srpska, based on the principles of sustainable development and the demands of European integration.

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ASSESSMENT OF THE EFFECTIVENESS OF TANNERY BASED SOLID WASTES MANAGEMENT IN ATIENO TANNERIES LIMITED NJIRU DISTRICT IN NAIROBI COUNTY, KENYA

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ABSTRACT

Solid wastes generated in Nairobi and its environs are posing a serious environmental challenge to the authorities and residents, especially the hazardous and non-biodegradable solid wastes from leather industries. Concerns and complaints from workers and residents living adjacent to "Atieno tanneries limited" are due to environmental related diseases, degradation of civil structures, natural environment and bad smell sensed within a 1km radius; pointing to the effect of tannery pollution of the environment. This study assessed the effectiveness of tannery based solid wastes management along the tanning stages, within and outside the tannery. The study established how the solid wastes with pollutants impacted on the environment indicating contamination of the ecosystems. The management in Atieno was recognized as ineffective.

Key words: *tanning pollutants, dump sites, tanning processes, environment, crude dumping.*

INTRODUCTION

In search of a covering material for himself, his hut and food, early man turned either to large leaves from plants or to the skins of the animals he killed. The skins were chosen for clothing as they were bigger, stronger and warmer. They putrefy if left in a damp condition. To stop all these, early man discovered tanning technology which converts hides and skins into leather which do not putrefy even after drying and wetting back. (Sharphouse, 1971). The environment is under increasing pressure from solid and liquid wastes emanating from the leather industry (Bosnic et al., 2000). The solid wastes generated during leather processing are significant since leather industry makes uses of only (20-25) % of the raw material in the finished leather, (75-80)% end up as wastes in the environment (Page, 2005). Since these wastes contain hazardous chemicals, they pose a risk to the environment because leather and leather products are non-biodegradable and contain toxic chemicals which become mobile after synergies in the environment thereby posing pollution threat to several ecosystems where they are discarded (Winter, 1979).

Environmental issues of leather industry in Africa are water pollution due to dumping of waste in rivers, lakes, and air pollution from hydrogen sulfide, ammonia gas and bad odors from tanneries, land pollution and poor management of solid wastes (TDLIA, 2002). In Kenya there are 13 commercial tanneries operating currently at 70 % capacity (MoLD, 2010). Their daily production is 40 million tonnes. In 2009, hides and skins were tanned into leather locally, which were: wet blue (46,151,080 square feet), crust leather (754, 071 square feet), finished leather (nil) (MoLD, 2010). Atieno Tanneries limited produces 4 tons of hides and 4.5 tons of skins daily. It was averaged that Atieno tanneries limited produces 10 tons of solid wastes per day which were disposed into the environment (Atieno 2013). These solid wastes would pose a real challenge to the environment unless sustainable management of containing them was put in place.

The present study was to assess the effectiveness of tannery based solid wastes management in Atieno tanneries limited in Njiru Nairobi County by establishing their management along the tanning stages and impact on the environment within and outside Atieno tanneries limited.

MATERIALS AND METHODS

This research used cross sectional survey for key informants. The key informants gave information on various management methods used in their sections and other relevant information. They were systematically interviewed with a schedule beginning with beam house, tan yard, crust and finishing yard supervisors respectively, effluent and dump site attendant and lastly the overall manager within the tannery.

DATA ANALYSIS

A table was used to analyse data from the interview schedule by grouping the information's into different sub headings of the tanning stages like operation units, types of wastes generated, approximation of total quantity, and identification of the management/disposal methods specifically used. This was corroborated with photographs taken during study.

RESULTS

General assessment of how Atieno tanneries limited manages the solid wastes at each tanning stage.

Atieno tanneries limited established around 1940 manufactures leather for local and international markets within Njiru area in Nairobi County. The tannery uses 150 000 litres of water, 3 000 kg of chemicals in beam house and tan yards, 25 kg of chemicals for retannage, dyeing and fatliquoring, 22 Kg for pigmentation and 10 Kg for lacquering per day; to tan between (300-350) pcs (4 tons) of hides and 3 000 pcs (4.5 tons) of skins daily in the drums. Paddles could hold 1500 goatskins, 1200 sheepskins and 70-80 hides. The assessment further found out that the tannery had three tanning stages; beam house, tan yard, crust and finishing yard. The tanning stages had 27 operation units to produce finished leather, which vary from time to time depending on the type and level of leather to be produced. The operation units that generated solid wastes of various quantities, degree and nature were found to be 26. Setting/vacuum/toggling drying in crust and finishing yard was the only unit that did not generate solid waste. Tannery based solid wastes generated were found to be in three main forms: - gross solid, semi/suspended solid (settleable & semi-colloidal), dust and condensed fumes/vapour wastes with their associates.

A total of 10 240.5 kg of solid wastes was estimated to be produced from the tannery; 2 080.5 kg averaged were gross while semi/ suspended solids were averaged at 8 160 kg. Their associates were averaged at 62.5 kg, per day.

SPECIFIC MANAGEMENTS OF TANNERY BASED SOLID WASTES FROM BEAM HOUSE STAGE INSIDE THE TANNERY AND THEIR IMPACT ON THE ENVIRONMENT

Table 1 shows the operation units, how solid wastes were generated, total quantity and management. Acronyms used in table are: R.U - Re used, C.D - Crude dumping, C.D.D.B - Crude dumping dried and burnt, C.D.D.T.D - Crude dumping, drained/dried, and transported to Dandora dump site. S.F.R.U - sold for re-use. P.T(S).F.B.D. T.D.D - primary treatment (sedimentation), filter bed dried, transported to Dandora dump site.

Table 3: Leather production operation units within the beam house (solid wastes generated, approximate quantities per day and their management methods)

Beam house operation units	Tannery based solid wastes generated	Approximate quantity generated per day (kg)	Management/disposal methods
Purchasing/selection	Coarse salt	30	R.U/ C.D.
	dung/dirt/soil	0.5	C.D.
	keratin waste	<	C.D.D.B.
	double reject skins	5 pcs	C.D.D.B.
Green trimming	trimmings	300	C.D.D.B.
Soaking	soaking sludge/soil/sand	2000	P.T(S).F.B.D. T.D.D
	spilt chemicals	<1	C.D.D.B
	Keratin wastes	20	
Lime sludge	lime sludge,(H_2S)↑	2000	P.T(S).F.B.D. T.D.D
Fleshing	lime trimmings, lime fleshings, lime loss, (H_2S)↑	1000	C.D.D.B/ C.D.D.T.D
Deliming	Drum fleshing,($NH_{3)}$ ↑	4	C.D.D.B/ C.D.D.T.D
	spilt chemicals	<1	C.D.D.B.
Degreasing/Bating	Fats/suspended proteins	1	C.D.D.B/ C.D.D.T.D
Other associated wastes	plastic sacks, light polythene bags/paper bags	12	C.D.D.B/ C.D.D.T.D
	broken wood	10	R.U/ C.D.D.B.
	corroded metal	1	R.U/S.F.R.U
	plastic jerry cans	5	R.U/ C.D.D.B.
	worn out boots	2 pairs	C.D.
	tying ropes	<1	C.D.D.B
	plastic bottles	2 bottles	C.D.D.B
Effluent and Solid Wastes Pre-Treatment Sites operations	Total Gross/suspended Solid wastes dumped.	5387.5 kg	R.U/S.F.R.U / C.D.D.B/ P.T(S).F.B.D. T.D.D

The solid and semi/suspended-solid wastes generated from this stage were managed, treated and disposed by physical methods majorly. Gross solid wastes were swept, picked and loaded into used plastic sacks and kept in the purchasing area (see Figure 1**)** they were later given back to hides and skins traders for re-use in their curing premises for the preservation of green hides and skins.

Figure 20. Used salt on floor and those packed in Plastic sacks (photographed by Oruko)

Contaminated salts were put in used sacks and dumped together with green trimmings, keratin, fats, lime fleshings, lime loss, dung, dirt, and sandy soil at the open dump site. During dry seasons the above wastes were packed on open handcart and dump at site to dry and later burnt as seen here below. The burnt ash was left at the site. During rainy seasons they were packed and dumped as shown below together with empty used sacks, papers, erry cans as in Figure 2**.**

Figure 21. From left, workers pushing cart Dumping of lime fleshings, drying and burning, fleshings stack in sacks and loading process at site for further dumping at Dandora (photographed by Oruko)

The above crude dumping method of wastes may be attributed to be the first source of sodium chloride, sulphide and total phenols pollution of the environment within the tannery. Wet gross solid wastes packed released a lot of leachates as in the 2nd part of Figure 3 which either percolated downward into the deep soil or seeped into water aquifers underground. Lateral movement over the surface entered open water bodies like river Nairobi, or flowed to nearby farms.

Figure 22. From left, waste collecting vehicle, leachate from stacked wastes, borehole water tank, the site where drainage enters Nairobi river (photographed by Oruko)

The above crude dumping may be attributed to be another source of sulphide, sodium chloride and total phenol pollution of the environments in and outside Atieno. Semi solids in the pond were not treated chemically. The over flow in the last pond were released to the Nairobi city sewerage system. The residence time observed in the ponds was one day. No samples were taken for laboratory analysis. Using litmus paper it was observed that the released effluent pH range was 4.0-5.0, below the recommended limit of Nairobi city water and Sewerage Company (NCWSC) implying that the discharge did not have enough time to settle as required. The settled sludge in pond one and two were not pumped into filter beds for de-watering processes during the study period, instead healthy maize, eucalyptus, tomatoes, beans, Amaranthus species and other unidentified herbs were observed growing on the dried sludge's as in the 1st part of figure 4, together with empty plastic bags, cups, papers and other wastes dumped inside them. One of them was also broken and required repair.

Figure 4: From left, healthy maize growing on dried sludge in the filter beds together with waste sacks, papers, polythene (Photographed by Oruko,)

In the first lime pond, next to the agitator was found a connection of an exhausting pipe as in Figure 5. The position of emptying the exhausting pipe was never made clear by the two key informants. The effluent attendant informed the researcher that the agitator worked for one hour in the morning and one hour in the evening when the work load reduced. Technically, it is supposed to run continuously to aerate the sludge and reduce anaerobic conditions development in the ponds that results in the formation of hydrogen sulphide gas.

Figure 5. From left, screening bar, oxidation ponds with agitator and exhausting pipe (photographed by Oruko)

SPECIFIC MANAGEMENTS OF TANNERY BASED SOLID WASTES FROM TAN YARD STAGE INSIDE THE TANNERY AND THEIR ENVIRONMENTAL IMPACT

Table 2 shows the operation units, how solid wastes were generated, total quantity and management in tan yard. Acronyms used in table are: R.U – Re-used, C.D - Crude dumping, C.D.D.B/T.D.D - Crude dumping dried and burnt/transported to Dandora dump, C.D.D.T.D - Crude dumping, drained/dried, and transported to Dandora dump site. S.F.R.U- sold for re-use. P.T (P).F.B.D. T.D.D-primary treatment (Precipitation), filter bed dried .Transported to Dandora dump site.

Table 4: Leather production operation units within the tan yard (solid wastes generated, approximate quantities per day and their management methods)

Tan yard operation units	Tannery based solid wastes generated	Approximate quantity generated per day (kg)	Management/disposal methods
Pickling	pickling sludge	2000	P.T.(P). F.D.B.
	Drum fleshing	5	C.D.D.B/T.D.D.
Tanning(chrome)	tanning sludge	2000	P.T.(P).F.D.B.
	Drum fleshings	20	C.D.D.B/T.D.D
	wet blue trimmings	20	C.D.D.B/T.D.D
Tanning(vegetable)	Unused veg tannins	100	
Basification	Ageing sludge (Piling up)	50	P.T.(P).F.D.B.
Selection/packaging	Nil	350 pcs – hides 3000 pcs – skins	Export only
Sammying + setting for local market	Sammying for hides setting for hides	12	
Setting for local market	Setting “skins”	25	C.D.D.B/T.D.D
Splitting	wet blue splits	300	C.D.D.B/T.D.D
Shaving	wet blue shavings	300	C.D.D.B/T.D.D
Other wastes	Plastic sacks polythene bags	12	C.D.D.B/T.D.D
	Broken wood	5	C.D.D.B.
	corroded machine fallings	2	C.D.
	corroded walls fallings	2	C.D.
	plastic jerry cans	5	S.F.R.U/C.D.D.B
	waste papers	7.5	C.D.D.B
Effluent and Solid Wastes Pre-Treatment Sites operations	Total Gross/suspended solid wastes dumped	4865.5 kg	P.T.(P).F.D.B. C.D.D.B/T.D.D, C.D. S.F.R.U,

The assessment found out that wastes from this stage were managed, treated and disposed of by both physical and chemical means. Gross Solid wastes like wet blue trimmings, shavings, wet drum fleshings, wet blue splitting's, corroded metals, roofs and walls fallings and their associates were packed in bags and dumped around the store and open dump site as in Figure 6.

Figure 6. From left, Gross solid wastes from tan yard packed in sacks and dumped inside the tannery (photographed by Oruko)

The above crude dumping of wastes may be attributed to be the first source of chrome, sodium chloride and total phenols pollution of the environment within the tannery. Semi solid from pickling, tanning and crust retannage operation units were directed to drainage channels fitted with rough screening bar to remove large suspended solids like drum fleshings, other proteins and floating solids. Some bars had been eroded and were allowing some suspended solids to pass. The sludge then drained into the first chrome sludge receiving pond. Some gross solid wastes (wet blue trimmings, shavings,) from this stage were kept inside the used sacks up to a maximum of 14 days at dump site; when they were later collected by the contracted waste collector for further dumping at Dandora. During wet seasons these dumped wastes released leachates as in the 3rd part of Figure 7 which percolated and seeped into the soil around the dump site and some drained or were washed by run-off into the Nairobi river. They scorched the grass, caused chlorosis (see figure 7) and, corrosion effect on the wall of store near dump site. Most of the Wet blue or vegetable splitting's and trimmings solid wastes were wrapped up with a rope and dumped around the stores along with shavings. They remained there throughout the study period.

Figure 7. From left, Dumped wet blue/vegetable tanned leather, chrome shavings, draining leachate and scorching effect due to dumping as observed at dump site in Atieno (photographed by Oruko)

These may be explained as extended sources of chrome, total phenol, sulphide and sodium chloride pollution of the environment. Semi solid chrome sludge was neutralized and precipitated with 100 kg of lime per 6000 or 5000 l of slurry released from drum or paddle into the first pond. The presumed purified liquid was allowed to flow into the Nairobi city sewerage system. Hydraulic retention time for sludge aeration was less than an hour while the mean cell-residence time was one day only, below the conventional 24 hours and 20 days for retention time and sludge age respectively according to (Buljan *et al*. 2011). There was no equalization pond. The drying beds had dried chrome oxides (cakes) which were over grown with unidentified herbs, young species of Eucalyptus trees and Amarantha as in the 4th&5th parts of Figure 8. The cakes had been there for the last 8 years according to one of the key informant.

Figure 8 From left; chrome sludge ETP systems, dried chrome sludge with higher plants growing in Atieno. (Photographed by Oruko)

SPECIFIC MANAGEMENTS OF TANNERY BASED SOLID WASTES FROM CRUST AND FINISHING STAGE INSIDE THE TANNERY AND THEIR IMPACT ON ENVIRONMENT

Table 3 shows the operation units, how solid wastes were generated, total quantity and management in crust and finishing yard.

Acronyms used in table are: R.U - Re used, C.D.D.B - Crude dumping dried and burn. C.D.D.T.D - Crude dumping, drained/dried, and transported to Dandora dump site. S.F.R.U - sold for re-use. P.T (F).F.B.D. T.D.D - primary treatment (Precipitation), filter bed dried. Transported to Dandora dump site. K.I.T – kept in tannery.

Table 5: Leather production operation units within the crust and finishing yard (solid wastes generated, approximate quantities per day and their management methods)

Crust and finishing operation units	Tannery based solid wastes generated	Approximate quantity generated per day (kg)	Management/disposal methods
Setting/washing	Retan sludge	10	P.T.(P).F.B.D.
Conditioning/washing	Retan sludge		
Chrome retan/syntans	syntan sludge		
Drum dyeing/fat liquoring/fixation	unused dye fatliqour sludge	0.5	P.T.(P).F.B.D.
Setting/vacuum/toggling drying	gaseous vapour↑	nil	Nil
Staking	staking dust	0.5	C.D.D.B.
Trimmings	crust trimmings	100	C.D.D.B/T.D.D
Buffing	buffing dust	10	C.D.D.B/T.D.D
	used sand paper	1.5	C.D.D.B.
De-dust	buffing dust	10	C.D.D.B.
1st pigmentation	condensed pigments fumes	0.5	C.D.D.B.
Plating	plating dust	0.1gm	C.D.D.B.
2^{nd} pigmentation	condensed pigments fumes	0.5	C.D.D.B.
Lacquering	Condensed fumes of lacquer	0.05	C.D.D.B.
	lindal leather	1.5	C.D./K.I.T.
CRUST AND FINISHED LEATHER	NIL	30 Pcs	SOLD IN LOCAL MARKET
Other wastes	Used plastic jerry cans polythene bags	1	C.D.D.B.
Effluent and Solid Wastes Pre-Treatment Site operations	Total Gross suspended condensed solid wastes	133.5 kg	P.T.(P).F.B.D. C.D.D.B. C.D./K.I.T. C.D.D.B/T.D.D.

The assessment established that dusts swept from staking, buffing and de-dusting machines spillage inside the tannery were collected manually by used plastic sacks while mechanical collection was done by cyclone pipe. They were dumped at the composite site and left to mix with other wastes as those from the pipe were directed to holding chamber. Buffing dusts from the holding chamber were later removed and put into used plastic sacks as seen in Figure 9. They were either dumped on site or transported to Dandora. During study period it was observed that some dust spilt on the ground near the chamber. This happened during the transfer process, when the dust was being removed from the holding chamber as in the 3rd part of Figure 9.

Figure 9. From left is dumped buffing dust in sacks, the holding the chamber and spillage near the chamber on the ground (Photographed by Oruko)

The above may be suggested as the extended sources of total phenols, chrome and sodium chloride pollution of the environment in and outside Atieno. The inefficiency reported and observed here may be attributed to lack of strict supervision during transfer process. Semi/suspended solids from this section were small and were handled in the tan yard because the drum for this operation was located there. Gaseous fumes were released through the wall furnace and wide open wire mesh door. There were no roof chimneys to release the gases upwards. This was a concern among the workers.

COLLECTION AND TRANSPORTATION OF TANNERY BASED SOLID WASTES FROM ATIENO TO DANDORA DUMP SITE AND IMPACT ON THE ENVIRONMENT

Solid wastes from Atieno tanneries limited were loaded manually by casual workers into the vehicle and transported to Dandora dump site by a licence waste collector called Julia G. Mrutere and sons Investment Company. The site is not a sanitary landfill, therefore dumping of hazardous waste like chrome wastes is illegal according to the Deputy Director of Environment Nairobi City Council. Toxic and hazardous wastes were supposed to be treated and disposed at Athi River plant, but the key informants interviewed were not aware. It was observed that the loaders and the vehicle spilt/dropped some wastes to the ground/along the road which remained scattered around the dump site/on spot as in figure 10. The lime fleshings developed anaerobic condition while stack in the used plastic sacks. When this was exposed during loading process, it increased the poor stench emanating from the tannery to the environment both inside and outside.

Figure 10. Chrome droppings along the road from Atieno tanneries limited and the loading site after inside the tannery (photographed by Oruko)

DISCUSSION

Efficient tanning process requires removal of wastes. Tannery processes generated more sludge than gross solids in beam house and tan yard with less in crust and finishing yards. Wastes from beam house remain a real challenge to the tanner in developing country where recycling of tannery wastes has not gained support. Kolomaznik, (2008) and (Amit *et al.*, 2006) agree that the production of sludge is increasing day by day as a result of waste water treatment. Lack of quantification, documentation and record keeping information on solid wastes production by the tannery was established as a challenge and neglected area by the tanner. Azeez (1997) states ‘estimates are not available for the solid wastes generated like salt, hair, fleshing, trimmings of untanned leather, buffing, shavings. Tanning process for export Leathers, ended at the basification stage as “wet blues” in the tan yard. Local market products were the ones that went beyond the basification stage and ended up as crust/ finished leathers. Mainuddin (2003) states “because of the acknowledged hazards of leather production, the processes are being discontinued in most European countries and the U.S.A and operations are moving overseas”. The operations which generates bulky and hazardous wastes were handled in developing country like Kenya, while the light operations which generated low quantity of wastes were completed in developed countries.

Since leather containing chrome salt is non-biodegradable in the environment wet blue splits, trimmings, shavings and dried chrome cake may need appropriate technology to dispose them, as chrome sludge disposal was found to be a challenge. Solid wastes from crust and finishing stage produced less sludge but generated volatile organic compounds and light solid wastes (dust) together with condensed fumes and vapors. They could easily be disposed by combustion in a well-controlled incinerator chamber and their ash dumped in a controlled sanitary landfill. Atieno had a kiln which was ineffective in burning solid wastes. Modern equipment and facilities suggested by (Buljan et al., 2011), (Durat et al., 2011) and found lacking in the Effluent Treatment Plant (ETP) like-non aerated grit and floating matter removal chamber, among others, implied that wastes like fats, waxes, mineral oils, floating non-fatty material (grease) entered and left the first pond untreated. Modern dewatering mechanical equipment like sludge thickener, filter press, were not fitted into the system. The sludge drying beds had higher plants growing in them signifying non-frequent use. No chemical treatment was done to the lime ponds. This means that residual amount of sulphides leaving the settling tanks may have been high. Atieno had a valid discharge certificate to release its effluents at this stage into Nairobi city sewer system.

Gross solid wastes could have been held in a Transfer station/depot with a well-constructed shade, larger receptacles for holding larger volumes of wastes before they were collected by a vehicle to Dandora dump site but they were observed missing, instead indiscriminate crude dumping on open spaces within Atieno was evident. Leachates from the crude dumped solid wastes should have been re-directed back to the ponds instead of draining into the Nairobi river and other ecosystems. Buljan *et al*., (2011) argues that effluent treatment process has high investment cost and its management requires skilled, trained and experienced personal to manage; unfortunately in Atieno no trained personnel were engaged here. Facilities and equipment installed as observed during study met some basic requirements but they were not positively used and some had limitations like Filter sludge drying beds. Buljan *et al.*, (2011) states “the output during rainy season’s drops considerably and there was the problem of malodour. One of the key informant reported delay in removing the sludge during rainy season. Associated wastes like used plastic sacks, papers bag, corroded wall fallings, corroded metal fallings, used jerry cans were observed to contain some residual chemicals which found their ways into the environment and caused pollution too.

Plants ecological succession observed in the chrome and lime sludge drying filter beds were unique and made an interesting finding that an ecologist would have wish to study especially the “seres” (plant colonization pattern of an acidic and alkaline environment) in a tannery dump site in Kenya.

CONCLUSION AND RECOMMENDATIONS

The conclusion of the study is that the management was ineffective because many solid wastes containing selected pollutants were crudely dumped, dried and burnt in Atieno. Create Environment, health and safety department in the tannery to address the short coming observed above.

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TREATMENT OF EAF-DUST IN DC PLASMA FURNACE - OFF-GAS COMPOSITION MODELLING AND COMPARISON WITH REAL MEASUREMENTS

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ABSTRACT

The non-standard waste materials based on iron and zinc, consisting of very fine particles, was melted in DC plasma furnace at high temperatures and with the violently mixing. Due to the large number of components, variable parameters and fast kinetics of the process, it is hard to follow the progress of the process. Modelling by using the HSC software in combination with real measurement of off-gas composition indicates the progress of the process and consequently provides the opportunity to optimize chemistry and to ensure the flexibility of the process. In addition, based on these measurements, it is possible to model the alignment for treatment of exhaust gases and prevent their harmful impact on the environment in a cost-effective manner.

Key words: *DC plasma furnace, smelting, modelling, EAF dust, off-gas.*

INTRODUCTION

In steelmaking industry, electric arc furnace (EAF) dust is well-known hazardous waste with a high concentration of heavy metals. In steelmaking process, dust forming is about 1-2 % by weight of the furnace charge. Due to content of leachable heavy metals such as Zn, Pb, Cd, and Cr, EAF dust is considered to be a hazardous waste (Stegeman et al., 2000). There are many EAF dust treatment methods (Zunkel 1997) that focused either its stabilization by glassification or cementation (Gress and Sarko 1993, Ek and Schlobohm 1993, Hilton 1998) or on recovering valuable metals by pyrometallurgical or hydrometallurgical processes (Hepworth et al. 1993, Hagni and Hagni 1994, Sumio et al., 1998, Xia and Pickles 1998, 1999, 2000, Colbert and Irons 1999, Pereira et al., 2001, Hayaishi et al., 2001). Despite all these methods, treatment of EAF dust is cost inefficient process, thus its disposal must be paid.

DC plasma arc furnace technology has been successfully used in many metallurgical applications such as: melting of iron units (DRI or scrap), smelting reduction of chrome fines for FeCr production, smelting reduction of ilmenite for titania slag production, smelting reduction of EAF dust for recovery of Cr, Ni, Mo and Zn and metal recovery from other metal-containing wastes (MacRae 1989, Mihovsky 2010).

For processing of EAF dusts, zinc and lead oxides must be reduced with the proper amount of carbon, at high temperatures (above 1500 ^{O}C). The dust is made into briquettes or pellets in order to obtain a material that can be easily handled and loaded into the furnace, and one that does not greatly increase energy consumption in the furnace during the reduction process (Ugarte et al., 1999, Issa et al., 2013). Issa et al. (2013) proposed the mathematical model for preparation of EAF dust based on empirical equation, determining the reducibility of the mixture. In this paper, mixture of EAF dust with coke, lime and cement, in the form of pellets, was melted into DC plasma arc furnace. Off-gas composition was measured and simulations whit HSC Chemistry software were done in order to detreminete optimal process conditions.

MATERIALS AND METHODS

In order to optimize the melting process of the EAF dust in the DC plasma arc furnace, the preparing process is essential. EAF dust was generated in the melting process of the steel scrap, in the plant "Sirmium Steel d.o.o.", Sremska Mitrovica. EAF dust was mixed with 10 wt. % of coke, 1 wt. % of lime and 3 wt. % of cement. The mixture was pelletized and dried on the air. The final chemical composition of the pellets is shown in Table 1.

Table 1: Chemical analyses of the pellets, weight %

Fe_2O_3	FeO	Fe	ZnO	PbO
17.75	3.96	0.00	37.06	1.75
S	Cu	Cr	C	Cl
0.89	0.28	0.29	9.01	2.60
SiO_2	Al_2O_3	MgO	CaO	MnO
8.53	1.48	6.17	8.40	1.84

Treatment of EAF-dust was done in 100 kW pilot plant DC-plasma arc furnace with the capacity of 150 kg of charge (Figure 1).

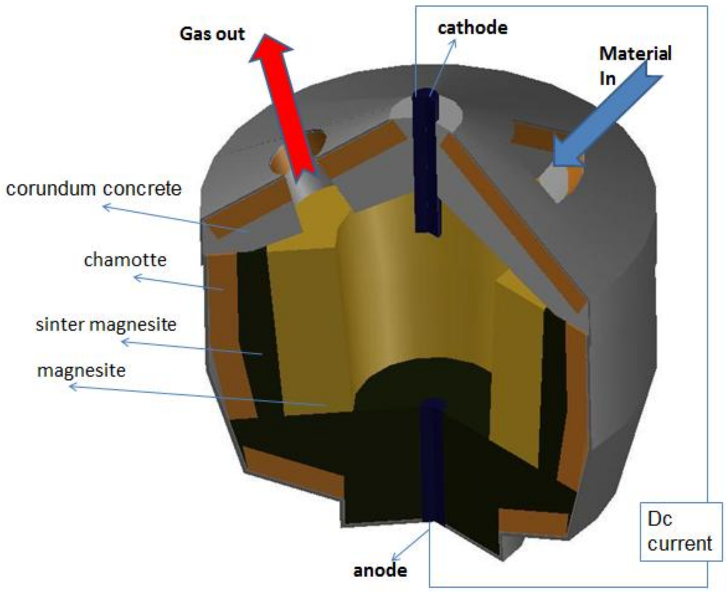
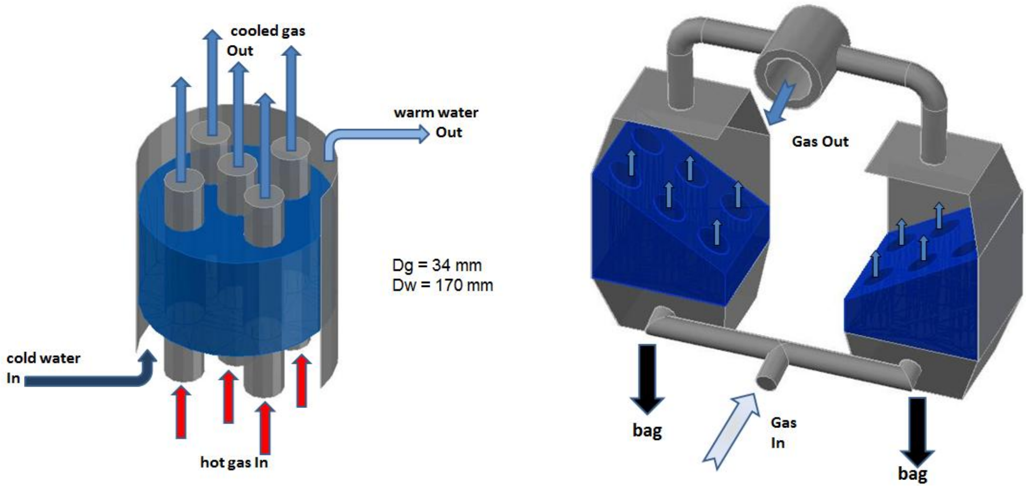


Figure 1. Scheme of DC arc furnace

Refractory of the furnace enclosure was made of magnesia based bricks and sinter magnesite, while cover was built of concrete based on alumina. This combination of refractories enables the furnace to work up to 1800 ^{O}C for hours without cooling. Furnace has a central graphite electrode, inlet for batch loading and outlet for gases. The length of arc is controlled automatically by computer software in command table, maintaining a specified power of the process.

Immediately after leaving the furnace, the gas reaches a temperature of up to 600 ^{O}C. Consequently, gas is cooled at the gas cooling system and then filtered in bag filter system to collect the ZnO (Figure 2). After leaving the bag filter system, gas is filtered again in conventional filter for preventing the harmful pollutant emission. The gas composition was measured with "Testo 340 Flue gas analyzer", immediate after gas was leaving the bag filter system. The following substances were measured: O_2, CO, NO, SO_2 and H_2. Simulation of output gas composition based on input elements in pellets (Table 1) was done in HSC software.



(a) *(b)*

Figure 2. Scheme of (a) the gas cooling system, and (b) bag filter

RESULTS AND DISCUSSION

The emission of CO, NO_x and SO_2 were measured over three periods of the smelting process: 1. charging the batch at low temperatures in the furnace, 2. melting the batch with increasing the furnace temperature, and 3. charging the batch at high temperatures in furnace. Results are shown on Figure 3.

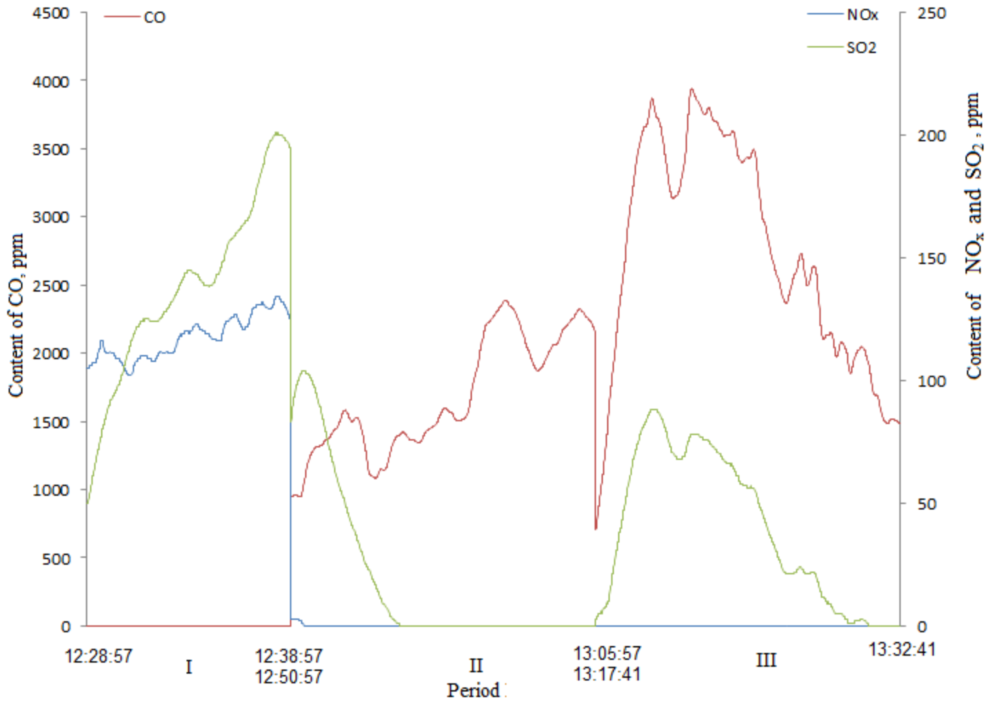
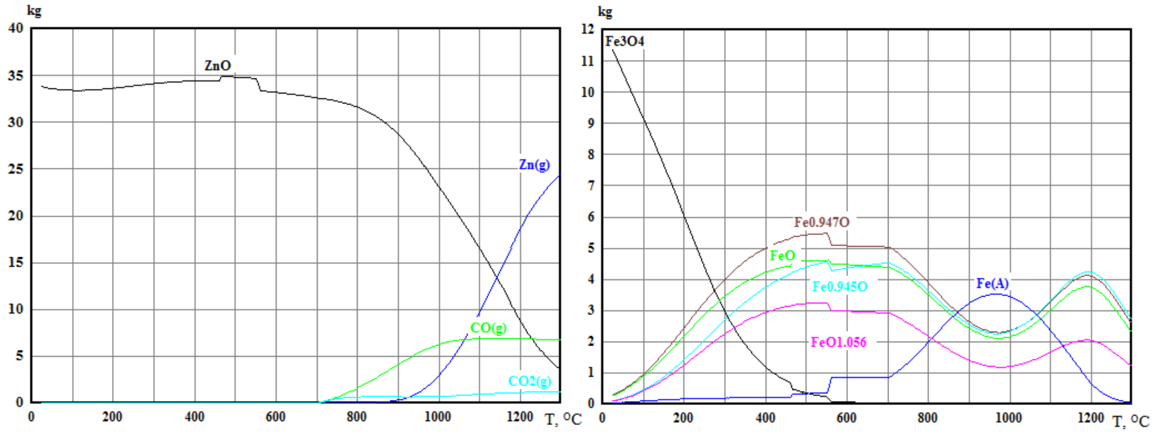


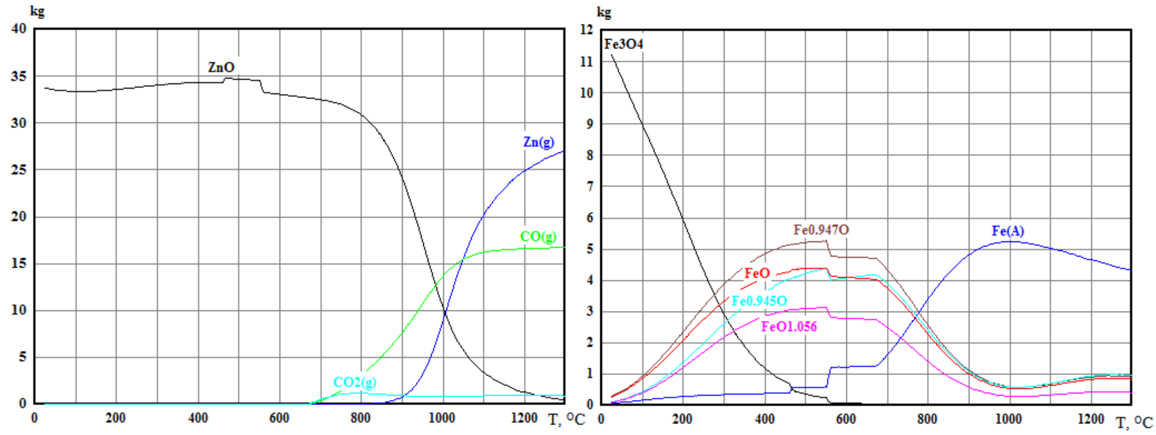
Figure 3. Emission of CO, NO_x and SO_2 in three periods of the smelting process

At the *first* period, on the beginning of the smelting process, temperatures are relatively low (under 600 ^{O}C). Consequently, carbon-monoxide was not produced, as it is confirmed in HSC simulation which can be seen on Figure 4. Also, in this period of the process higher share of NO_x and SO_2 was recorded. Sulphur from the charge was realized and reacted with oxygen, but soon it is exhausted due to its low content in the pellets (Table 1), as it is obviously in the period two on Figure 3. In the period *two* temperatures are increasing and carbon-monoxide was realized, so its content will increase with time. Reduction atmosphere in the furnace does not allow formation of NO_x. At period *three*, high temperatures are achieved and new amount of charge was inserted into the furnace. The sulphur content is much lower than in first period and it decrease with the time until it is excluded from the pellets. Due to rapid carbon reaction with metal oxides, content of CO-gas was high and then it was decreasing over time of this period, because carbon content in the pellets was reduced. At the end of this period pellets are melted and liquid metal and slag are formed.

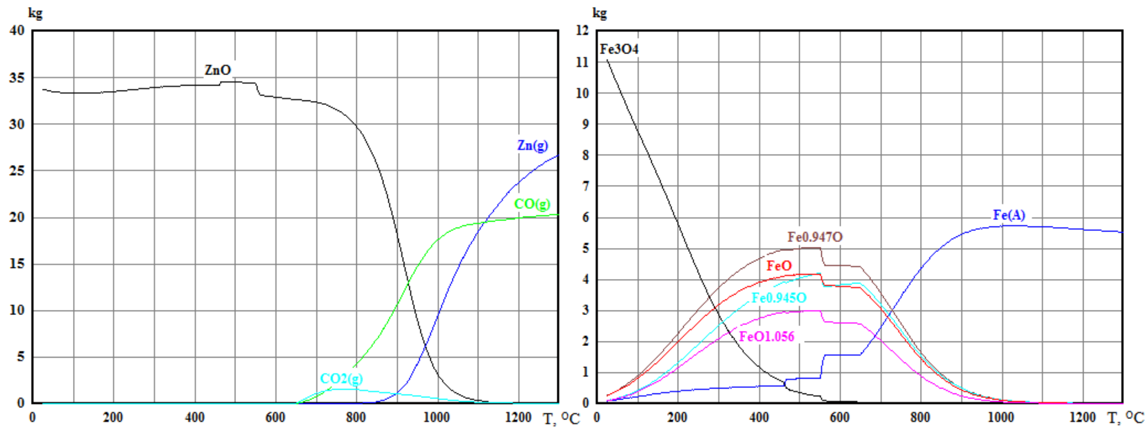
By simulation on HSC Chemistry software it is possible to determinate the optimal chemical composition of pellets, for EAF dust smelting in term of minimum energy consumption and better reduction of metal oxides (primary Fe and Zn). As input of simulation, data from table 1 were used. The variables for simulation are coke, lime and cement content. Results are shown by graphs on Figure 4.



(a) 5% C



(b) 9% C



(c) 14% C

Figure 4. Simulation with HSC Chemistry software - pellets with different amounts of carbon

On Figure 4 - diagram (a), carbon content was reduced to 5% and proportion of other elements has slightly increased. Diagram (b), on Figure 4, corresponds to the composition in Table 1, and diagram (c) corresponds to the increase of carbon content up to 14% and proportion of other elements has slightly decreased.

With increasing content of carbon in pellets, share of $CO_{(g)}$ in the furnace will increase and transformation $Zn_{(g)}$ to ZnO particles will move to the left, i.e. to the lower temperatures (Figure 4). Iron oxides will reduce to liquid iron with 5% of C content, while with 9% of C, iron oxides will reduce but not completely. At 14% of C content, all iron oxides will reduce to liquid iron as it is shown on diagram (c) in Figure 4. Based on these simulations, rising of the carbon content in pellets up to the 14% should have a positive impact on the performance of the smelting process.

CONCLUSIONS

Based on real time off-gas composition measurement, monitoring of the smelting process in the furnace is possible. Also, based on these results, with delicate adjustment the optimized charging system can be established which will reduce overall energy consumption. Correlation between furnace atmosphere and exhaust gases can be found, so control of the furnace atmosphere is possible. This will improve the chemical processes, primarily the reduction of metal oxides. In addition, the present results can be used for the design of exhaust gas treatment plant.

On the other hand, HSC simulation of pellets composition has been shown as good tool for optimization of smelting process, in terms of adjusting the composition of raw materials.

Further research should be focused on founding relationship between different composition of pellets and off-gas composition on various charging times, as well as with HSC simulations of pellets composition.

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THE ASSESSMENT OF THE DANUBE AND TISZA WATER QUALITY IN SERBIA

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ABSTRACT

The paper presents water-quality assessment of Danube and Tisza water quality using multivariate statistical methods. Factor analysis/principal component analysis and cluster analysis, were applied for the evaluation of variations of a water quality data set obtained during 2011 year of monitoring of 14 parameters at 14 different sites. Using factor analysis/principal component analysis, three factors were obtained with Eigenvalues >1 summing more than 84 % of the total variance in the water data sets, which is adequate to give good prior information regarding data structure. Cluster analysis performed to detect similarity group between the sampling points.

Key words: *water quality, multivariate statistical methods, factor analysis, cluster analysis*.

INTRODUCTION

It is well known that environmental data are usually characterized by high variability, because of a variety of natural and anthropogenic influences. The best approach to avoid misinterpretation of environmental monitoring data is the application of multivariate statistical (chemometric) methods for environmental data classification and modeling (Vujović et al., 2012). The application of different multivariate statistical techniques such as Cluster Analysis (CA), Discriminate Analyssis (DA) and Principal Component Analysis (PCA) helps in the interpretation of complex data matrices to better undarstand the water quality (Gupta et al., 2009). Multivariate statistical methods including factor analysis have been used successfully in hydrochemistry for many years. Surface water, groundwater quality assessment and environmental research employing multi-component techniques are well described in the literature. Factor analysis attempts to explain the correlations between the observations in terms of the underlying factors, which are not directly observable (Singovszka and Balintova, 2012). The basic objective of cluster analysis is to discover natural grouping of objects. The cluster analysis techniques have been used in many areas such as manufacturing, medicine, nuclear science, radar scanning and research and development planning (Prakash and Dagaonkar, 2011). The paper presents water-quality assessment of Danube and Tisza Rivers using multivariate statistical methods: factor analysis (FA)/principal component analysis (PCA) and cluster analysis (CA).

STUDY AREA

The total length of the Danube River is approximately 2,800 kilometers and its length in the territory of Serbia is 588 km, or approximately 20% of its total length. The Danube River basin covers 87% of the country's territory. It also represents the most developed and densely populated part of Serbia and comprises the Tisza River sub basin, the Sava River sub-basin, and the Velika Morava sub-basin (Milenkovic et al., 2005). The Tisza River Basin, with its total extent of 157,186 km², is the largest sub-basin in the Danube River Basin.

The data sets of water quality, provided by the RHSS (Republic Hydrometeorological Service of Serbia) from 14 monitoring sites consisted of 14 water-quality parameters monitored during 2011 year in a quality monitoring network of Danube and Tisa Rivers. Republic Hydrometeorological Service of

Serbia is testing systematic water quality in several monitoring stations. Water sampling localities are shown in Figure 1.

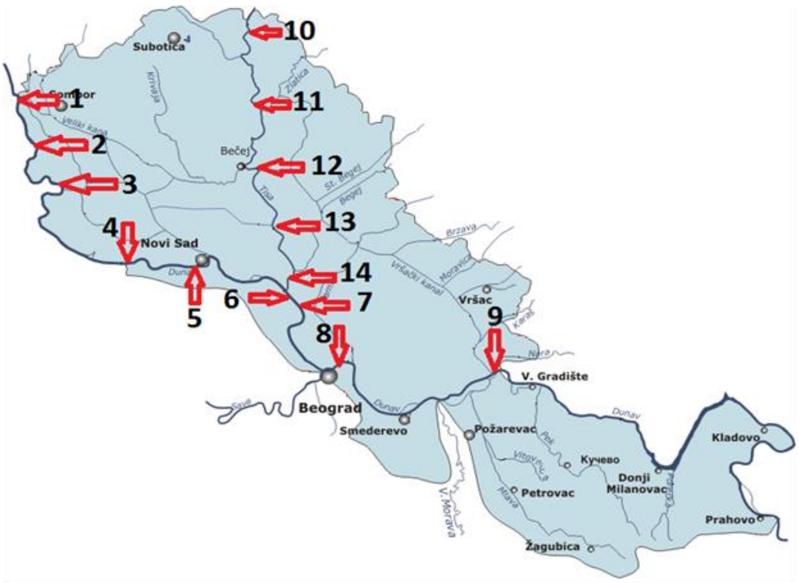

Figure 23. Water sampling localities

(1. Bezdan; 2. Apatin; 3. Bogojevo; 4. Bačka Palanka; 5. Novi Sad; 6. Slankamen; 7. Čenta; 8. Pančevo; 9. Banatska Palanka; 10. Martonoš; 11. Padej; 12. Novi Bečej; 13. Žabalj; 14. Titel)

FACTOR ANALYSIS (FA) /PRINCIPAL COMPONENT ANALYSIS (PCA)

Factor analysis (FA)/Principal component analysis (PCA) were used the correlation matrix of observation (X) to estimate a sorted matrix of eigenvalues (λ) and corresponding eigenvectors (factor loading V). The characteristic equation is [X-λI] V=0, where each eigenvalue λ is associated with an eigenvector V. The factors with eigenvalues equal to or greater than one are retained using Kaiser criterion. Varimax rotation was used to yield a simpler factor structure (Al-Rawi, S., M. and Shihab).

CLUSTER ANALYSIS

Hierarchical agglomerative clustering is the most common approach, which provides intuitive similarity relationships between any one sample and the entire data set, and is typically illustrated by a dendrogram. The dendrogram presents a picture of the groups and their proximity to one another, with a reduction in the dimensionality of the original data. Cluster analysis starts with a data matrix, where objects are rows, and observations are columns. The table constructed there of gives a measure of similarities or differences between the observations. Distances are normally used to measure the similarity or dissimilarity between two data objects (Varol and Sen, 2009., Prakash, M.M., Dagaonkar). Commonly, distance functions, such as the Manhattan and Euclidian distance functions, are used to determine similarity. The similarities-dissimilarities are quantified through Euclidean distance measurements, the distance between two objects, i and j, is given as:

$$d_{ij}^2 = \sum_{k=1}^{m}\left(z_{ik} - z_{jk}\right)^2 \tag{1}$$

where d_{ij}^2 donates the Euclidean distance, and *z* are the values of variable k for object i and j, respectively, and m is the number of variables.

The aim of the CA was detecting similarities and dissimilarities among the sampling sites and explaining the observed clustering in terms of affected conditions.

RESULTS AND DISCUSSION

All mathematical and statistical computations were carried out using Microsoft Office Excel 2007 and software package Statistica (version 10) for Windows.

Factor analysis is applied to physico-chemical parameters of natural water bodies with the aim classification and data summation as well as segmentation of heterogeneous data sets into smaller homogeneous subsets (Vujović et al., 2013). Factor loadings were categorized as strong and moderate corresponding to the absolute loading values of >0.75, 0.75-0.50, respectively (Liu et al., 2003).

The selected parameters for the estimation of surface water quality characteristics were:

- temperature (T)
- suspended solids (SS)
- dissolved oxygen (DO)
- total hardness (TH)
- pH
- electrical conductivity (EC)
- ammonium nitrogen (NH_4-N)
- nitrate nitrogen (NO_3-N)
- orthophophates (PO4-P)
- total phosphorous (TP)
- calcium (Ca^{2+})
- magnesium (Mg^{2+})
- biochemical oxygen demand (BOD_5)
- surface-active substances (SAS)

From these data, three factors, explaining 84 % of the total variance, was estimated on the basis of a Kaiser criterion of the eigenvalues greater or equal 1 and from a Cattel scree plot (Figure 2).

The application of FA/PCA analysis has led to identification of three latent factors responsible for the data structure. The factor analysis generated three significant factors which explain about 84% of the variation in the data set (Table 1). Each factor that is significantly related to specific variables represents a different dimension of water quality.

Table 1: Results of factor analysis/principal component analysis

Variable	Factor Loadings (Varimax raw) Extraction: Principal components (Marked loadings are >.700000)		
	F1	**F2**	**F3**
T	0.178444	**-0.783452**	-0.033570
SS	**-0.893240**	-0.055120	0.017465
DO	0.633462	**0.716273**	0.113039
TH	**0.853742**	0.442813	0.160692
pH	0.524868	**0.771396**	-0.097859
EC	**-0.894248**	-0.087347	0.272784
NH_4-N	-0.289276	**-0.809000**	0.052125
PO_4-P	0.190532	0.475637	0.611846
NO_3-N	**0.912950**	0.351281	-0.099223
TP	**-0.941284**	0.031246	0.116898
Ca^{2+}	0.673728	0.424296	0.502286
Mg^{2+}	**0.875157**	0.430031	0.026470
BOD_5	**0.711038**	0.315939	0.393084
SAS	0.286753	0.201967	**-0.858465**
Eigenvalue	6.682123	3.439296	1.639835
Variance (%)	**47.7294**	**24.5664**	**11.7131**

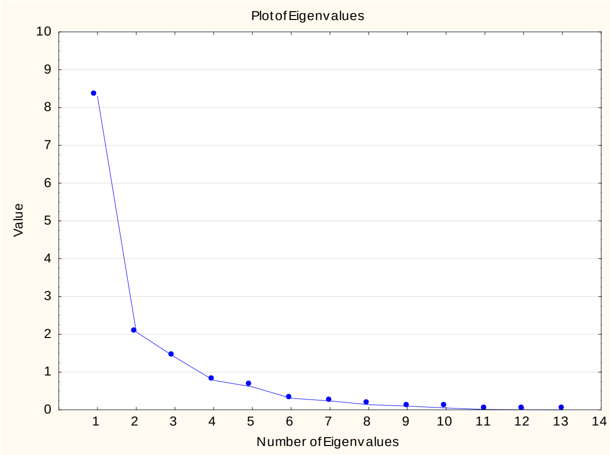

Figure 2. Scree plot

Cluster analysis was performed according to factor F1 that accounting for about 47% of the total variance which is correlated with: suspended solids SS; TH; EC; NO_3-N; TP; Mg^{2+}**;** BOD_5.

CA grouped 14 monitoring stations into two clusters of similar surface water quality characteristics. CA was performed on the standardized dataset (mean of observations over the whole period) using the Ward’s method with Euclidean distances as a measure of similarity and the single linkage cluster method were used to obtain dendrogram. Cluster analysis performed to detect similarity group between the sampling points. At the end of the clustering analysis, there were considered two clusters that can be seen on the dendogram in Figure 3.

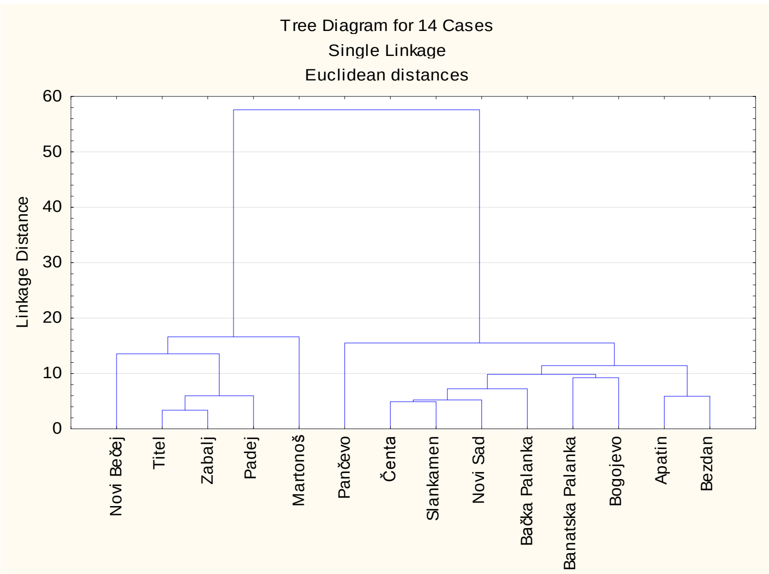

Figure 3. Cluster analysis dendrogram of the monitoring stations in relation to the first factor F1

Under the EU Water Framework Directive (2000/60/EC) the International Commission for the Protection of the Danube River (ICPDR) is the platform for coordination amongst the Danube countries including EU Member States, accession countries and other Danube riparian states for the implementation of the provisions of the Directive at transboundary level. In addition to the Danube River Basin planning, the ICPDR is taking an active role in sub-basin planning as well. One of the key objectives of the EU Water Framework Directive (WFD) is to ensure that all water meets good status by 2015. Within the frame of (ICPDR) activity Trans-National Monitoring Network (TNMN) had been established. ICPDR and TNMN experts defined five clases system for the evaluation of water quality which are mainly in accordiance with Water Framework Directive (WFD). Based on the data obtained and classification of surface water, according to the TNMN standards, The Danube and Tisa River belongs to the classes I and II. Water quality parameters (minimum and maximum values) are shown in table 2.

Table 2: Water quality parameters (minimum and maximum value) measured on Danube and Tisza Rivers- monitoring stations

Parameters	Min.	Max.
SS	15 mg/l	44.33 mg/l
	Bezdan	Martonoš
TP	0,08 mg/l	**0,14 mg/l**
	Novi Sad	Žabalj
PO_4-P	0,033 mg/l	0,069 mg/l
	Martonoš	Žabalj
NH_4-N	0,05 mg/l	0,13 mg/l
	Bezdan, Apatin, Bogojevo, Bačka Palanka	Banatska Palanka
NO_3-N	0,90 mg/l	1,71 mg/l
	Novi Bečej	Bezdan
BOD_5	1,68 mg/l	2,51 mg/l
	Padej	Bezdan
pH	7,96	8,25
	Žabalj	Bezdan, Apatin
EC	456,67 µS/cm	543,70 µS/cm
	Bačka Palanka	Titel
SAS	0,02 mg/l	0,05 mg/l
	Bezdan, Apatin, Novi Sad, Banatska Palanka, Martonoš, Žabalj, Titel	Slankamen

CONCLUSIONS

The factor analysis generated three significant factors which explain about 84% of the variation in the data set. Each factor that is significantly related to specific variables represents a different dimension of water quality.

Cluster analysis was performed according to factor F1 that accounting for about 47% of the total variance which is correlated with: suspended solids SS; TH; EC; NO_3-N; TP; Mg^{2+}**;** BOD_5.

CA grouped 14 monitoring stations into two clusters of similar surface water quality characteristics. Based on the data obtained and classification of surface water, according to the TNMN standards, The Danube and Tisa Rivers belongs to the classes I and II.

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DECREASING VULNERABILITY OF RECYCLING SYSTEM OF ELV IN SERBIA THROUGH THE INTEGRATION PROCESESS

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ABSTRACT

Business environment conditions have introduced very reliable organizations with the goal to be competitive on the global market. In order to achieve this goal, organizational vulnerabilities must be treated permanently because in the time of crisis they may lead to the catastrophe. This paper proposes a model for assessment of management of organizational vulnerabilities with enhancement achievements of regular management. The model is based on the process approach which is combined with appropriate indicators. The functioning of proposed model is illustrated through the data collected from several end of life vehicles (ELV) recycling centres in Serbia. The obtained results represent the input data for decreasing overall vulnerability of recycling system of ELV in Serbia through the integration processes.

Key words: *management of organizational vulnerabilities, ELV recycling centres, process approach.*

INTRODUCTION

Coping with the organizational vulnerabilities has become one of the basic assumptions of modern business. Organizational vulnerabilities represent the most relevant causes of the decline of organizational business performance. Amongst all, vulnerabilities may lead to organization complete collapse. There are different ways to overcome organizational vulnerabilities and one of the most effective forms is effective vulnerabilities management. Coping vulnerabilities may be treated as a part of organizational resilience (McManus, 2007). Research field of resilience exists in the areas such as development, engineering, climate change, ecosystems, weather disasters, etc. Entities (systems) that can be described by using the word resilience, in most cases have the ability to bounce back to the initial condition in a short period of time. Initial condition relates to the time period that preceded the impact of any disturbance. Relationship between resilience and vulnerabilities is an issue in many science fields, from environmental change to socio-economical systems (Vogel, 2007) and the consensus about their total relationship has not been established.

The foundation for assessment and decreasing vulnerability of recycling system of ELV in Serbia is process approach. Steps that set direction to the process approach can be found in the papers that treat resilience of social - ecological systems. If process approach is the focus, resilience can be seen as the ability of a system to recover and adapt to disturbances in the environment, while continuing to operate as if the characteristics of change have never occurred (Manyena, 2006). Having in mind this, it can be concluded that resilience is a process and not an outcome.

In this paper, the decreasing vulnerability of recycling system of ELV in Serbia through the integration processes is analyzed. An organization is presented through its own processes and management of organizational vulnerabilities is described through the set of indicators (McManus, 2007) which needs to be assessed on each process level. In order to be resilient, an organization needs to have resilient processes and in the same time, management of the organizational vulnerabilities must be improved over time.

Centers for ELV dismantling have become a hot topic considering efforts that are being made towards meeting the standards prevailing in the EU. Like all other organizations, centres for ELV recycling face various risks and uncertainties in the business. Since the network of centers for ELV dismantling of Serbia has yet to be developed, it is clear that their business as well as the interactions between the environment and the environment should be thoroughly examined. It takes a lot to invest in the development of the centers so assessment of risk in their business becomes inevitable and defining the metrics of vulnerability becomes imperative. In theory and engineering practice, new demands in terms of environmental protection, sustainable development and social responsibility have been emerged frequently. Environmental protection requires the reduction of emissions and usage of recycled materials which have a major impact on all sectors of the global economy, including all vehicles. Solutions for reducing emission of harmful gases can be found in the development of new technologies and vehicles that are using fuel whose exploitation is followed by small amount of carbon (Winkelman, 2009).

This paper is proposing the model for assessment of organizational vulnerabilities management on the organizational level because decreasing vulnerability need to be started with the input data that describe the current state. The paper is structured as follows: literature review of organizational vulnerabilities is presented in the section 2, the model for assessment of vulnerabilities management in ELV recycling centre is presented in the section 3, in section 4 the illustrative example of one ELV recycling centre assessment is presented and section 5 sets the conclusion.

THE LITERATURE REVIEW

Currently in Serbia, the process of dismantling and recycling of ELV can be described as completely disorganized (Arsovski, 2010). Subsystems and vehicle parts are disassembled and they are placed on the market with a limited or low valued technological processes and procedures. On the other hand, the level of resource utilization of motor vehicles at the end of the life cycle is extremely low (below 60% of the total vehicle weight) compared to the centres for recycling in the EU countries. Vehicle manufacturers in Europe have their own concept of recycling ELV and developed network of recycling centers. Their goal is to minimize the adverse environmental impacts throughout the ELV. That's why even at the stage of vehicle design, the requirements of recycling - the time required for removal of a given ELV or selection of materials suitable for recycling is taken out in account.

In the terms of business, organizational vulnerabilities must be treated permanently because in the time of crisis they may cause significant problems or even catastrophe. As an answer to vulnerabilities issue, social systems may show resilient features. Components of resilience in a social system can be defined through five thematic areas where the appropriate action is possible to be implemented (Twigg, 2007): (1) management, (2) risk assessment, (3) knowledge and education, (4) risk management, (5) decreasing vulnerabilities and preparing for disturbances and reaction to them. Very complex issue in this area is to define main vulnerabilities and to assess the measure of their management. Vulnerability is a complex subject thanks to its own nature, so it cannot be easily reduced to a single metric. This makes vulnerabilities hard to quantify. Even more complex is to define a unique threshold of risk, danger or harm for an organization in general. Similarly, a measure of resilience is still extremely difficult to acquire so named problems are burning issues that are open for further research, especially in organizational science (Stephenson, 2010, Aleksic et al., 2013).
In the global business conditions, organizations need to be engaged in a systematic process of prevention, preparedness, mitigation, response and recovery and business continuity. It is not sufficient for organizations to have a draft plan that provides scenarios for disaster or emergency. Threats and risks in business require direct facing in the scope of a business process, a dynamic and interactive relationship with a goal to ensure the continuity of the main activities of an organization, during and after major crisis events. The concept of resilience has become incorporated into the knowledge of the corporate strategy of a number of leading companies on a global scale (Booz Allen Hamilton 2004). During the process of strategy implementation, the most used technology is information and communication technology (ICT). ICT has big influence on business operations and capability, organizational capability and core capabilities from the resilience perspective (Pham and

Jordan, 2006). In the time of crisis, improvisation concept in the terms of resilience can be valuable solution but it is not sufficient. The positive result of improvisation is learning that is directed how to improve condition. That may be achieved through the re-utilization of improvisation or through the action component of improvisation. Other technologies and resources may also be valuable for organizations. Trends of management bring together different approaches in achieving of sustainable development and social–ecological resilience (Plummer and Armitage, 2007). Analysis of the sustainability of organizations shows that it is very important to carry out an evaluation in natural resource management. An evaluative framework for this analysis brings three broad components: ecosystem conditions, livelihood outcomes and process and institutional conditions. It may be assumed that an appropriate way for achieving sustainability is coping with vulnerabilities. This may be analyzed from the organizational level perspective, management of organizational resources, etc. Provision of recycling goals can be achieved by usage of defined procedures that should be followed during the evaluation process of the recyclability of ELV parts and components. A certain number of different types of recycled plastic materials is specified and approved for production and installation in new vehicles. Compared with new materials, recycled materials have to meet the same technical specifications and their production needs to be cheaper. If these two conditions are fulfilled, recycled materials are the first choice but the quality of the product must not be changed. The goal is to maintain a high level of performance, thermal and physical endurance as well as the aesthetic aspect, so parts made from recycled materials can be incorporated in any part of the vehicle.

THE MODEL FOR MANAGEMENT OF ORGANIZATIONAL VULNERABILITIES ASSESSMENT

The basis for management of organizational vulnerabilities assessment can be described as mapping related factors which are the same in every science field that treats vulnerabilities. In the field of ecology which has treated the vulnerabilities of ecosystems for many years, generally accepted definition of vulnerability is presented as a multidimensional concept that consists of exposure, sensitivity and adaptive capacity (Turner II et al., 2003). These dimensions should be incorporated into the assessment.

The demands of market shape the organizations, so organizations have to manage its own vulnerabilities and strive in the moments after disturbances. Besides that, the process approach is found to be very important. This way, one organization can be described by its processes and their interconnections. Different reference models can be used to represent the organization as well as reference standard (ISO 14258 - Concepts and Rules for Enterprise). In this paper, the organization is represented by its business processes. In theory and in practice there is a large number of the process distribution. Classification framework of processes comprises four divisions of the master processes (Arsovski, 2006): (1) management, (2) management of resources, (3) implementation and (4) measurement, analysis and improvement. Besides the division into four master processes, the basic classification is also used (Oakland, 2004): (1) process of management, (2) the main processes and (3) support processes. From the aspect of value creation, the processes are divided into key processes and support processes, which involve the management process. The recycling system of ELV in Serbia should be observed in the wider scope than ELV recycling centres. For this purpose, all stakeholders need to be analyzed as well as process on the state level. These relations are presented in the figure 1.

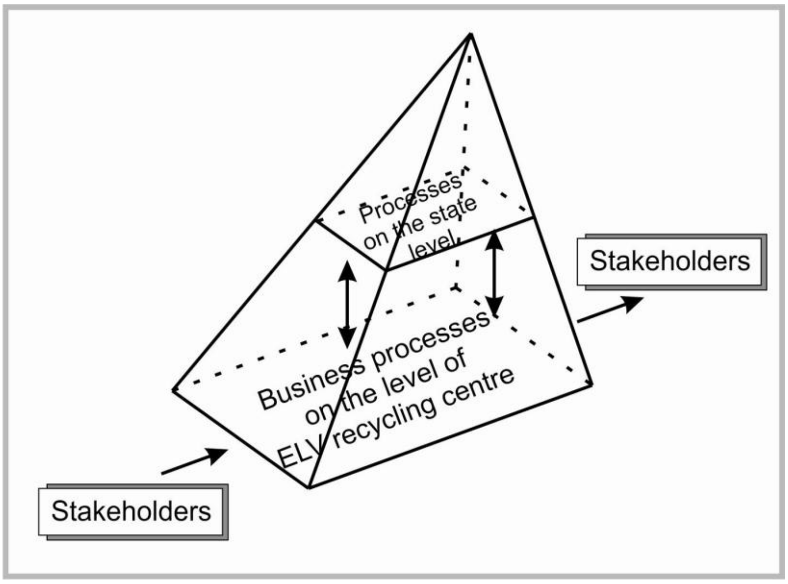

Figure 1. Relations between entities in the model of recycling system of ELV in Serbia

ELV recycling centres are very dependent on ICT technology in the scope of communications with other entities. ICT usage may enhance the availability and the speed of documents and information flow. Besides that, it is possible to raise the skills and the quality of employees' engagement which indicates the great impact of ICT on the organization. Business processes on the level of recycling centres are: (1) Process of management, (2) Marketing and sale process, (3) Design and Development process, (4) Procurement process, (5) Production process which covers collection, selection, dismantling, processing, schroeders operations, (6) Support processes which covers environmental protection, occupational health and safety, HRM, external services such as incineration. Processes on the state level include financial support, registration of vehicles, law regulation and economic development.

DATA MODELLING

The importance of each business process depends on multiple factors, such as the type of activity, connections with other processes and others. It can be assumed that the relative importance of business processes on the enterprise level has different values. Weight value of business processes are almost unchanged during a predefined period of time and involve a high degree of subjective assessment of the management team. In this paper, the relative importance of business processes (RIp) and the relative importance of management of keystone vulnerabilities indicators (RIi) are given by scale (1-5). Thus the next assumption is introduced – the members of management team express their judgments using rating from 1 to 5 for indicator values (VI) as well as for the weights of processes and weights of indicators. In this paper the small and medium enterprises are in the focus so it can be assumed that decision makers of management team can made decisions by consensus. In the table 1, the model for assessment of management of organizational vulnerabilities with relevant indicators is presented. The obtained values of indicators on the process level may be summarized horizontally which gives an overall value of indicator in the organization or they may be summarized vertically in order to present the value of management of organizational vulnerabilities on the process level.

Table 1: The assessment of management of organizational vulnerabilities with relevant indicators

Indicators of management of organizational vulnerabilities	***Referent processes in ELV recycling centre***					
	Process of management	Marketing and sale process	Design and Development process	Procurement process	Production process	Support processes
1. Planning Strategies	$RIp_1 \cdot RIi_1 \cdot VI_1$	$Rip_2 \cdot RIi_1 \cdot VI_1$	$Rip_3 \cdot RIi_1 \cdot VI_1$	$Rip_4 \cdot RIi_1 \cdot VI_1$	$Rip_5 \cdot RIi_1 \cdot VI_1$	$Rip_6 \cdot RIi_1 \cdot VI_1$
2. Participation in Trainings	$RIp_1 \cdot RIi_2 \cdot VI_2$	$Rip_2 \cdot RIi_2 \cdot VI_2$	$Rip_3 \cdot RIi_2 \cdot VI_2$	$Rip_4 \cdot RIi_2 \cdot VI_2$	$Rip_5 \cdot RIi_2 \cdot VI_2$	$Rip_6 \cdot RIi_2 \cdot VI_2$
3. Capability and Capacity of Internal Resources	$RIp_1 \cdot RIi_3 \cdot VI_3$	$Rip_2 \cdot RIi_3 \cdot VI_3$	$Rip_3 \cdot RIi_3 \cdot VI_3$	$Rip_4 \cdot RIi_3 \cdot VI_3$	$Rip_5 \cdot RIi_3 \cdot VI_3$	$Rip_6 \cdot RIi_3 \cdot VI_3$
4. Capability and Capacity of External Resources	$RIp_1 \cdot RIi_4 \cdot VI_4$	$Rip_2 \cdot RIi_4 \cdot VI_4$	$Rip_3 \cdot RIi_4 \cdot VI_4$	$Rip_4 \cdot RIi_4 \cdot VI_4$	$Rip_5 \cdot RIi_4 \cdot VI_4$	$Rip_6 \cdot RIi_4 \cdot VI_4$
5. Organizational Connectivity	$RIp_1 \cdot RIi_5 \cdot VI_5$	$Rip_2 \cdot RIi_5 \cdot VI_5$	$Rip_3 \cdot RIi_5 \cdot VI_5$	$Rip_4 \cdot RIi_5 \cdot VI_5$	$Rip_5 \cdot RIi_5 \cdot VI_5$	$Rip_6 \cdot RIi_5 \cdot VI_5$

The defined indicators of management of the organizational vulnerabilities in organizations are in focus of many scholars (Aleksic et al., 2013, Stephenson 2010). Indicators of management of the organizational vulnerabilities presented in this paper are adapted from McManus (2007) because this set of indicators has very good correspondence with the selected type of organizations.

ILLUSTRATIVE EXAMPLE

The organization that was used for model testing is recycling ELV centre Reomat from the region of Central Serbia. Reomat centre is consisted from several interconnected functional entities:

- Receipt and registration of ELV,
- ELV storage,
- plant for removal and discharging of working fluid (fuel, oil, coolant, etc..)
- plant for dismantling of motor vehicles and the selection of components and materials,
- storage for disassembled components and materials selected,
- storage of working fluids and toxic materials and substances
- warehouse and plant for compacting shell / chassis,
- transportation (special vehicles for transport of waste vehicles and vehicles for the transport of hazardous and toxic materials).

In addition to these functional units, Reomat centre also has:

- facility for assessment, cleanup and repair of components (parts, engine, transmission, etc.)
- storage of repaired components (spare parts for vehicles in use)
- store for the repaired - replaced parts.

When analyzing the vulnerability of the organization, a large number of inputs can be obtained from the risk analysis. Outputs from that analysis represent the input data for the analysis of the management of organizational vulnerabilities. In the table 2 is presented survey that explains how to assess indicators' values on the level of ELV recycling centre.

Table 2: The survey for assessment of indicators of management of organizational vulnerabilities in ELV recycling centre

1. Planning Strategies	How is the planning strategy in line with the real possibilities of the processes of organizational system? To what extent is the top management involved in planning strategy and whether is it harmonized with the process? Are short-term and long-term goals which have already been set realistically achievable?
2. Participation in Training	How often training in the framework of the organizational system are done? What are the barriers to participate in the training? Is there a defined intense of management for carrying out regularly training?
3. Capability and Capacity of Internal Resources	How well equipped is the facility that has the function of the Crisis center in the event of unfortunate events? How complicated is to involve employees in solving the problems caused by adverse event? To what extent are the internal resources ready to support the flow of the process in case of adverse events?
4. Capability and Capacity of External Resources	Is the organizational system secured with an insurance company in case of identified adverse events? How well is organization connected with the external resources (ie. stakeholders)? What is the level of expected assistance from external resources in case of adverse events?
5. Organizational Connectivity	To what level is the process fault-tolerant to information and communication technology faults during the product development? How is the fault-tolerant to physical errors of information and communication technologies? To what level is the process fault-tolerant to information and communication technology faults in the interaction with other processes?

Indicator 1 (Planning Strategies) is the most evident in the process of management which is organized by strategic planning. In this process, plans that are being implemented in other processes with an emphasis on legislation and financial incentives from the government are defined. Participation in training may be required for the implementation of any process. It is necessary to consider the appropriateness and effectiveness of trainings. Internal resources have impact on the processes comprising all the elements necessary for their normal functioning and operation of the organization. They include physical resources, process resources and the human resources. The impact of this indicator is easily recognizable in the procurement and production. External resources will have the greatest impact on the organization in terms of the knowledge transfer and providing resources for the functioning of the organization. Their influence is theoretically the easiest to observe in the process of design and development and in production. Vulnerability of ICT in the enterprise can be manifested in all processes. When assessing the value of the vulnerability management indicator, relevant information may be obtained during the evaluation of process performance. In the table 3 are presented obtained results from the Reomat ELV recycling centre

Table 3: The assessment of management of organizational vulnerabilities with relevant indicators

Indicators of management of organizational vulnerabilities	***Referent processes in ELV recycling centre***					
	Process of manageme nt	Marketing and sale process	Design and Developmen t process	Procureme nt process	Production process	Support processes
1. Planning Strategies	21	21	15	21	24	18
2. Participation in Trainings	18	15	12	15	18	12
3. Capability and Capacity of Internal Resources	30	36	12	42	45	36
4. Capability and Capacity of External Resources	30	36	9	36	42	30
5. Organizational Connectivity	21	18	12	18	21	21

Summarized data from the table 2 may present vulnerability of each business process (Figure 2) or the values of each vulnerability indicator on the organizational level (Figure 3).

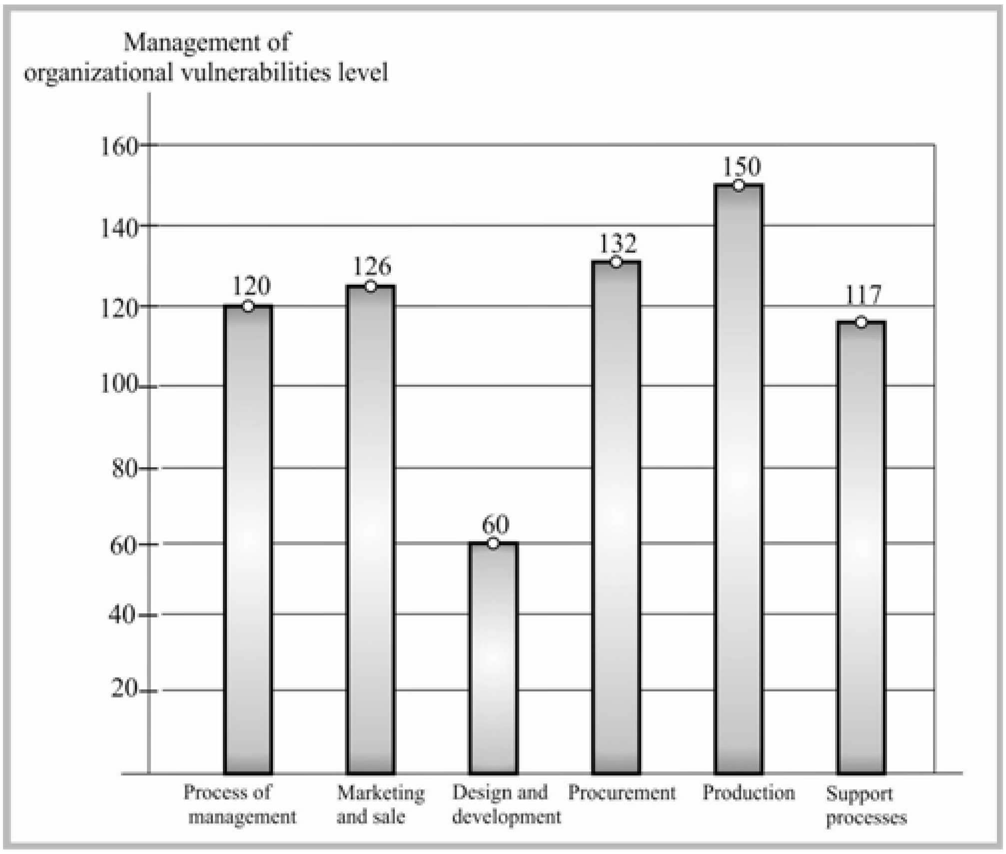

Figure 2. The vulnerability level of each business process

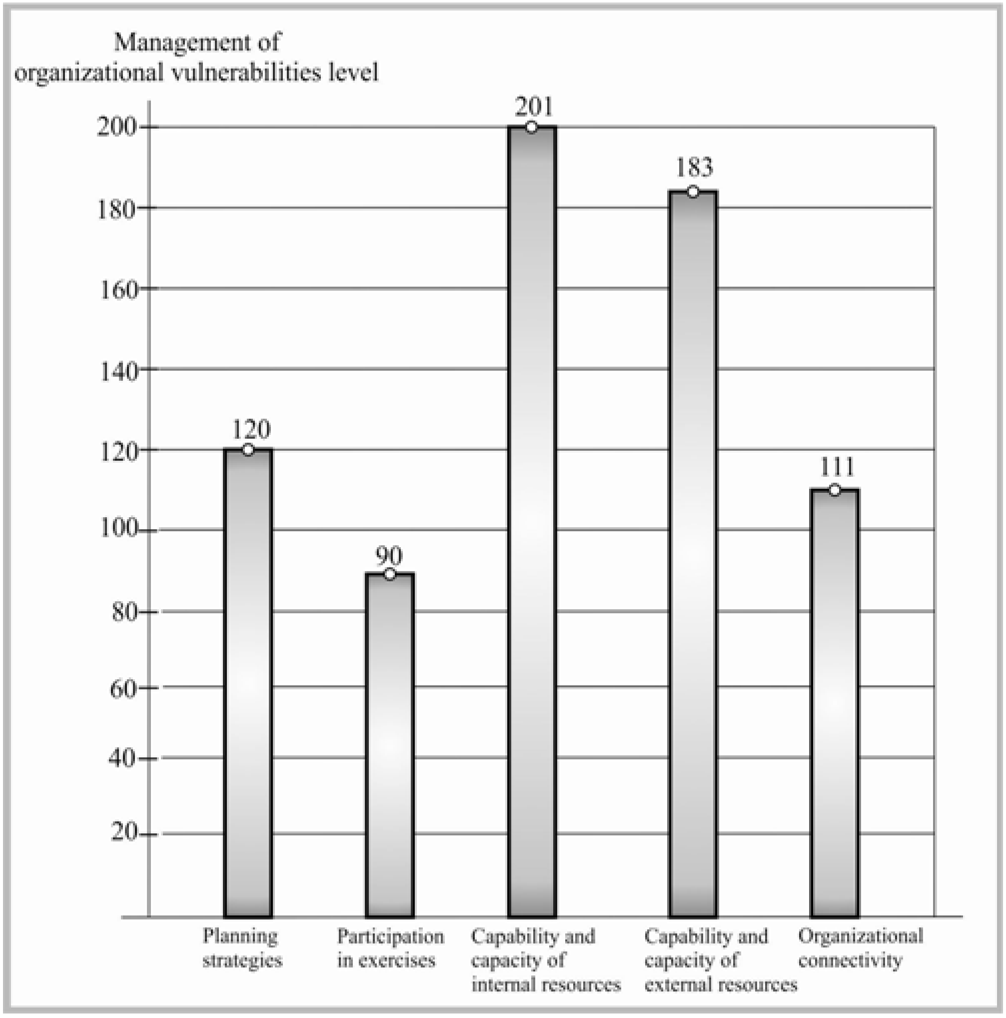

Figure 3. The values of each vulnerability indicator on the organizational level

The results of organizational vulnerability management analysis may address current state and future trends of this ELV recycling centre in Central Serbia. Through the analysis of business processes it can be concluded that the lowest level of vulnerability management is in the field of design and development (60 points) and within the processes of support (117 points). The highest score may be noticed in the process of production. This could be expected because in the field of design and development there are almost no employees and the activities of this process are very rare and they are usually done by outsourcing. Relatively high level of vulnerability management in the production process is the consequence of high technological level and resources for the process realization in the current conditions.

From the aspects of management of organizational vulnerabilities indicators, the lowest level is assessed within Participation in exercises (90 points), Organizational connectivity (111 points) and Planning strategies (120 points). Higher results are obtained within the Capability and capacity of external resources (183) and Capability and capacity of internal resources (201).this indicates that decreasing of vulnerability may be achieved through the application of „soft“ methods in the field of education and trainings , organizational design and through the improvement of management especially strategic management.

CONCLUSION

Based on the real state, it can be concluded that the centres for ELV recycling are very needed in Serbia, and that their construction and sustainable development will significantly improve the domestic industry. To ensure their smooth operation and existence in stable and crisis situations, it is necessary to provide guidance on the assessment of their management of vulnerabilities.

The industrial management practice shows that in almost every enterprise, organizational vulnerabilities represent the most relevant causes of the decline of organizational business performance and may lead to very significant issues. The different ways may be defined for overcoming the vulnerabilities of the organization, and one of the most effective forms is effective management of organizational vulnerabilities. In this paper, a model for evaluation of management of organizational vulnerabilities on the process level and on the enterprise level is proposed. The proposed model was tested on centre for ELV recycling in the region of Central Serbia. The analysis done by proposed model was in a very good alliance with the real situation in practice.

The conclusion which should be emphasized is that the relative importance of the business processes and indicators of organizational vulnerabilities are given by scale (1-5). All the changes, such as the changes in the number of processes/indicators (or relative importance) can be easily incorporated into the model. The further research will cover the scope of process improvement measures as well as improve the overall management of organizational vulnerabilities.

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AWARENESS ON WASTE MANAGEMENT IN THE CITY OF ZRENJANIN

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ABSTRACT

This paper analyzes the importance of waste management in the City of Zrenjanin. A survey was conducted, was done by interviewing its residents, the results provide insight into how the waste management in the City of Zrenjanin. The aim of this study was to examine the awareness of waste management and to determine what actions citizens are directed towards the preservation of the environment and the motives for certain actions.

Key words: *Waste management, environmental protection, Zrenjanin.*

INTRODUCTION

City of Zrenjanin, like many in Serbia is faced with serious problems in their development that are a poorly developed infrastructure, and bad habits and lack of concern for the environment. Ministry of Environment and Spatial Planning recognized as one of the biggest environmental problems in Serbia, inadequate waste management. Waste management in the right way in a city is an important factor in protecting the environment and what is done in a way that provides the least risk to health and life of people and the environment. " The Universal Declaration of Human Rights with a new 31 Article states: "Every human being has the right to maintain the ecological balance in their environment, which it shares with all other living beings, plants and animals, whose survival as a guarantee for the survival should be ensured. " U.S. Public Health Service published the results do with 22 kinds of diseases in people with inadequate removal of waste. The problem of this study is the management of waste the city of Zrenjanin. As a major research problem observed is low awareness among citizens about the importance of preserving the environment through waste management adequately.

MATERIAL AND METHODS

Empirical research was carried out, based on a survey conducted among residents of the City of Zrenjanjina. The research methodology is based on the formulation of the survey on waste management (Table 1). Questions are normally designed to incorporate awareness of the respondents about the problem ie. basic claims and findings and incorporate respondents' opinions on various aspects of the subject dealt. Part of the survey are further sub- target students Technical Faculty "Mihajlo Pupin" in Zrenjanin, in order to comprehend the awareness and knowledge of young educated ljidi. The second part of the questionnaire were randomly distributed in order to look into the minds of people with different levels of educational attainment and of different ages. Information based on data from surveys are basically quantification type, with elements of qualitative type in a few questions. Data were statistically analyzed after which the results are displayed on a graph for better visibility. The objectives of this study are:
- Consideration of awareness on waste management in an appropriate way in the City of Zrenjanin.
- Determining the attitude of citizens about whether they think the proper way affect the protection of the environment and whether it adequately manage the waste that is garbage.

- Determine what actions and activities undertaken by citizens about environmental issues.
- Analysis of the awareness of the citizens in the segments of sustainable development, such as environmental protection and waste management.
- Detecting bottlenecks and find solutions that would affect the Waste Management Plans in Zrenjanin to a higher level.

Table 1: Survey " Waste Management (trash) "1

Dear Sir / Madam , the survey is carried out to the student writing on the faculty. The survey was anonymous and the data from it in any way will not be abused. Please carefully fill out the survey. Thank you for your cooperation and for your time. * Note: The possible responses are regulated by the numbering so that circling number 1 give complete denial of the question, and by rounding the number up to 5 confirm the question. For example: 1 - no, 2 - way, 3 - maybe 4 - a, 5 - to (descriptions of numbers are adjustable according to the set question).		
Waste Management (Collection)		
Ordinal	Questions	Answers
1 th	Did you know that most of the waste materials can be recycled?	1 2 3 4 5
2 th	To what extent do you believe that waste sorting and recycling pozitivmo its further impact on the lives of every individual?	1 2 3 4 5
3 th	Do you think that you are well informed about the collection, storage and disposal of waste?	1 2 3 4 5
4 th	Do you think that the sorting of waste is fully enabled in Zrenjanin?	1 2 3 4 5
5 th	Do you throw the waste in a place not designed for it?	1 2 3 4 5
6 th	Do you throw in PET containers that are designed for that purpose?	1 2 3 4 5
7 th	* If the 6 given the negative response, write why:	
8 th	Do you think that there is in the municipality of Zrenjanin dovaljan number of containers provided for waste that is recycled?	1 2 3 4 5
9 th	Do you think that the task of the state to organize and motivate people to perform separation of waste?	1 2 3 4 5
10 th	* If the 9th answered positively, write your suggestions on how the government could motivate people to perform separation of waste:	
11 th	Did you know that recycling contributes Reducing landfill and soil degradation?	1 2 3 4 5
12 th	Did you know that when the materials we recycle, getting new products reduces the need to use natural resources?	1 2 3 4 5
13 th	Did you know that the raw resources of the planet are limited?	1 2 3 4 5
14 th	Did you know that it is far more energy when we get new products, processing of natural resources, but when it is made from recycled materials.	1 2 3 4 5
15 th	Do you think that in the future to modify people's awareness towards waste generated?	1 2 3 4 5

RESULTS AND DISCUSSION

We will now graphically presents the research results, which are based on surveys of waste management. The following table (table 2). Provides insight into the social features respondents and respondents who underwent a survey on waste management.

*Table 2: Social characteristics of the respondents of the "Waste Management"**2***

Social characteristics of respondents (rounded)					Total
What is your gender?	M	F			
	25	*16*			
How old are you?	*15-30*	*30-45*	*>45*		
	15	*12*	*14*		
The level of education?	PS	*SSS*	*VŠ*	*VSS*	
	10	*17*	*4*	*10*	*41*

1 Seminarski rad, „Održivi razvoj u Opštini Zrenjanin“ Mila Zakin
2 Seminarski rad, „Održivi razvoj u Opštini Zrenjanin“ Mila Zakin

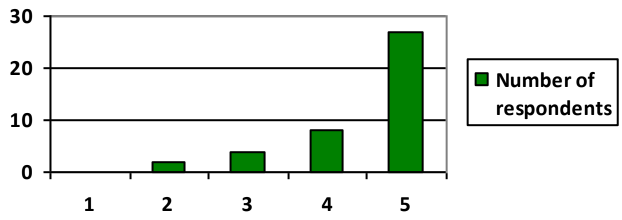

Figure 1. Familiarity of recycling waste materials

Based on the perceived informisnosti citizens (Fig. 1), it can be concluded that the majority of respondents were instructed to most of waste materials can be recycled, while a minority respondents who did not know enough about. It is very gratifying that none of the respondent to fully not commented that was not fully addressed the majority of waste recyclable materials.

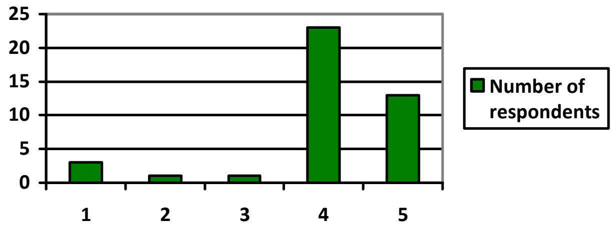

Figure 2. Citizens' opinions about the impact of waste segregation and its further recycling in the life of every individual

Based on the perceived informisnosti citizens (Fig. 2), it can be concluded that the majority of respondents believe that waste sorting and recycling pozitivmo its further impact on the lives of every individual. Emphasis has been given to the minority that does not share the view that adequate waste management has positive results on each individual, and should be more widely explained exactly how waste sorting and recycling pozitivmo its further impact on people's lives.

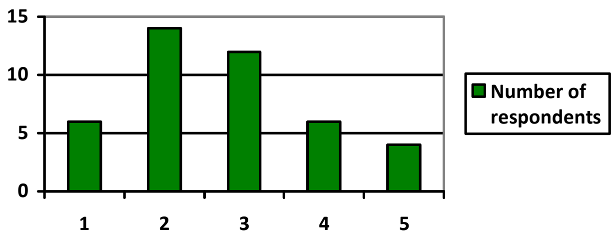

Figure 3. Being informed about the collection, storage and disposal of waste

Based on the perceived informisnosti citizens (Fig. 3), it can be concluded that in the majority of citizens believe that they are not sufficiently informed or are not sure that you are well informed about the collection , storage and disposal of waste. Given that citizens are aware of the most positive that adequate waste management has a positive effect on each individual we have seen in the previous figure, 2 (Fig. 2), they should use their majority opinion and inform them about how, in what way and where to dispose of waste and to present them with all the benefits that you would as a result of a higher percentage of citizens about the waste.

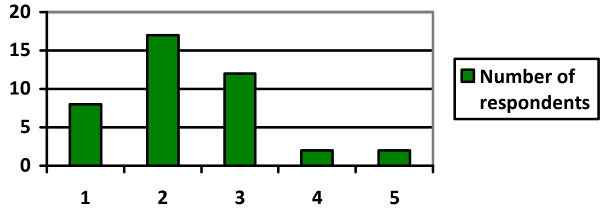

Figure 4. The possibility of sorting waste in the municipality of Zrenjanin

Addition, based on the opinions of citizens (Fig. 4), it can be concluded that in the majority of citizens believe that waste segregation is not fully enabled in the municipality of Zrenjanin, a percentage was vague due to lack of information, while a small number declared that he thought the separation of waste enabled. Sorting waste is poorly developed, the PUC shall classify only five containers, cardboard, nylon and metal by means of contracts it has signed with certain companies. Company made the purchase of certain raw materials at the main landfill, purchase of raw materials already sorted or sent his team to carry out those waste separation among the received waste.

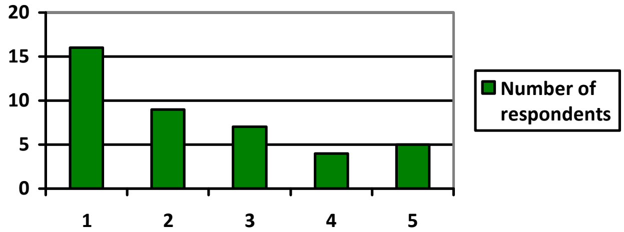

Figure 5. Waste Disposal in places not designed for it

Addition, based on the testimony of citizens (Fig. 5), it can be concluded that the majority of people dispose of waste in a place designated for that purpose, with fewer pleaded not waste disposed in places provided for that purpose. To encourage citizens to dispose of waste only in places for this purpose, they should be first made available to the containers, cans, recycled islands, recycling yard, etc., in order to properly dispose of the waste. In the last few years, the town was covered in the buckets and containers for recycling a waste, but a lot to do on the availability of waste disposal. When talking to disposal must be emphasized that it is necessary separation of waste at a larger scale. In addition to classic containers are only containers for PET packaging as for other types of waste sorting is not enabled. It is necessary to introduce more containers for waste separation, such as: 1. In the season of pruning trees, mowing and landscaping, it is necessary in each settlement is 1 or 2 dedicated container for it to be otherwise would not have green mixed with other household waste or be left with the trash. 2. That in every neighborhood of the designated disposal of hazardous waste. 3. In the next five containers for packaging, provide containers/bins for aluminum cans, glass, paper/cardboard, and other materials that can be recycled. When enabled citizens to a particular type of waste disposed of at prescribed places, and they do not, they should be strict penalties warn. Citizens need to continually emphasize the benefits of proper disposal of waste and the benefits of that, inform them, for example through leaflets, letters to the PUC, a variety of activities and educational workshops. It might also be introduced to the containers is vividly emphasized the importance of proper disposal of certain types of waste. Residents living in buildings have the advantage as regards the possibility of classification of waste, and the account that should be introduced to the citizens who live in the houses have the ability to classify the waste.

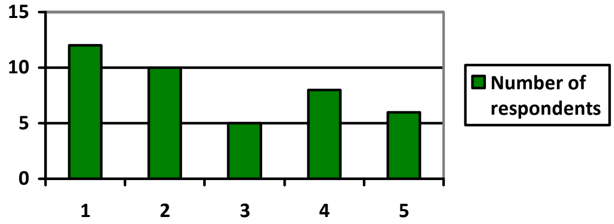

Figure 6 . Disposal of PET into containers that are designed for that purpose

Addition, based on the statement of Citizens (Fig. 6), it can be concluded that a slightly higher percentage of respondents said that they do not delay in PET containers for this purpose, but it should be noted, however, that a considerable number of the expectations pleaded properly disposed PET bottles.

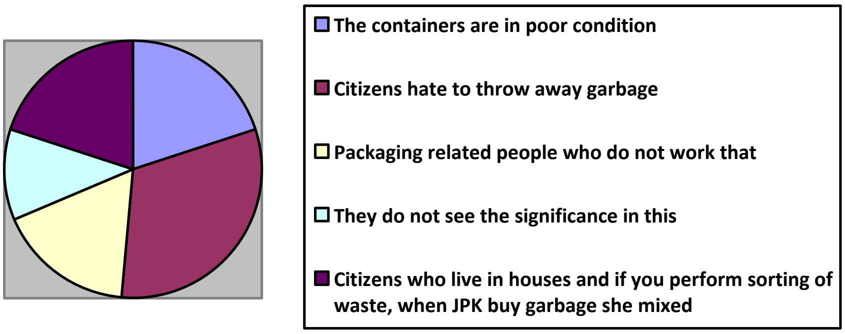

Figure 7. Reasons for inadequate waste PET bottles

Based on the plea of the respondents (Fig. 7), we conclude that the answers given in a number of unfounded, although the containers are in poor condition, they serve a purpose, also people should be made aware that although PET relations between people who are responsible for it, they was sold to entrepreneurs who are authorized to purchase it so that packaging be properly used, ie. recycled. You need people to visualize it as their duty to throw the packaging appropriate place. They also need to present predosti recycling of PET, it would be best to each container is indicated graphically what is saving and recycling plastic saves. The only established excuse for not sorting and throwing plastic package on the contingency of the citizens who live in the houses do not have the ability to perform separation of waste, as it PUC during the collection mixed with other waste. It is necessary to allow selecting plastic waste when they gather and to the citizens who live in the houses could become aware of proper disposal.

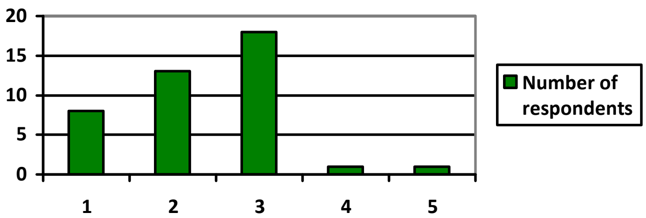

Figure 8. Number of containers provided for waste that is recycled Municipality of Zrenjanin

According to the statements of Citizens (Fig. 8) it can be concluded that it is their opinion that there is a sufficient number of recycling containers. Many of the respondents remained neutral as a result of interest and information for certain segments of the community functioning.

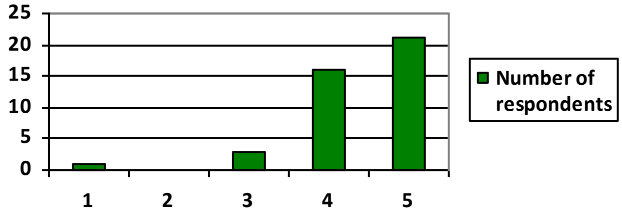

Figure 9. State responsibility to organize and motivate people to perform separation of waste.

Based on the analyzed statements citizens (Fig. 9), it can be concluded that the majority of respondents agreed that the task of the state to organize and motivate people to perform separation of waste.

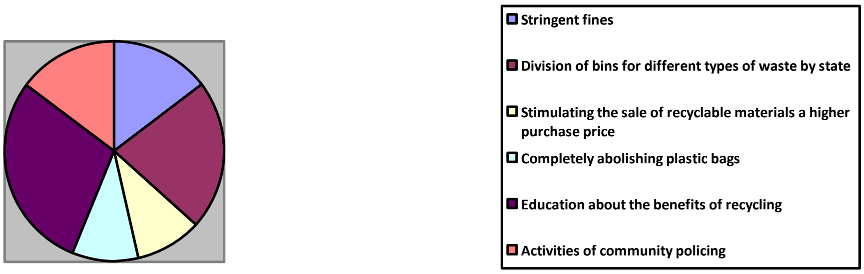

Figure 10. Proposals to state to motivate people to perform separation of waste

Suggestions that the government could implement to motivate people to perform separation of waste are shown in Figure 10 (Fig. 10).

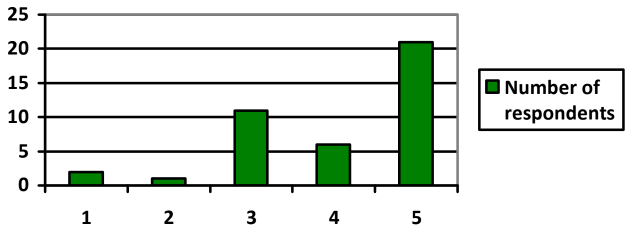

Figure 11. Contribution to Reducing landfill recycling and degradation of soil

Addition, based on the opinions of citizens (Fig.11) can be concluded that in the majority of citizens believe that recycling contributes Reducing landfill and soil degradation, a significant percentage of respondents was vague due to lack of information, and very few pleaded thought that recycling does not affect Reducing the landfill and soil degradation. The results were very positive, because according to them it can be concluded that the respondents in the most educated on certain benefits of recycling, the product may have an increased level of activities aimed at protecting the environment.

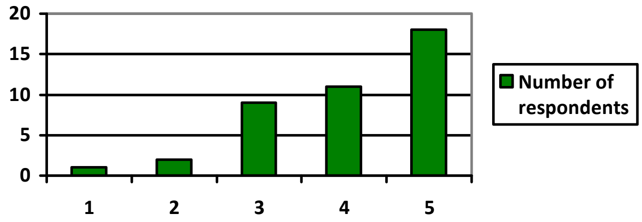

Figure 12. Informing citizens about the need to reduce the use of natural resources using recycling

Addition, based on the results (Fig.12) it can be concluded that citizens in large numbers informed that the recycling of used materials for new products reduces the need for natural resources. Very few of those who are not familiar. The number of those not versed to be reduced to zero raising awareness through education on the products themselves to a greater extent . Some examples of these are the five bottles that promote the benefits of recycling.

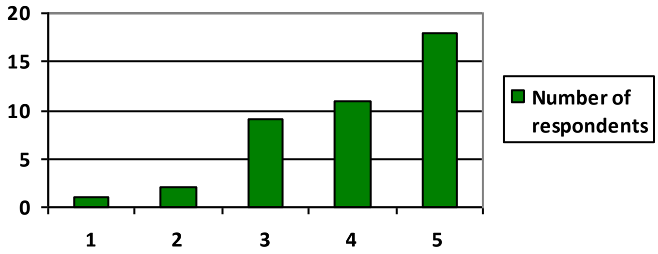

Figure 13. Informing citizens of the limited raw material resources of the planet

Addition, based on the results (Fig. 13) it can be concluded that citizens in large numbers informed that the raw resources of the planet are limited. There are many people who are not familiar. The number of those not informed, to be reduced to zero, the constant information and placing an emphasis on the preservation of raw resources and present it as an alarm for the future.

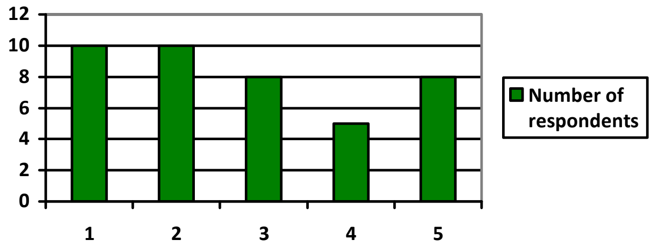

Figure 14. Familiarity of citizens to higher consumption in the acquisition of new products the processing of natural resources

Addition, based on the results (Fig. 14) it can be concluded that the majority of respondents were not sent to a far greater power when the new products obtained by processing natural resources , while minority declared that it is addressed. It is necessary to inform citizens about saving sirovnihskih resources in this way and show them to be very important because the raw resources of the planet are limited, they should also be told to spend more money and resources that could be focused on something significant to human life.

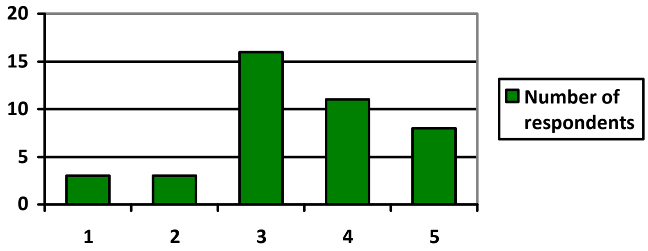

Figure 15. Change in the minds of people in the future to waste

Addition, based on the results (Fig. 15) it can be concluded that the largest percentage of respondents declared indefinite, the rest is distributed to most who thinks that there will be a change of consciousness and the minority that thinks that a change awareness on waste will not occur. It is very positive that the majority of respondents think that the awareness of waste changed for the better in the future.

CONCLUSIONS

Based on the research it can be concluded that people's awareness of waste management in an appropriate manner and the benefits of the treatment of various types of wastes are not yet fully developed. If waste management seriously, result would be drastic changes that lead to a better functioning of the local community in many areas. Not only must change our habits, but must lead to a change of consciousness in the fields of environmental protection. Only with a positive attitude and acceptance of the changes that are needed to make sustainable development went upward, Zrenjanin be a success in many fields. Given the fact that the solutions are directed towards the conservation of natural resources that affect the quality of life of people, their use would provide a clear picture of the quality of the functioning of the local community, and therefore to the citizens within their community social responsibility raised to a higher level.

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TEXTILE RECYCLING

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ABSTRACT

Textile recycling involves the use of scrap fabric to make new products. The share of textile materials in household waste is about 5-10%. In addition, household textile waste is generated from industrial production of textiles and of the manufacturing industry. Technological textile waste together with consumer textile waste represents a significant potential for use and recycling. Textile material made from natural and synthetic fibers can be recycled. The environmental impact of textile production is not well documented, so *in this paper we give an overview of recycling technology for textile recycling. Recycling textile in the word becomes more and more important while in Serbia it was entirely omitted.*

Key words: *recycling, textile, natural and synthetic textile materials, environmental, waste material.*

INTRODUCTION

Textile recycling is the method of recycling all the textile waste during the whole process of fabrics-making or reprocessing used clothing, fibrous material and clothing scraps from the manufacturing process. Recycled textiles in municipal solid waste are found mainly in discarded clothing, although other sources include furniture, footwear, and nondurable goods such as sheets and towels. Recycled textiles are based on green aspects and gradually become popular.

Most of the textile waste is composed of natural and synthetic polymeric materials such as cotton, wool, polyester, nylon, polypropylene, polyethylene and others. Natural fibers can take hundreds of years to decompose, and once in the landfill may release methane and carbon-dioxide gas into the atmosphere. The even more durable textiles manufactured from synthetics are designed not to decompose (for nylon 30 to 40 years is necessary to decompose). In the landfill they may release toxic substances into groundwater and surrounding soil. During production, synthetics fiber release nitrous oxide, which is much more powerful greenhouse gas than CO_2 (Nadkarni, 1999).

A variety of technologies have been developed in response to customer demands for recycled products and as alternatives to land filling. Typically recycling technologies are divided into primary, secondary, tertiary, and quaternary approaches. Primary approaches involve recycling a product into its original form; secondary recycling involves melt processing a plastic product into a new product that has a lower level of physical, mechanical and/or chemical properties. Tertiary recycling involves processes such as pyrolysis and hydrolysis, which convert the plastic wastes into basic chemicals or fuels. Quaternary recycling refers to burning the fibrous solid waste and utilizing the heat generated. All these four approaches exist for fiber recycling.

TEXTILE WASTE AND RECYCLING

According to the Secondary Materials and Recycled Textiles Association (SMART) and the Council for Textile Recycling (Brill, 1999), more than one thousand businesses and organizations employing many tens of thousands of workers divert some 2 million tons of textile waste from the solid waste stream. In the Figure 1 is given EPA report of municipal solid waste in 2011 year. Textile waste can be classified as either pre-consumer or post-consumer. Pre-consumer textile waste consists of two by-product materials from the textile, fiber and cotton industries. Each year 750,000 tons of this waste is recycled into raw materials for the automotive, furniture, mattress, coarse yarn, home furnishings, paper and other industries. Approximately 75 % of the pre-consumer textile waste is recycled.

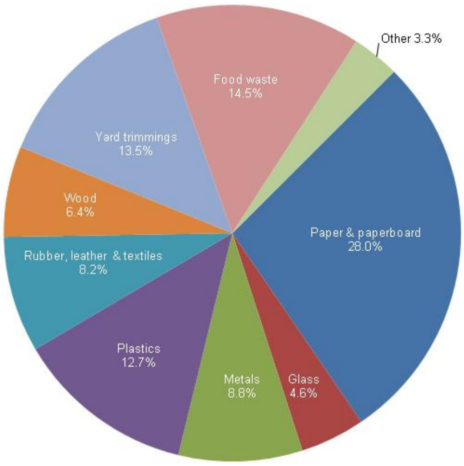

Figure 1. Analysis of municipal solid waste composition for 2011 year (EPA).

Post-consumer textile waste consists of any type of garments or household article, made of some manufactured textile, which the owner no longer needs and decides to discard. These articles are discarded either because they are worn out, damaged, outgrown, or have gone out of fashion (Aguilar-Virgen et al., 2013). They are sometimes given to charities but more typically are disposed of into the trash and end up in municipal landfills. Approximately 1,250,000 tons of post-consumer textile waste (4.5 kg per capita) is recycled annually.

However, the recycled amount represents less than 25% of the total post-consumer textile waste that is generated. Almost half (48%) of the recovered post-consumer textile waste is recycled as secondhand clothing, which is typically sold to third-world nations. Approximately 20 percent of the material processed becomes wiping and polishing cloths. Finally, 26 percent of this post-consumer waste is converted into fiber to be used in products similar in nature to those manufactured from pre-consumer textile waste.

According to a U.K. industry source, about 50% of collected textile is reused, and about 50% are recycled. About 61% of recovered wearable clothes are exported to other countries. In some African country, as may as 80% of people wear used clothing. The issue of sending used clothing to Africa is generated some degree of controversy as to the benefits of such initiatives, where it can have a negative impact on local textile industry, native dress and local waste generation.

For textile to be recycled, there are basic differences for natural and synthetic fibers. For natural textile:

Figure 2. Label recycling of cotton

- ✓ Incoming unwearable material is sorted by type of material and color. Color sorting results in fabric that does not need to be re dyed. The color sorting means no re-dying is needed, saving energy and avoiding pollutants.
- ✓ Textile are then pulled into fiber or shredded, sometimes introducing other fibers into the yarn. Depending on the end use of the yarn, other fibers may be incorporated.
- ✓ The yarn is then cleaned and mixed through a carding process.
- ✓ Then the yarn is re-spun and ready for subsequent use in weaving or knitting (special processes).
- ✓ Some fibers are not spun into yards, however. Some are compressed for textile filling such as in mattresses.

In the case of synthetics textile the process is rather different. Polyester based textiles, garments are shredded and then granulated, and processed into polyester chips. These are subsequently melted and used to create new fibers for use in new polyester fabrics. The fiber produced from recycled garments and fabrics are of the same high quality as those produced from virgin polyester derived directly from oil.

Recovery and recycling provide important environmental benefits:

- ✓ Decreases landfill space requirements, bearing in mind that synthetic fiber products do not decompose, and that natural fibers may release greenhouse gases;
- ✓ Reduced pressure on virgin resources;
- ✓ Reduced consumption of energy and water;
- ✓ Results in less pollution, as fibers do not have to be transported from abroad and
- ✓ Lessened demand for dyes.

RECYCLING TECHNOLGY FOR TEXTILE

There are four methods for textile recycling. The first method is mechanical recycling, the second is chemical recycling and the third method is thermal recovery. The last is other method such as the usage in blast furnace instead of the coke. The recycling method of the post consumer textile waste is mainly the mechanical recycling. A part of synthetic fiber manufacturer carries out the chemical recycling.

Figure 3 shows an example of mechanical recycling of synthetic fiber (Toyobo Company, Japan). It is re-melting of Nylon 66 air bag edge materials. Cutting chips of non-coating nylon air bags are collected and re-melted with special chemicals in order to increase it strength and modulus. The recycled resin can be used for molding goods such as engine cover for automobile and others.

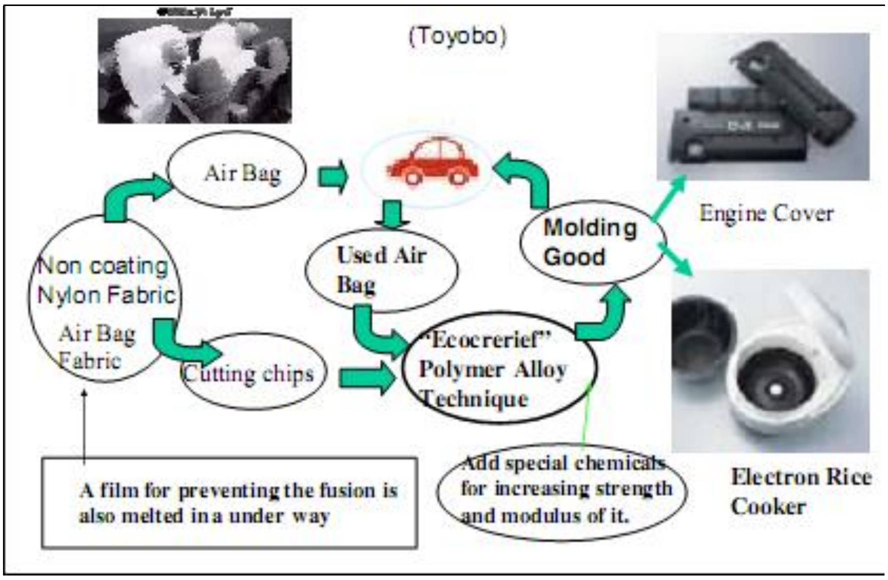

Figure 3. Example of mechanical recycling of synthetic fiber (Toyobo Company, Japan).

The chemical recycling of the same synthetic fiber - Nylon 66 is completely different. Figure 4 shows an example of chemical recycling which is applied in DuPont Company. There are some methods to de-polymerize Nylon 66 to hexamethylene diamine and adipic acid. But in this process separation and purification must be carried out, so it becomes the cost increase. The ammolysis process is very effective. This process is to recover only the hexamethylene-diamine from Nylon 66 and Nylon 6. Adipamid from Nylon 66 and aminocaproamide from Nylon 6 are changed to hexamethylene diamine.

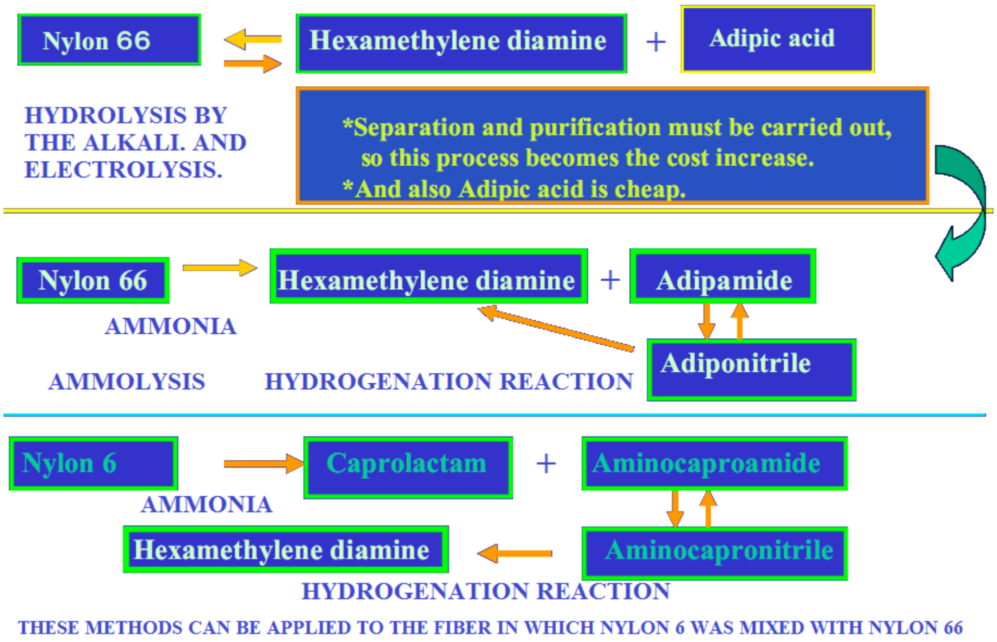

Figure 4. Example of chemical recycling of synthetic fiber (DuPont, U.S.A)

Chemical recycling of polyester is shown in Figure 5. PET bottle and PET fiber can be de-polymerized by ethylene glycol, and it changes in bis-2-hydroxyethyl terephthalate (BHET). The ester interchange is down by methanol and re-crystallization is down, then the crude dimethyle-terephthalate (DMT) is obtained. This DMT can be used for the raw material of the polyester fiber. In this process the technology which removed different polymer and dyestuff, additives and finishing agent such as the pigment has been developed by Teijin (Japan). The production scale of the recovery polyester fiber to DMT is approximately 10,000 tons per year. In addition, the hydrolysis is done to make PTA from the raw material of the PET bottle. This process is so called bottle-to-bottle or fiber-to-fiber process.

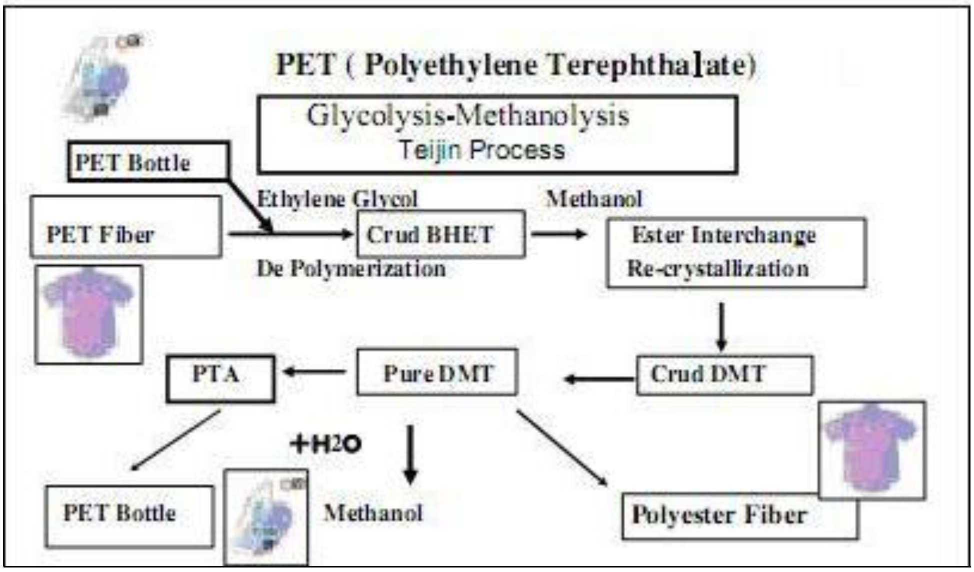

Figure 5. Chemical recycling of polyester (PET bottle to polyester fiber)

This process saved raw materials and was estimated to conserve energy consumption by up to 30% over virgin polyester manufacturing. It is also estimated that this technology prevented up to 13 million plastic bottles (about 254,000 kg of polyester waste) from ending up in landfill sites (Hayes, 2010). Teijin Fibers' closed-loop recycling system from polyester products, known as EcoCircle, prevent clothes from ending up in landfills and can be sustained perpetually. Fabrics produced from these fibers are high quality (Lee et al., 2013), sophisticated, and innovative for use in the ready to wear and active markets for men and women.

Fiber-to-fiber closed loop recycling offers additional benefits such as fiber stability and yarn size equal to that of virgin fiber, no color limitations, it can achieve "pure white". Further, reduction of fuel-based inputs needed for manufacturing products, garment diverted from landfills and incinerators; further CO_2 emission reductions, potential for recycling in perpetuity to a product of equal quality, and extraction of synthetics from some blends.

ECONOMIC AND ENVIORMENTAL ASPECT OF RECYCLING TEXTILE

Synthetic fibers are the most popular fibers in the world – it's estimated that synthetics account for about 65% of world production versus 35% for natural fibers. Most synthetic fibers (approximately 70%) are made from polyester, and the polyester most often used in textiles is polyethylene terephthalate (PET). In the Figure 6 is given global fiber production from 1970 to 2009. The majority of the world's PET production, about 60%, is used to make fibers for textiles; about 30% is used to make bottles. It's estimated that it takes about 104 million barrels of oil for PET production each year, that is 70 million barrels just to produce the virgin polyester used in fabrics. That means most polyester (70 million barrels worth) is manufactured specifically to be made into fibers, not bottles, as many people think. Of the 30% of PET which is used to make bottles, only a tiny fraction is recycled into fibers.

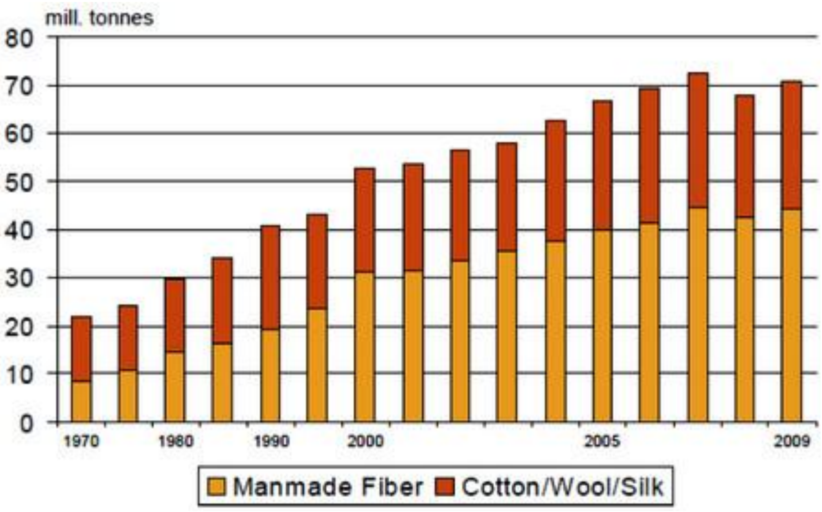

Figure 6. Global fiber production

Recycling of polyester uses less energy that is needed to produce virgin polyester. Various studies all agree that it takes from 33% to 53% less energy. If we use the higher estimate, 53%, and take 53% of the total amount of energy needed to make virgin polyester (125 MJ per KG of ton fiber). The amount of energy needed to produce recycled polyester in relation to other fibers is given in Table 1. Also the content of carbon-dioxide emission in to the air is less than production from virgin polyester (Table 2).

Table 1. Embodied energy used in production of various fibers

Types of fibers	Energy use in MJ per kg of fiber
Hemp, organic	2
Flax	10
Hemp, conventional	12
Cotton, organic, India	12
Cotton, organic, U.S.A	14
Cotton, conventional	55
Wool	63
Recycled PET	66
Viscose	100
Polypropylene	115
Polyester	125
Acrylic	175
Nylon	250

Table 2. CO_2 emission in to the air (kg of CO_2 per ton of spun fiber)

Types of fibers	Crop cultivation	Fiber production	Total
Polyester, U.S.A.	0	9.52	9.52
Cotton, conventional, U.S.A.	4.2	1.7	5.9
Recycled PET			5.19
Hemp, conventional	1.9	2.15	4.1
Cotton, organic, India	2	1.8	3.8
Cotton, organic, U.S.A	0.9	1.45	2.35

Despite the savings of both energy and emissions from the recycling of PET, the fact is that it is still more energy intensive to recycle PET in to a fiber than to use organically produced natural fibers.

Recycling in Fashion industry

Fabrics made from recycled items are now becoming more commonplace with recycled polyester made from recycled drinks bottles now being made by companies such as Patagonia, Marks and Spencer, and Armani jeans. Armani jeans have been incorporating eco fabrics and design since the mid 90’s. Their first eco project started in 1995 with the development of a process to recycle denim. This was revolutionary for the time and the jeans were displayed at the Science and Technology Museum of Milan. Later that year, Armani Jeans developed new materials using 60% recycled wool and recycled cross dyed cotton and introduced hemp eco washes into the collection. This experimentation has continued with the production of an organic knitwear range, the use of pure alpaca and the engagement with fair-trade cotton projects in Peru and Bolivia and recycled polyester.
Levi`s has created a line of shoes made of old jeans “Reused Jean Shoe”.

Some fashion businesses use fabric waste generated during the manufacturing process or material that has been designated as unusable due to minor faults.

Companies like From Somewhere specialise in creating collections from this kind of fabric, and refer to this process as ‘upcycling’ rather than recycling.

Recycling polyester fiber is only one aspect of material production that can help promote sustainability in the fashion industry. As the demand for clothing grows, fashion industry professionals must identify and target any areas within the production chain and implement more sustainable processes or practices with less negative impact.

CONCLUSION

Textile waste is not a large waste stream by weight or volume but has a significant environmental impact connected to the production of textiles. Research on new recycling techniques are needed both in the area of separation and production based on recycled fibres. Some of the materials used in textiles today (e.g. cotton) are not sustainable even with a rather high grade of reuse and recycling.

A significant percentage of recycled products are used by the automobile industry to create thermal and acoustic insulation material for motor vehicles, for packaging and technical products. The automobile industry uses waste fiber in webs bonded. Moreover, the manufacturing sector uses 15% of collected textiles as rags. In Poland, the waste from recycling is used to make paper or rags for industry. Recycled textile material can be used also, in the carpet industry.

To reduce the environmental impact from textiles, the design of clothes need not only be focused on fashion but also on the life cycle of the clothing item. A short lived clothing item (due to fashion, inherent properties or other) needs to be designed with recycling in mind while a long lived clothing item should be designed to last long, perhaps with some parts interchangeable to enable easy repair and to make it suitable for the second hand market.

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WATER QUALITY IN URBAN AREAS (GROUND WATER, DRINKING WATER, WASTE WATER AND FACILITIES)

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NUTRIENT REMOVAL FROM DOMESTIC WASTEWATER BY PURE (*CHLORELLA VULGARIS*) AND MIXED ALGAL CULTURES

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ABSTRACT

The recent high demographic development has accelerated water pollution. Nutrient discharges to natural waters have contributed to an increase in many problems such as eutrophication. Water quality legislation has increased the standards regarding nutrient removal in order to overcome eutrophication problems in receiving waters. With more stringent standards imposed regarding nutrient removal, processes have been developed to remove compounds containing nitrogen and phosphorus. However, nutrient removal from wastewaters is still a significant concern in many countries due to its high cost. Therefore, effective and low cost technologies for nutrient removal from wastewaters are in great demand. Moreover, the harvested microalgal biomass, itself, constitutes a raw material for the production of different high-value chemicals and bio-fuels such as biodiesel, bioethanol, biogas, biohydrogen, etc. The combination of wastewater treatment with algal cultures and production of biofuel/chemicals from this algal biomass serve for sustainability as well. In this context, this study investigated the nutrient removal from domestic wastewater by using two different algal cultures, Chlorella vulgaris and a mixed algal culture in semi-continuous reactors with different solid retention times. Significant nitrogen and phosphorus removal efficiencies were achieved. The produced algal biomass will be used for bio-gas and bio-hydrogen production in the next step of our research.

Key words: *Wastewater, Algae, Nutrients, Eutrophication, Biofuel.*

INTRODUCTION

The recent high demographic development has accelerated water pollution. Nutrient discharges to natural waters have contributed to an increase in many problems such as eutrophication. Water quality legislation has increased the standards regarding nutrient removal in order to overcome eutrophication problems in receiving waters. With more stringent standards imposed regarding nutrient removal, processes have been developed to remove compounds containing nitrogen and phosphorus (Pastor et al., 2008). However, nutrient removal from wastewaters is still a significant concern in many countries due to its high cost. Therefore, effective and low cost technologies for nutrient removal from wastewaters are in great demand.

The production of valuable products as a part of waste management activities serve for sustainability if the techniques used are economically and technically feasible. As a result, there is a continuous effort to find ways of extracting valuable products from domestic, industrial, and agricultural wastewater. The nutrient management of wastewater treatment bears one of these opportunities by producing algae which can then be converted into different high-value chemicals and bio-fuels such as biodiesel, bioethanol, biogas, biohydrogen, etc. (Uludag Demirer et al., 2013). In other words, the harvested microalgal biomass, itself, constitutes a raw material for the production of different high-value chemicals and bio-fuels. Combining wastewater treatment with algal cultures and production of biofuel/chemicals from this algal biomass do not only contribute to the existing problem of nutrient removal in wastewaters but also reduce the carbon footprint of wastewater treatment activities.

Microalgae are one of the most important bio resources that are currently receiving a lot of attention due to a number of reasons. The world is faced with energy challenges in the near future and it is reported that fossil fuel reserves will be depleted in half a century (Chisti, 2007). It has been estimated that biomass could provide about 25% of global energy requirements and can also be a source of valuable chemicals, pharmaceuticals and food additives (Briens et al., 2008).

With the depletion and increase in prices of petrochemical fuels, the advent of innovative ways of generating biofuels using microalgae has the potential of off-setting these pertinent challenges (Park et al., 2011). In addition, the growing of urban population poses a serious threat to the environment due to the release of copious amounts of domestic municipal wastewater. The use of microalgae is desirable since they are able to serve a dual role of treatment of wastewater as well as generating biomass for biofuel production with concomitant carbon dioxide sequestration. In addition, wastewater remediation by microalgae is an eco-friendly process with no secondary pollution as long as the biomass produced is reused and allows efficient nutrient recycling (Rawat et al, 2011).

The discharge of industrial and municipal wastewater poses serious environmental challenges to the receiving water bodies (Arora and Saxena, 2005). The major effect of releasing wastewater rich in organic compounds and inorganic chemicals such as phosphates and nitrates is mainly eutrophication (Pizarro et al., 2006). This problem can be solved by the use of microalgae whereby the waste water is used as feed for microalgal growth. The advantage is that while the microalgae will be removing excess nutrients in the wastewater, there will be concomitant accumulation of biomass for downstream processing (Rawat et al, 2011). The use of a wide range of microalgae such as Chlorella, Scenedesmus, Phormidium, Botryococcus, Chlamydomonas and Spirulina for treating domestic waste water has been reported and efficacy of this method is promising (Wang et al., 2010). Research conducted by Chinnasamy et al. (2010) demonstrated that a consortium of 15 native algal isolates showed >96% nutrient removal in treated wastewater. Biomass production potential and lipid content of this consortium cultivated in treated wastewater were (9.2–17.8) tons/ha·year and 6.82%, respectively. About 63.9 % of algal oil obtained from the consortium could be converted into biodiesel (Chinnasamy et al., 2010). There was a rapid decrease in the levels of metals, nitrates and phosphates after exposing the wastewater to microalgal treatment for short cultivation periods (Wang et al., 2010). This clearly shows that microalgae are efficient at removing metals and nutrients from the wastewater to meet the stringent requirements according international standards. Domestic wastewater streams have been frequently used as a readily available and cost-effective substrate for microalgal growth for biomass production and nutrient removal (Moreno-Garrido, 2008; Wang et al., 2010; Kong et al., 2010).

In this context, this study investigated the nutrient removal from domestic wastewater by using two different algal cultures, *Chlorella vulgaris* and a mixed algal culture in semi-continuous reactors with different solid retention times.

MATERIALS AND METHODS

Culture Types and Cultivation

Two types of cultures were used in the experiments. The axenic *Chlorella vulgaris* culture was obtained from Culture Collection of Algae and Protozoa (Sams Research Services Ltd, CCAP No: 211/11B) and the mixed algal culture was collected from Araç Creek in the vicinity of Karabük University Campus, Karabük. Both of the cultures have been cultivated with enhanced bold’s basal medium (3N-BBM+V). The content of the medium is as follows (g/L); $NaNO_3$: 0.75, $CaCl_2.2H_2O$: 0.025, $MgSO_4.7H_2O$: 0.075, $K_2HPO_4.3H_2O$: 0.075, KH_2PO_4: 0.175, NaCl: 0.025, Na_2EDTA: 4.5 $x10^{-3}$,, $FeCl_3.6H_2O$: $5.84x10^{-4}$, $MnCl_2.4H_2O$: $2.46x10^{-4}$, $ZnCl_2$: $3x10^{-5}$, $CoCl_2.6H_2O$: $1.2x10^{-5}$, $Na_2MoO_4.2H_2O$: $2.4x10^{-5}$, Vitamin B1: 1.2 $x10^{-3}$, Vitamin B12: 1 $x10^{-5}$.

Wastewater Used

The domestic waste water collected from the supernatant effluent of the primary settling tanks at Ankara Tatlar municipal wastewater treatment plant was used in the experiments. The characterization of the waste water is depicted in Table 6.

Table 6: Characteristics of the domestic wastewater used in the experiments

Parameter	Value
Optical Density @ 685 nm	0,09 ± 0
TS (mg/L)	413 ± 17
VS (mg/L)	269 ± 17
TS (%VS)	65
Chlorophyll-a (mg/L)	N.D.
pH	7,95
tCOD (mg/L)	254 ± 2,5
sCOD (mg/L)	78,5 ± 0,3
TN (mg/L)	42,1 ± 2,1
TKN (mgL)	42 ± 5,9
Organic-N (mgL)	11,5
TAN (mgL)	30,5 ± 1,2
NO3-N (mgL)	< 1
NO2-N (mg/L)	< 0,01
O.PO4-P (mg/L)	4,9 ± 0,3

Semi-continuous Reactors

Six 1-L gas wash bottles were used as reactors. Reactors labeled with X were inoculated with axenic *Chlorella vulgaris* while reactors labeled with Y were inoculated with mixed culture collected from Araç Creek. The reactors coded with 1, 2 and 3 were run at 2days, 4 days and 8 days solids retention times (SRT), respectively (Table 5). The reactors were operated at (30±1)˚C with 120 μmol m^{-2} s^{-1} continuous illumination using T8 fluorescent tubes (OSRAM L18/840). In 24 hour cycles a predetermined volume of the mixed liquor from reactors were withdrawn and same volume of domestic wastewater stored at 0^oC was added to the reactors. All the analytical analyses were conducted on the mixed liquor withdrawn from the reactors. For example, for the reactors with 4 days of SRT, the daily replaced volume was 250 ml. The pH value of each reactor was adjusted to 6 with 5 N H_2SO_4 daily, after the reactors were feed with domestic wastewater. Mixing and aeration were accomplished by pumping ambient air at 0.5 vvm with the help of an air pump (Resun, Model No: AC-9602).

Table 7: Reactor Configurations

Reactor	SRT (day)	Culture Type Used
X1	2 days	*C. vulgaris*

X2	4 days	*C. vulgaris*
X3	8 days	*C. vulgaris*
Y1	2 days	Mixed culture
Y2	4 days	Mixed culture
Y3	8 days	Mixed culture

Analytical Methods

TS, VS, TKN and chlorophyll a analyses were performed according to Standard Methods (2005). Optical density was measured with a spectrophotometer at 685 nm (Hach, Model No: DR2800). Total COD , soluble COD (Lovibond GmbH, Catalog No: 2 42 07 20/2 42 07 21), total nitrogen (Lovibond GmbH, Catalog No: 53 55 50) , total ammonia nitrogen (Lovibond GmbH, Catalog No: 53 56 00/53 56 50), nitrate (Lovibond GmbH, Catalog No: 53 55 80), nitrite (Lovibond GmbH, Catalog No: 51 23 10), and ortho-phosphorus (Lovibond GmbH, Catalog No: 53 52 00) analysis were done with commercial test kits.

RESULTS AND DISCUSSION

Three semi-continuous reactors at SRT of 2, 4 and 8 days were operated for both cultures as seen inTable 5. However, the reactors with 8 days of SRT (X3 and Y3) failed to reach steady state conditions. The Initial chlorophyll a content for X3 and Y3 were reduced from 22.24 mg/l to 0.52 mg/l and 18.42 mg/l to 0.39 mg/l, respectively. The reduction in chlorophyll a concentration was also visually observed with the color change in these reactors. The 8 days of SRT was not appropriate for algae to grow in the tested domestic wastewater. Therefore, reactors X3 and Y3 were terminated and their results are not presented or discussed here.

During the semi-continuous runs on the treatment of domestic wastewater, the pH, optical density (OD) at 685 nm, total solids, volatile solids, total nitrogen, total ammonia nitrogen, orthophosphate and COD parameters were monitored periodically. The pH parameter was observed to maintain the cultures at an optimum pH for growth. As the pH was adjusted 6 with 5N H_2SO_4 after addition of the domestic wastewater to the reactors, the pH in the mixed liquor was observed in the range of 8 to 11 in the following day. The pH of the reactors can be seen in
Figure *24*.a through Figure 27.a.

OD at 685nm was used to quantify the algal biomass concentration in the reactors. Total Solids and Volatile Solids and Chlorophyll a concentrations are also other methods used for monitoring the algal biomass in the reactors. Measurement of optical density is a relatively quick and easy method compared to other analytical methods. The trends in optical density and total solids was very similar in all the 4 reactors as it can be seen in a
Figure *24*.b. and
Figure *24*.c. through Figure 27**.**b and Figure 27.c., respectively. Steady algal biomass is one of the indicators of steady state conditions in the reactors.

In reactor X1, the initial OD at 685nm was around 0.95. It increased to a range of 1.2-1.6 in X1 and then decreased to 0.35 on Day 7 (Figure 1.b). This abrupt decrease is thought to be due to the low SRT applied to the reactors. To achieve SRT of 2 days, 50% of the mixed liquor in the reactor was replaced with domestic waste water daily. However, OD values recovered gradually afterwards and reached to 0.99 on Day 11. This indicated the growth of the *C. vulgaris* culture in the reactor. This is supported by the total solids concentration shown in Figure 1.c. It indicated a similar trend with respect to OD. That is a decreasing trend in Total Solids (TS) was observed beyond Day 2. Yet, it recovered after four days and stabilized in a range of (950-1100) mg/l. The Volatile Solids (VS) concentration beyond the first week of operation where the culture was adopted to operating conditions was in the range of (500-660) mg/l (Figure 1.c).

A sharp increase followed by a decrease in OD after around a week of operation was also observed in X2. However, the extent of the decrease was not as sharp as X1. This is probably due to the higher SRT (4 days) applied to the reactor (Figure 2.b). Beyond this period, the OD values varied between 0.9-12. The TS and VS data was mostly stable (Figure 2.c) indicating steady-state operation. The VS concentration ranged between 500-650 mg/l beyond 10 days of operation. When the VS concentration data in both reactors are compared, it will be seen that they are very similar. This is an important finding since one of the objectives of this study is to subject the produced algal biomass to further processing for biofuel production.

In a reactor Y1, the OD trend was similar to reactor X1. The initial OD of reactor Y1 was 0.95. It increased to around 1.8 initially and after a decrease to around 1.3 it was stable at 1.5-16 during Days 6-10. However, it was then decreased sharply and reduced to 0.75 on Day 15. This period was followed with a gradual increase until Day 20. Then, it ranged between 1.1-1.3 until the end of the experiments. Similar to Reactor X1, the low SRT led to an initial reduction in the algal biomass, then the mixed cultures was adopted to operating conditions and the OD concentration was stabilized. This is an indication of steady growth of the mixed algal cultures (Figure 3.b). This trend was slightly observed in the solids data (Figure 3.c).

In reactor Y2 a sharp increase followed by a slight decrease in OD, where it was stable for about 10 days (Days 4-13). This period corresponded to OD level of around 2.2 which was significantly higher than that of Reactor Y1. Then, a gradual decrease pattern was observed between Days 15-26 at the end of which the OD dropped to 0.01 level which indicated the wash-out of the culture from the reactor (Figure 4.b). The solids data revealed steady operation until Day 26 from which the solids in the reactor promptly decreased (Figure 4.c). These observations indicated the unsuitability the 4-days SRT level for the continuous growth of the mixed algal cultures studied.

Another indicator which provides quantitative information on the algal biomass is chlorophyll a concentration of the mixed liquor. In reactor X1, high chlorophyll a contents of 24-33 mg/l were observed. Moreover, the ratio of (O.D. 664)/(O.D.665) which indicates healthy algal growth between the values of 1.0-1.7 (Standard Methods, 2005) , were determined as 1.61-1.68 for X1. In reactor X2, chlorophyll a contents of (28-44) mg/l were observed. The ratio of (O.D. 664)/(O.D.665) were determined as 1.51-1.60 for X2 indicating healthy algal growth in reactor X2. In reactor Y1, the observed chlorophyll a contents were in the range of (28-29) mg/l. The ratio of (O.D. 664)/(O.D.665) were in the range of 1.61-1.69 indicating healthy algal growth in this reactor.

Nutrient Removal

When the TN and TAN values are considered in reactor X1 (Figure 1.d-e), it will be seen that very high removal efficiencies were achieved. Namely, (81-90)% for TN and (83-91)% for TAN were obtained. As seen from Figure 1.f, a relatively high performance was observed for phosphorus removal (68-83) %.

In reactor X2, the TN and TAN removal rate was significantly higher (Figure 2.d-e). Namely, (93-98) % for TN and (98-100) % for TAN (beyond the first week of operation) were obtained. Similarly, a relatively high (85-99) % performance was observed for phosphorus removal as well (Figure 2.f). Based on these figures, it can be stated that SRT of 4 days resulted in superior performance with respect to nutrient removal for *C. vulgaris c*ultures.

In mixed culture with 2 days of SRT (Y1), TN and TAN removal rates were slightly better than the *C. vulgaris* cultures. Namely, (88-97) % for TN and (88-100) % for TAN were obtained (Figure 3.d-e). A high removal performance was also observed for phosphorus removal (90-98) % beyond Day 20 as it can be seen from Figure 3.f.

In reactor Y2 high nutrient removal performance was observed until Day 25 (Figure 4.d, e, f). However, since the algal biomass was washed out in this reactor, the nutrient removal efficiencies are not further discussed here.

The Chemical Oxygen Demand (COD) removal performance of algal cultures was low as expected (Figure 1.g through Figure 4.g). Since the reactors were operated with continuous light source, the aerobic respiration of algal biomass was minimal. The governing activity of algal biomass was synthesis of carbohydrates by converting light energy and atmostpheric CO_2 into chemical energy, i.e. photosynthesis.

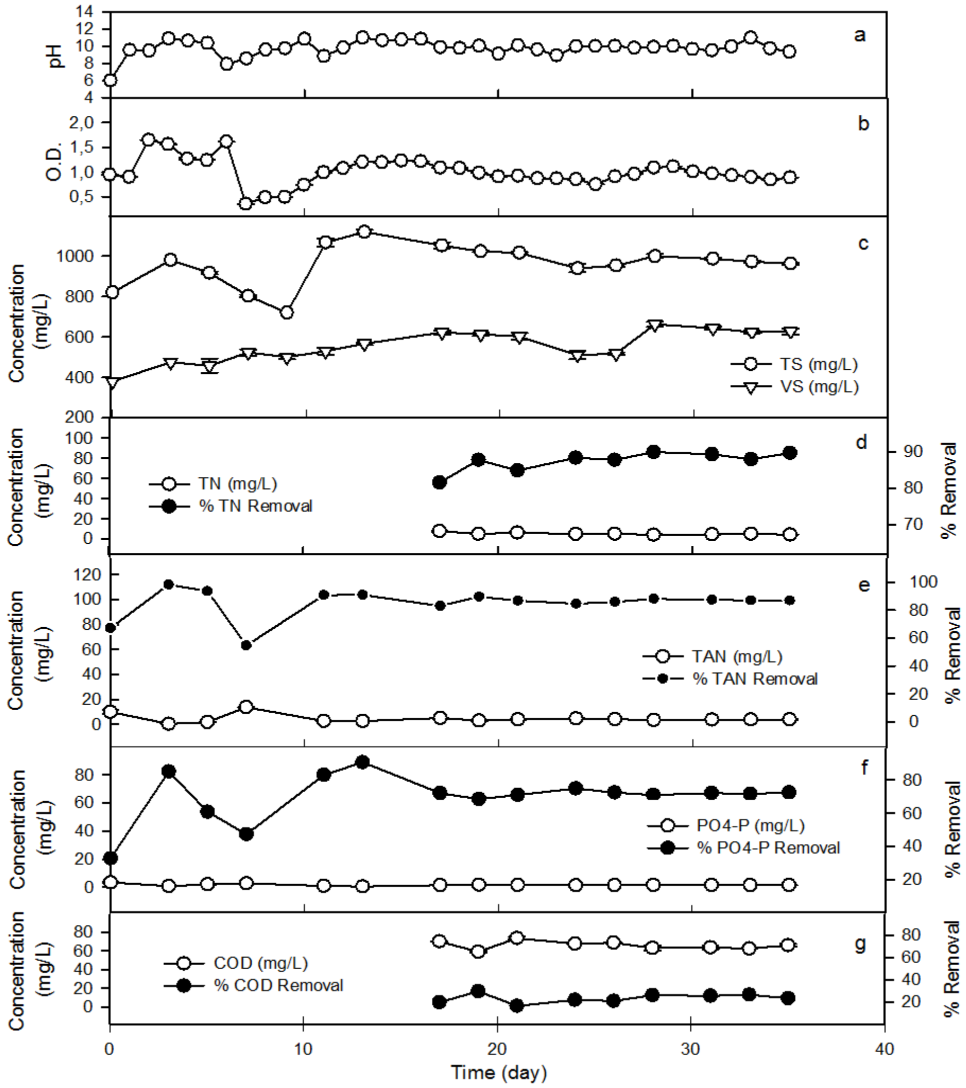

Figure 24. Mixed liquor characteristics of reactor X1, a) pH; b) Optical Density at 685nm; c) Total Solids and Volatile Solids Concentration; d) Total Nitrogen Concentration and Total Nitrogen Removal Percentage; e) Total Ammonia Nitrogen Concentration and Total Ammonia Nitrogen Removal Percentage; f) Orthophosphate Concentration and Orthophosphate Removal Percentage; g) COD Concentration and COD Removal Percentage

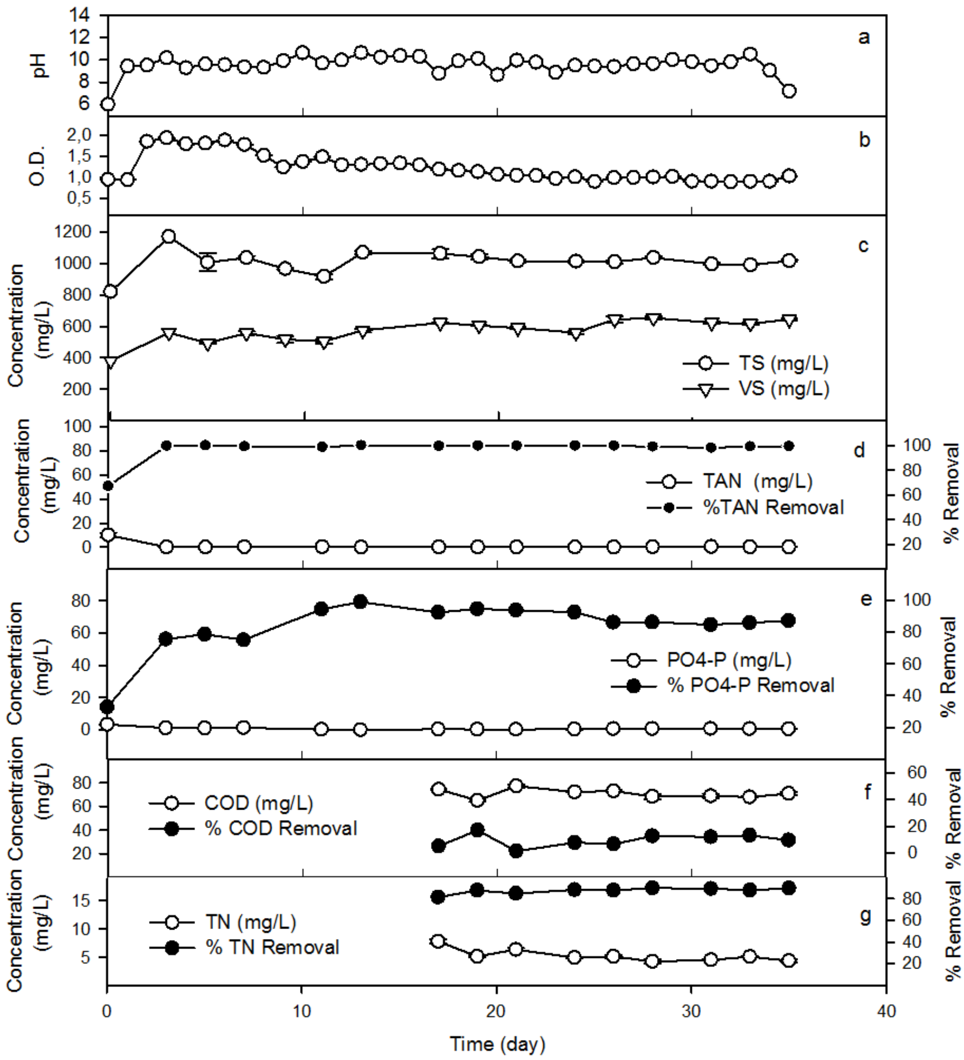

Figure 25. Mixed liquor characteristics of reactor X2, a) pH; b) Optical Density at 685nm; c) Total Solids and Volatile Solids Concentration; d) Total Nitrogen Concentration and Total Nitrogen Removal Percentage; e) Total Ammonia Nitrogen Concentration and Total Ammonia Nitrogen Removal Percentage; f) Orthophosphate Concentration and Orthophosphate Removal Percentage; g) COD Concentration and COD Removal Percentage

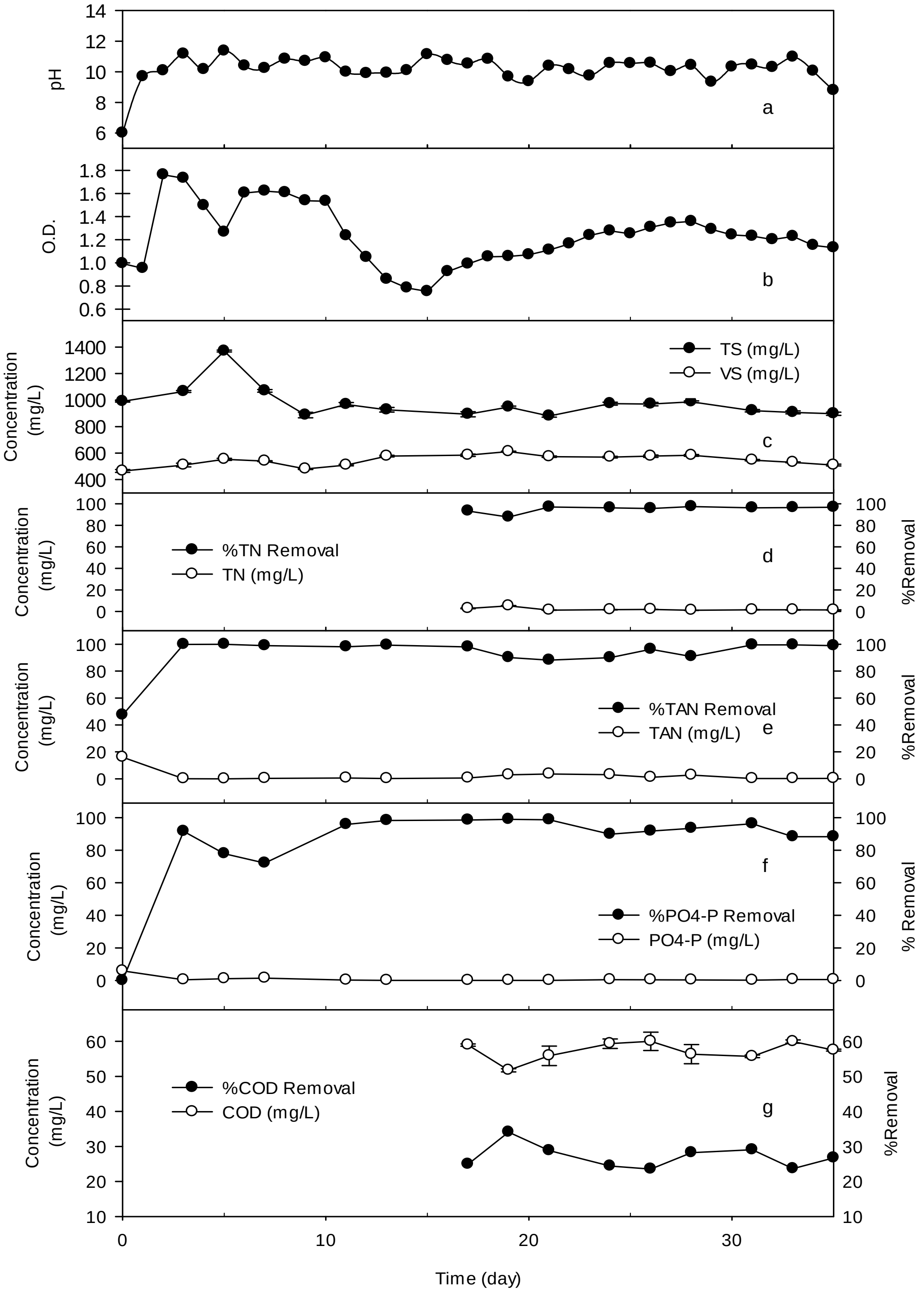

Figure 26. Mixed liquor characteristics of reactor Y1, a) pH; b) Optical Density at 685nm; c) Total Solids and Volatile Solids Concentration; d) Total Nitrogen Concentration and Total Nitrogen Removal Percentage; e) Total Ammonia Nitrogen Concentration and Total Ammonia Nitrogen Removal Percentage; f) Orthophosphate Concentration and Orthophosphate Removal Percentage; g) COD Concentration and COD Removal Percentage

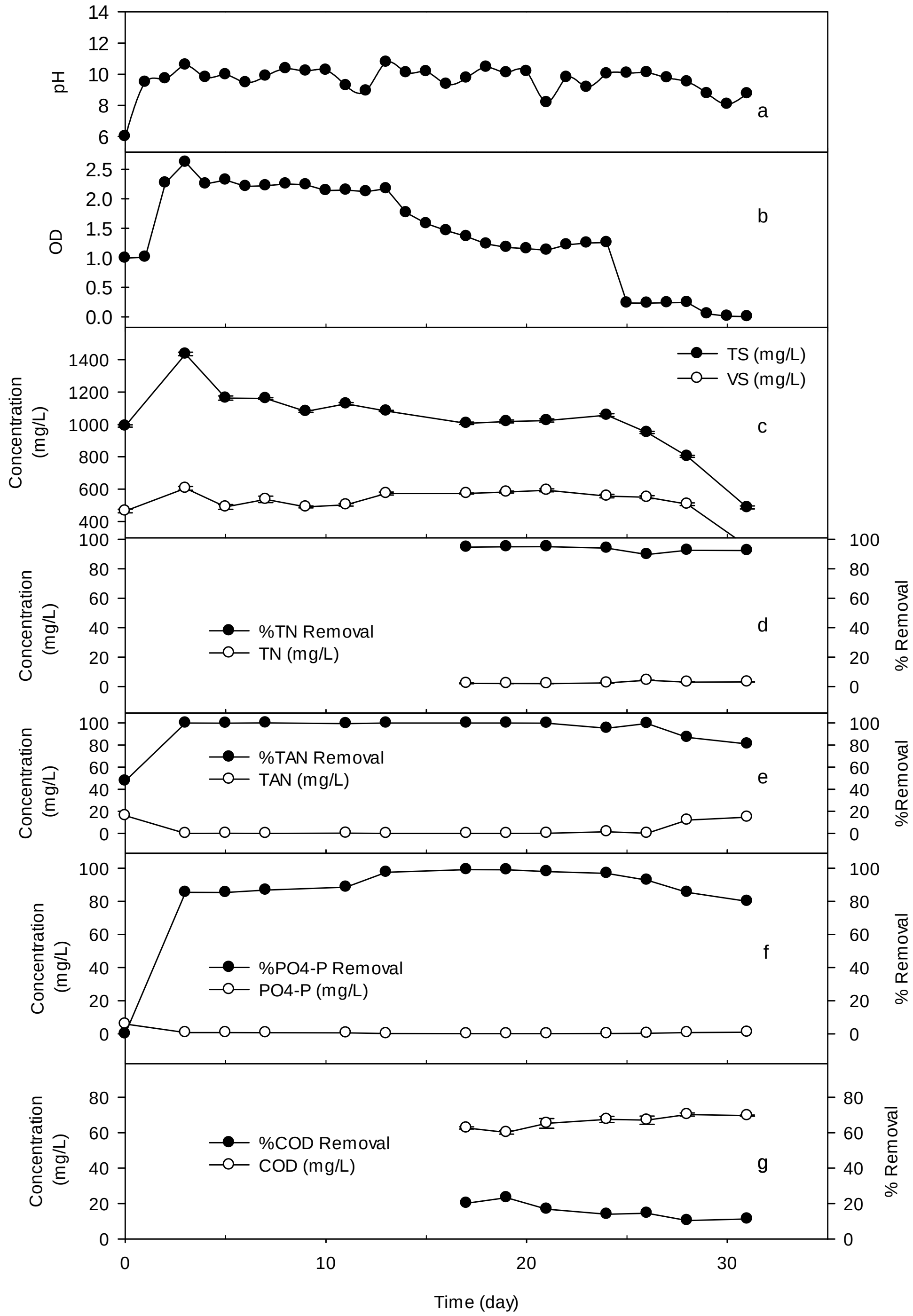

Figure 27. Mixed liquor characteristics of reactor Y2, a) pH; b) Optical Density at 685nm; c) Total Solids and Volatile Solids Concentration; d) Total Nitrogen Concentration and Total Nitrogen Removal Percentage; e) Total Ammonia Nitrogen Concentration and Total Ammonia Nitrogen Removal Percentage; f) Orthophosphate Concentration and Orthophosphate Removal Percentage; g) COD Concentration and COD Removal Percentage.

CONCLUSIONS

In this study, treatment of pretreated domestic wastewater with algal biomass was studied. In the tests' run, 8 days of SRT was found too long for the domestic wastewater tested. At two days of SRT, both the reactor inoculated with *C. vulgaris* and mixed culture achieved over 80 % TN, TAN and over 68% ortho-phosphate removal rates. The nutrient removal rates were slightly higher in the reactors seeded with mixed culture was relatively higher than the reactors seeded with *C. vulgaris*. When the rectors were run with 4 days of SRT, TN removal rates were increased to over 93 %, while TAN and ortho-phosphate removal rates were increased to over 98 % and 85 %, respectively. These results indicated that for the wastewater tested SRT of two days was more ideal for nutrient removal than SRT of four days. In reactors seeded with mixed cultures and operated with 4 days of SRT, the algal biomass was washed out. Considering that at 2 days of SRT, the mixed culture reactors achieved as high as 97 % TN removal and 98 % ortho-phosphate removal, it was expected to observe nutrient limitations and washout of algal biomass at SRT of 4 days.

In this study both of the cultures achieved successive nutrient removal rates and proved to be applicable for treatment of domestic wastewater where the discharging water bodies are sensitive to external nutrient loads. Moreover, the produced algal biomass can be converted to bioenergy with different processing techniques.

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PROJECT PEDAGOGY EFFECTIVENESS EVALUATION IN HIGHER EDUCATION

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ABSTRACT

The objective of environmental engineering BSc education is to develop competences like complex system approach, problem recognition and resolution, lifelong learning and responsible attitude for the environment in addition to high level scientific knowledge. To achieve this goal, besides professional academic training, environment education needs to be implemented, where project pedagogy –as the strategy of environment pedagogy- can be efficiently applied. The study aims to prove the effectiveness of project education in terms of professional knowledge as well as in environmental attitudes by the results of project „Load of impurities in low water streams" validated by two-group environmental pedagogy experiment. Based on the results it can be stated, that project pedagogy can be well integrated with traditional pedagogical methods and may become their efficient supplement in environmental engineering BSc education.

Keywords: *environmental engineering education, environmental education, environmental awareness, responsible attitude, environmental attitude*

INTRODUCTION

The objective of environmental engineering BSc education is to establish and develop competences like complex system approach, problem recognition and resolution, lifelong learning and responsible attitude for the environment in addition to develop high level theoretical scientific knowledge. Experiences gathered since the new system has started show, that students' performance and their attitude to the professional courses taken are not efficient enough in this form of education. They are not motivated to learn due to the lack of direct experiences, their need for self-controlled learning is not geared. Students can't see coherencies between different subjects and they are not able to apply what they have learned. Their system-based approach is not adequate and the scope is not enough for developing general and professional competences. The current Environmental Engineering BSc education provides high level theoretical scientific knowledge, but it's not appropriate enough to develop competences laid down in directives and requirements of the education. By fragmenting content of ecological and engineering subjects to different courses, ecological approach can't be ensured. Students can acquire decision making and responsibility skills, but it assumes teaching and learning based on personal experiences.

In the first semester of year 2011/2012, we started a two-group environmental-pedagogy experiment with the aim to confirm that we can develop missing competences through project pedagogy methods, beside high level theoretical scientific education.

Project education is a special, open educational strategy focusing on problems and aims at solving complex problems from real life through activity-orientation. Methods, techniques and materials used enlarge the school frame and provide natural learning environment. [1] Achieving success motivate students to set and reach additional goals. This way self-controlled learning skills evolve, students can formulate their personal goals, learn how to work to achieve these goals, and because of success – as a positive feedback – they can set further goals and motivate themselves. [2]

In the course of project education, students work for a goal, which is appealing and interesting for them. They can choose their partners and work with a flexible schedule. They don't have to meet external requirements, so learning based on personal motivation is a natural consequence. Solving problems motivates students to know more about their topic and they can prepare their products. Learning process is not a pressure, learning is not an obligation, it is a tool for reaching their goals. [3]
The project "Load of impurities in low water streams" would like to demonstrate the results achievable by project education in Water quality protection course of Environmental Engineering BSc.

WATER QUALITY PROTECTION PROJECT: "LOAD OF IMPURITIES IN LOW WATER STREAMS"

This project for environmental engineering students is needed, because:

- Water qualification of Low water streams in Hungary is incomplete; many streams remained without qualification since the launch of WFD.
- During their higher level studies, students should acquire routine in water qualification, it being a basic competence of this profession.
- Exploring the pollution of streams require field trips, and wide knowledge about the catchment area.
- Knowledge of the measuring principles does not mean that students can apply them.
- Natural scientific learning methods (experiments, observation, measure) do not or minimally appear in the education.
- Engineers' society do not have an ecological view, despite that sustainability requires that. Engineers are thinking in a short time effects while working out technologies, but processes are longer in the environment.

Location of the project: Óbuda University (ÓE), Rejtő Sándor Faculty of Light Industry and Environmental Protection Engineering (RKK)
Field exercise location: Aranyhegyi-stream and its catchment area, Solymár and Pilisvörösvár Waste-water Cleaning Plant
Target audience: ÓE RKK Environmental Engineering BSc, second and third grade.
Number of the whole group: 17 students
Duration of the project: 14 educational weeks (one semester)

The problem to be solved by the project group members was the level of pollution in our low water streams and their inadequate quality. Project goal was to explore the basin of the Aranyhegyi-stream and assess the factors influencing quality of the low water stream. During the project work, students worked in four smaller groups (Table 1),that were setup on the first class with the help of a notional map.

Table 1: "Load of impurities in low water streams" project's modules and module devices

Load of impurities in low water streams			
I. Living water - Natural water ecosystem (5 students)	II. Function of waste-water in water quality (5 students)	III. Effects of agricultural activity on water quality (3 students)	IV. Effects of urbanisation processes (4 students)
Exploration of the catchment area	Formation and contents of waste-water	Environmental pollution effect of animal husbandry	Processes and effects of urbanisation
Ecological water qualification through testing macro invertebrates	Waste-water cleaning	Effects of crop production that endanger water quality	Effects of bed-directing
Ecological water qualification through testing macro vegetation	Effects of cleaned waste-water on receivers	Ecological husbandry	Precipitation husbandry

Students could choose module groups based on their personal interest, and then they formulated the problems to be solved. In their work, great emphasis was put on tasks aiming at appropriate water utilization, re-utilization of water and protection of water ecosystems, helping this way to develop environmental awareness, ecological approach and responsible behaviour for the environment.

The output (product) of the project was a water quality map of Aranyhegyi-stream, taking into consideration the expectations of the WFD and established a pattern to qualify other low water streams.

Students collected data and information during the project period and analysed them. The project leader teacher gave a list of literature to the students; this was the first step to collect information from. Students were looking for further literature within their topics and analysed them too. They did biological, physical and chemical tests, which were necessary for the qualification. They appointed test holes during field inspection.

Students discovered coherency of causes and effects based on their tests' results and direct experiences in the environment. They could formulate how problems of water pollution should have been solved. Groups worked independently, they fulfilled tasks and decided responsibly. They prepared a written report together, which contained specifications of the catchment area; pollution sources influencing the quality of the stream with exact coordinates (waste-water cleaning plants, agricultural areas, settlement, rainwater duct, illegal waste deposition, etc.); descriptions of measurements; and their independent researches. They presented this summary at the end of the project. In addition to this summary, they made many various and valuable output materials. They made some records of measurements, articles and a poster for the World Water Day which motivates for sustainable water management. Students made a macro invertebrate cyclopaedia, that can facilitate testing macro invertebrates of Aranyhegyi-stream in the future. They made a cyclopaedia of plants to help testing macro vegetation and a creative machinery measuring water discharge.

In the planning, organisational and construction period we used the following pedagogical methods:

- Methods in the planning period helping to discover personal goals:
  - Thinking aloud, maps of concepts, conversation, heuristic conversation, disputation, explanation
- Methods during organisational period facilitating independency, creativity and research:
  - Observation, collection, analysis, planning
- Methods in the construction period to facilitate independency, creativity, research and cooperation:
  - Observation, measurement, collection, analysis, testing, data processing, systematization, interviews, field work, product, case study, project method, field trip.

Presentation and assessment at the end of the project was very important, because students got feedback of their work. The presentation was a team work, in front of the other teams and an invited jury. After the presentations each team evaluated their own and other team's (modules) works, while the jury evaluated the whole project and wok of the module teams too.

Portfolios and independent works of students were good for evaluating personal achievements within the project. The greatest advantage of the evaluation of independent work is that the learning process and the way to achieve the goal become visible for both the student and the teacher. [4] Portfolios contain plans, drafts, tasks and self-evaluation forms of the students. Making this portfolio helps developing self-evaluation skills, self-reflection and meta-cognition during learning process.

During “Load of impurities in low water streams” project we used many activity-oriented methods in addition to traditional methods (e.g. lectures, explanation, etc.). By enlarging the learning place field work ensured an active, constructive learning space in contrast to passive learning [5], which is very important in environmental engineering education. There are a lot of expectations towards graduated environmental engineers, and we can teach these skills in this kind of learning process. Results of the questionnaire we made and the self-evaluating sheets of the students can show us the efficiency of the project.

EFFICIENCY OF PROJECT EDUCATION IN DEVELOPING COMPETENCES, TWO-GROUP ATTITUDE SURVEY

In our two-group environmental pedagogy experiment, project method was the independent variable, while the dependent variables were the changed knowledge and skills.

At the beginning of the semester second-grade students taking up Water quality protection course and third-grade students taking up Technologies of waste-water cleaning course were given an opportunity to be a member of the project. Joining was voluntary, and members did not get credits for the project, because it was just an extra-curricular experimental course. Students could take up project course in their free time. We chose 17 students (the course was oversubscribed) for the project group. These students were not obliged to visit practical lessons of Water quality protection course, but they had to listen lectures. The Technologies of waste-water cleaning course contains only lectures, that is why students from the project group had to listen them, and at the end of the semester they had to pass the exam normally.

This is how we made the two groups; first is the project group with 17 members, who visited lectures and the project instead of practical lessons; and the second group with 25 members, who visited lectures once a week and practical lessons twice (normal process).

I made a survey at the beginning and at the end of the semester too in both groups. I analysed how dependent variables have changed during the semester.
I used a written questionnaire and answers from students’ self-evaluation sheets. In this way I could analyse students’ environmental attitude, participation in work, intensity, and efficiency of the method.

Before the survey I made these hypotheses:

- Environmental responsibility and ecological thinking of the project group will change significantly in a positive way against the control group
- Project group’s environmental attitude will change in a positive way too
- Responsibility of the project group will increase and they will be more informed.

Method of the survey

We used a socio psychological survey, that is used for measuring global environmental attitude. It was made by Dunlop and Van Lier, it’s name is New Ecological Paradigm (NEP). [6] It contains 15 statements (Table 2) that examine the effect of humanity to the biosphere, in 5 independent factors. It examines the emotional part of environmental attitude, maximum 75 points.

Table 2: Questions (made by Dunlop and Van Lier) for the emotional part of environmental attitude
(1: Totally false, 2: Mostly false 3: Do not know 4: Mostly agree, 5: Totally agree, true)

1. Because of the increase of the population, we are going to reach Earth's keeping capacity.	1	2	3	4	5
2. People have rights to change the natural environment for needs to be satisfied.	1	2	3	4	5
3. If people change the environmental processes, it may produce fatal consequences.	1	2	3	4	5
4. Human ingenuity ensures that Earth will not become unliveable.	1	2	3	4	5
5. People destroy the environment irresponsibly.	1	2	3	4	5
6. The Earth has plenty of natural resources; we only should learn how to exploit them.	1	2	3	4	5
7. Plants and animals have the same rights to life as people have.	1	2	3	4	5
8. The balance of the nature is strong enough to overcome the effects of developed industrial societies.	1	2	3	4	5
9. Despite of our special abilities, we are subordinated to the laws of the nature.	1	2	3	4	5
10. The so-called "ecological crisis" we must face, is an exaggeration.	1	2	3	4	5
11. The Earth is like a spaceship, where we have finite number of space and resources.	1	2	3	4	5
12. People are destined to reign over the nature.	1	2	3	4	5
13. The balance of the nature is very sensitive and can easily capsize.	1	2	3	4	5
14. People must know processes of the nature to control them.	1	2	3	4	5
15. If everything continues as before, we will reach a big Ecological disaster very soon.	1	2	3	4	5

Two parts of environmental attitude: emotional and behavioral attitude are not always in line with each other, as we can see in other analysis too. A survey made by Attila Varga in eco- and not eco-schools [7] and an attitude survey made by Angéla Perényiné Somogyi [8] in adult population and children population show that emotional attitude is more positive than behavioral attitude. During environmental education it is very important that students can learn some options for actions; and be able to use them too (e.g. during the project, students observed their water consumption).
By answering the questions referring to behavioral attitude (Table 3) maximum 60 points can be reached.

Table 3: Questions of measuring behavioral attitude in environmental attitude
(1: Totally false, 2: Mostly false 3: Do not know 4: Mostly agree, 5: Totally agree, true)

1. News of environmental pollution are made me upset.	1	2	3	4	5
2. I am worried about shrinking water resources of the Earth	1	2	3	4	5
3. I would like to use (or maybe I use) renewable energy resources in my household.	1	2	3	4	5
4. I warn the others when they pollute the environment.	1	2	3	4	5
5. I am not worried about the purity of drinking water.	1	2	3	4	5
6. I am aware of the environmental footprint of products I buy.	1	2	3	4	5
7. I like to bath in bath tub.	1	2	3	4	5
8. I often hike in the nature.	1	2	3	4	5
9. I wash the dishes in running water.	1	2	3	4	5
10. I like to pay more for "green", environmentally friendly products.	1	2	3	4	5
11. I am worried about people do not take care of the environment enough.	1	2	3	4	5
12. I usually take part in village/city cleaning days.	1	2	3	4	5

My survey contained 10 questions (opened and closed questions too) and they were directed to sustainable use of water and environmental awareness.

I made this survey twice with the same groups (project group and control group); first was at the beginning of the project, on the 12th of September, 2011; second was after the project, on the 15th of February, 2012.

RESULTS OF THE SURVEY

I tried to guess what students think about serious global and local problems with the first and the second question of the questionnaire (*1: What do you think, what are the most serious problems of humanity? 2: What do you think, what are the most serious (environmental) problems in Hungary?*).
Answers of the members of the project group showed us, that after project work they could accurately formulate problems and raised several new aspects. At the beginning of the semester the greatest problems were: global warming, great use of not-renewable resources ("hunger for energy") and lack of drinking water. In the second time, most of the students wrote overpopulation and lack of drinking water. New aspects appeared too: e.g. lack of information and environmental awareness, irresponsible use of lands, "people think they are almighty", urbanization. These are problems that students faced during the project.

For the question of problems in Hungary, at the first time most students wrote air pollution and the problem of waste deposit, the lack of use of alternative resources, and problems of water pollution. At the second time, they rather wrote deposit and collection of waste and illegal deposition, the second most written aspect was air pollution. A new aspect appeared here too: environmental awareness, lack of responsibility and wasteful lifestyle.

At the first time most of the members of the control group wrote global warming as the most serious environmental problem of humanity, and wasting of not-renewable resources.

In the answers we found overpopulation, poverty, famine, pollution and waste of fresh water, the lack of environmental education, irresponsibility and the lack of environmental awareness too. At the second time most of the students wrote overpopulation, global warming, water pollution and waste of fresh water.

Environmental problems in Hungary by the view of the control group are the un-sustainable waste management, e.g. the lack of selective waste collection, and illegal waste disposition causing environment pollution, followed by the pollution of natural water and air pollution. At the second time the most common problem was about waste too, but new aspects appeared also: flood, inland inundation, drought and pollution of rivers. National problems are wasting lifestyle and smog too.
Answers of the project group and control group were not too different, but it was perceptible that during the project, members of the project group became more informed, and they approach had changed. At the end of the project they could accurately formulate global and local problems and they could isolate these problems too.

I used a statistic program, called SPSS 11.5 to analyse the rest of the questions. First step was an analysis of significance to find out if there was a significant difference of environmental attitude between the project and control group at the beginning of the project. Second step was a repeated analysis of significance based on the answers given at the end of the project. Applied tests: ANOVA test, t-test and paired t-test.

Objective of question 3 of the questionnaire (*Do you know how much water you use daily? Possible answers: Yes, exactly; More or less; No, I have never counted it; No I am not interested in*) was to see changes in water usage habits during the project.

At the beginning of the semester, difference between the two group was not significant ($p = 0{,}209$) – we can say significance if p is lower than 0,05[1]. By the end of the semester it changed, members of the project group started to pay attention how much water they use daily (Figure 1).

1 It means: responsibility level is 95% (*), Type I risk is 5%. The significance of the relationship can be (**) – 99% responsibility or (***) – 99,9% responsibility. Significance of the test is (**) if $p<0{,}01$; and (***) if $p<0{,}001$

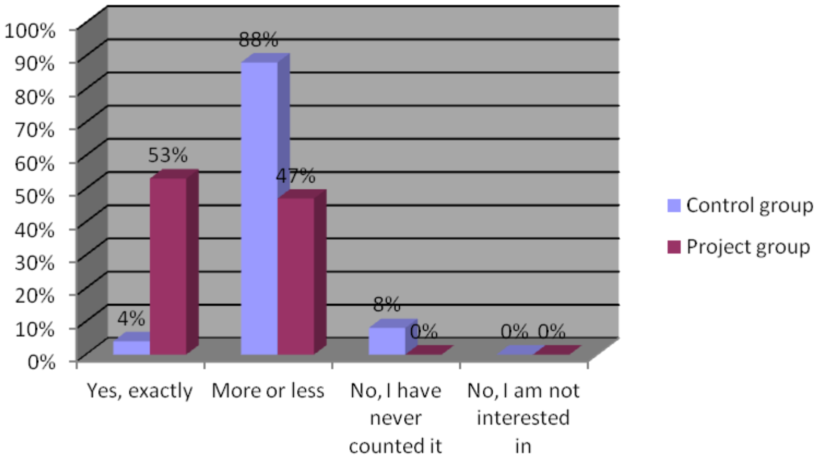

Figure 1. Change in water usage at the second time, at the end of the semester

We made a paired t-test on the answers of this water usage question, the result shows a positive change in environmental awareness and water usage habits by the project members, at the end of the semester they paid more attention to their water usage.

We made an ANOVA-test on the answers of question 4 of the questionnaire (*How do you strive to reduce waste in your household? I avoid of purchasing over packed products, I use sustained shopping bag, I avoid of purchasing mineral water and soft drinks packed in PET, I compress PET, I try to recycle, I collect waste separately, I do nothing*). It showed, that at the beginning of the project, there was no significant difference in waste reduction between the two groups, but by the end of the project it became significant2 (Figure 2). The result of the paired t-test proved that environmental attitude of students taking part in the project had positively changed, the importance of waste reduction had been increased.

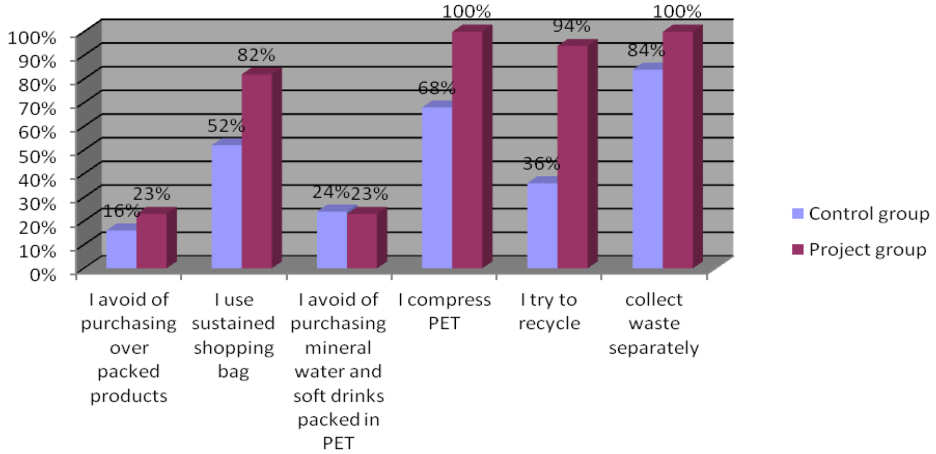

Figure 2. Difference between the two groups int he question of waste reduction at the end of the semester

The analysis of question 5 of the questionnaire (*Do you understand the meaning of conscious water usage – gray water, domestic waste water, etc? Yes, totally; Roughly, but it is enough; Partly, but I should be more informed; No, I have never thought about it*) also shows that the project has a positive effect to environmental awareness. The results of the ANOVA shows at the beginning of the project, that difference between the two group was not significant (p=0,742), but at the end of the project it was3 (Figure 3).

2 1: at the beginning: p = 0,242 (not significant), 2: at the end of the project: p = 0,000 – significant with (***) responsibility
3 P=0,033 (*) responsibility

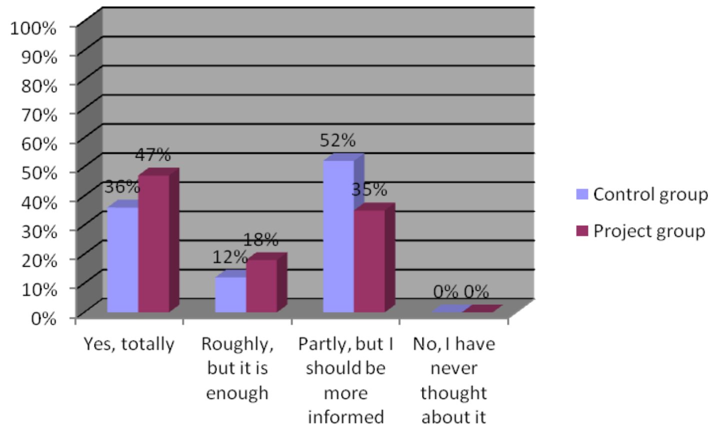

Figure 3. Conscious water usage answers show significant difference between the two groups at the end of the semester

Paired t-test of conscious water usage also shows, that by the end of the semester project group members' attitude had significantly changed4. Answers given to question 6 (*How do you economize water? – I do not economize; I pay attention to water usage during teeth brushing, shower, etc.; I use water-saving equipment; I collect rain water; Other, e.g.:…)* do not show significant difference5 between the two groups at the beginning of the semester, but it became significant6 by the end of it (Figure 4).

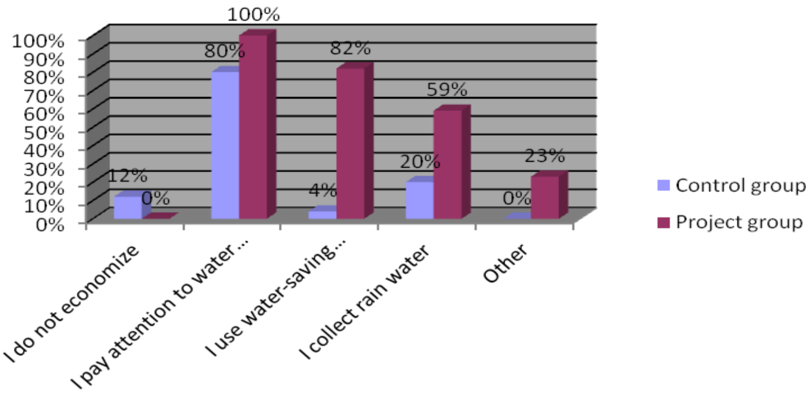

Figure 4. The difference between the two groups at the end of the semester in water economization question

Paired t-test also verified the change in the project group's attitude.7

I presented 4 variables in the previous section that all prove success of the project, moreover it had a positive effect to its members. Now, I show a new global variable, called environmental awareness index. This index is formed and standardized from the 4 earlier variables. At the beginning of the project, groups were similar to each other.8 But at the end of the project I observed significant difference.9 Moreover 63,3% of heterogeneity of the environmental awareness can be explained by taking part in the project. Time comparison presents that project had a significantly positive effect to environmental awareness.10 These results clearly demonstrate the efficiency of project method in environmental education.

4 p = 0,000 (***) responsibility
5 P = 0,351 (not significant)
6 p = 0,000 (***) responsibility
7 P = 0,006 (**) responsibility
8 P = 0,191 (not significant)
9 p = 0,000 (***) responsibility
10 p = 0,001 (***) responsibility

Answers given to question 7 (*What are the most important points in shopping for you?)* in the second survey show clearly that during project work the shopping habit of project members changed, instead of "value for money", environmentally friendly point came to the first place (Figure 5).

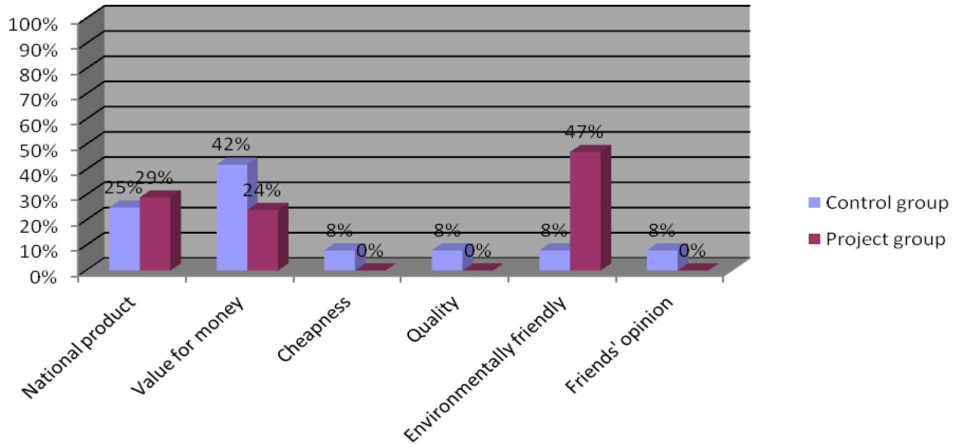

Figure 5. Difference between project and control group at the end of the semester in shopping habits question

By question 8 of the questionnaire *(Please, list some web sites and journals, related to environmental protection, that you know)* I wanted to know how well-informed students were and how much they read. My hypothesis was, that students read very few professional literature and they were not very well-informed. They don't have enough information about everyday happenings in the environment. They are not motivated enough, that is why I thought, that during project work their informational level would be increased. When I analysed the answers, I considered 4 aspects: student got 0 if he/she did not write anything; 1-2 if he/she wrote at least one but maximum 2 web sites/journals; 3-4 if he/she wrote at least 3 but maximum 4 web sites/journals; and 5 if he/she wrote 5 or more than 5.

This test proves that within the project group informational level has positively and significantly[11] changed (Figure 6), but within control group it has not changed at all.[12]

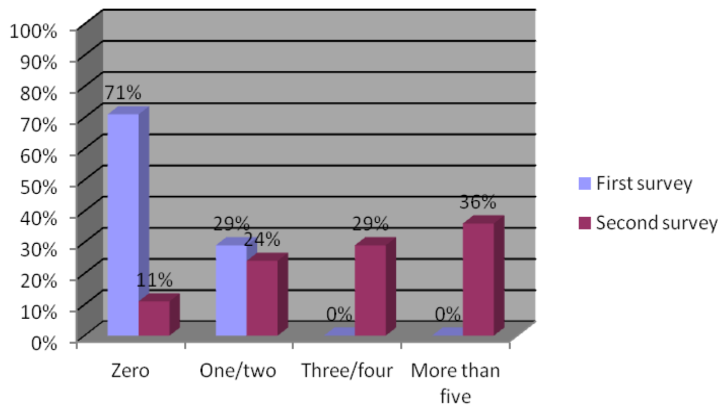

Figure 6. Journals and websites known by the members of the project group in the first and second survey

Results show that by the end of the semester members of the project group became better informed, they knew more websites and journals.

11 P = 0,001 (***) responsibility
12 P = 0,575 (do not significant)

Question 9 of the questionnaire (Table 2) was about the emotional part of environmental attitude. I calculated mean of answers to NEP (1 to 5 points each). Maximum points were 75, because each statement (15) could get 5 points maximum. Higher score means more positive environmental attitude of the student.

Within project group the average was 51 points at the beginning of the semester, by the end of the semester it increased a little bit (Figure 7). All surveys within both groups showed positive environmental attitude, since the neutral environmental attitude's points were 36 in the scale of NEP. [7] Within the control group environmental attitude points were positive, but did not present any change, both at the beginning and at the end of the semester they were 51 points.

In the project group this 2-point difference with a paired t-test was not significant.13

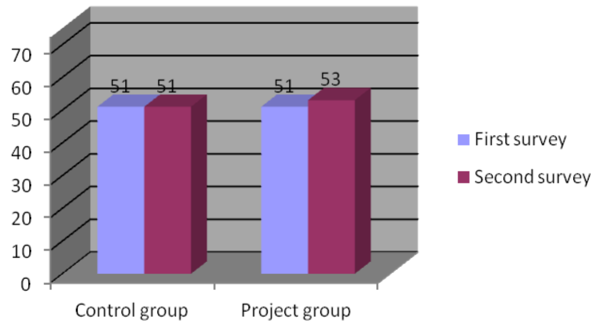

Figure 7. Mean points of environmental attitude within control and project group in the first and second survey too

In the project group this 2-point difference with a paired t-test was not significant.14 Question 10 of the questionnaire (last) was about behavioral environmental attitude (Table 3). I distinguished two dimensions: 1) thinking and opinions of the environment15 and 2) activity for the environment.16 I took 5 variables to the thinking/opinion dimension, maximum points were 25. I took 7 variables to the activity dimension, maximum points were 35. Maximum points were altogether 60.

Paired t-test proved that project had a positively significant effect to its members (at the beginning it was 37 points but to the end it increased to 41 points).17 Within the control group there was no significant change in points18 (Figure 8). Results of the two-dimension test in thinking/opinion dimension did not show any significant change, so project did not change the thinking about the environment.19 All the four surveys' (project group before and after the project, control group before and after the project) mean points were 18, which is 72% of the maximum 25 points. Environmental attitude points (in the previous section) showed positive change within the project group, so I could

13 p=0,259 (not significant)
14 p=0,259 (not significant)
15 I list the following statements here:
- News of environmental pollution are made me upset.
- I am worried about shrinking water resources of the Earth
- I am not worried about the purity of drinking water.
- I am aware of the environmental footprint of products I buy.
- I am worried about people do not take care of the environment enough.

16 I list the following statements here:
- I would like to use (or maybe I use) renewable energy resources in my household.
- I warn the others when they pollute the environment.
- I like to bath in bath tub.
- I often hike in the nature.
- I wash the dishes in running water.
- I like to pay more for "green", environmentally friendly products.
- I usually take part in village/city cleaning days.

17 P = 0,012 (*) responsibility
18 P = 0,578 (not significant)
19 Project group: P=0,136 (not significant)
Control group: p= 0,752 (not significant)

expect that the behavioral environmental attitude had also changed positively. Paired t-test verified the positive effect of the project within behavioral environmental attitude points, because at the beginning their mean was 20 points, and by the end it increased to 23 points. 20 This is a prominent result – taking into account the facts proven by the previous tests, that emotional environmental attitude is more positive, than behavioral one-, because the project increased the members' behavioral environmental attitude points too.

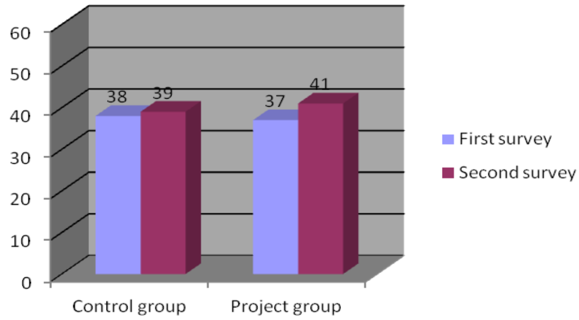

Figure 8. Mean points of behavioral environmental attitude within control and project group in the first and second survey too

SUMMARY, CONLUSIONS

Environmental attitude test with questionnaire proved the positive effects of the project method in environmental education. Hypotheses set at the beginning of the semester got validated. During the project there was a positive change in environmental behavior and responsibility towards the environment too. Statistics showed that there were more positive changes in the behavioral dimension of the environmental attitude, than in the emotional dimension. Results acknowledged, that the project method reached its goal; members became more environmentally friendly in their everyday lives. All in all, I can say that the project developed required skills set in the directives and requirements of the education. Moreover end term exams of students proved that their knowledge has also grown significantly. Project method integrated in the environmental engineering education strategy, by supplementing its high level academic qualification, can be a suggested method in environmental engineering BSc education.

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20 p = 0,022 (*) responsibility

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MODELING COMPETITION AMONG ACETICLASTIC METHANOGENIC SPECIES DURING ANAEROBIC DIGESTION OF MUNICIPAL BIOSOLIDS

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ABSTRACT

In typical mesophilic anaerobic digesters, acetate-cleaving Archaea generates 70% of the total methane. There are only two genera, Methanosaeta and Methanosarcina, known to be capable of performing aceticlastic methanogenesis; the former has a lower acetate utilization rate and predominates in conventional mesophilic digesters. In this study, a competitive aceticlastic model framework with groups representative of Methanosaeta and Methanosarcina was built into BioWin™, an industry-standard whole-plant wastewater process simulator, to study the effects of operational parameters on competition among the aceticlastic methanogens. Methanosarcina predominance was predicted for SRT <15 d. Intermittent feed (three one-hour periods per d) of acid phase digester contents with high VFA (8,000 mg COD/L, 60% acetic) could not significantly extend the SRT range of Methanosarcina predominance; in this scenario, Methanosaeta was still predicted to predominate at gas phase SRT of 18 d. Despite lower SRTs, the Methanosarcina-dominated digesters had greater stability indices than conventional mesophilic digesters. Bioaugmenting a primary digester with a Methanosarcina-enriched slipstream (15% of the average digester feed) enhanced stability of a 20 d SRT Methanosaeta-dominated digester during a representative peak event.

Keywords: *Anaerobic digester, aceticlastic methanogenesis, SRT, Methanosaeta, Methanosarcina*.

INTRODUCTION AND BACKGROUND

Mesophilic anaerobic digestion is widely practiced in the municipal wastewater treatment industry to achieve solids reduction and stabilization and to reclaim energy from biogas. The inherent variability of solids loadings, combined with thermodynamic challenges to co-dependent anaerobic microbial consortia, can lead to digester instability. In typical mesophilic anaerobic digesters, approximately 70% of the degraded chemical oxygen demand (COD) is converted to methane by acetate-cleaving Archaea (Jeris and McCarty 1965; Smith and Mah, 1966). There are only two genera, *Methanosaeta* and *Methanosarcina*, known to be capable of performing aceticlastic methanogenesis. *Methanosaeta* has a higher affinity for acetate (lower half saturation constant, K_S) and predominates due to the long solids retention time (SRT), low volatile fatty acid (VFA) concentration, and non-inhibitory levels of ammonia in typical mesophilic municipal wastewater solids digesters. However, *Methanosaeta* has a lower acetate utilization rate and, consequently, has less capacity to process acetate during peak loads and periods of instability where VFAs accumulate. A digester predominated by *Methanosarcina* would offer an enhanced ability to process acetate and, theoretically, improve digester stability. In this study, a competitive aceticlastic model framework with groups representative *Methanosaeta* and *Methanosarcina* was built into BioWin™, an industry-standard whole-plant wastewater process simulator. The competitive aceticlastic model was structured such that it was intended to be applicable to mesophilic municipal wastewater solids digesters. The primary objective of the study was to evaluate the potential of different digester configurations and operating modes to select for *Methanosarcina* predominance.

MODEL DESCRIPTION

BioWin™ (EnviroSim Associates Ltd 2009) is a commercially available wastewater process simulator and is widely used throughout the industry. The anaerobic digestion part of the model is based on the "four population" model concept: heterotrophs, propionic acetogens, hydrogenotrophic methanogens, and aceticlastic methanogens. BioWin™ default kinetic, stoichiometric, and switching parameters for aceticlastic methanogens and common parameters for endogenous residue are described in detail elsewhere (Figdore, 2011). BioWin™ Version 3.1 includes a Model Builder tool that allows users to enter stoichiometry and rate equations for user-defined models. The rate equations and stoichiometric coefficients used for competitive aceticlastic growth and decay are reported elsewhere, in the standard matrix format used by IWA's ADM1 Model (Figdore, 2011). Table 1 shows a comparison of kinetic and stoichiometric terms (a) used in the default BioWin™ model for lumped aceticlastic methanogens, (b) reported by Conklin et al. (2006) from literature for pure and enrichment cultures of *Methanosaeta* and *Methanosarcina*, (c) measured by Conklin et al. (2006) for bench scale enrichment cultures, and (d) selected for use in the competitive aceticlastic model developed under this study.

Table 1: Comparison of key kinetic and stoichiometric terms for acticlasitc methanogens

Term	Units	BioWin lumped aceticlastic methanogens (at 35°C)	Reported by Conklin et al. (2006)	Measured by Conklin et al. (2006) for enriched reactors	Used in this study
Methanosaeta					
μm	1/d	0.46	0.060*	0.126*	0.090
k	mg COD/mg COD-d	4.6	2.2*	2.8*	2.6
k	mg COD/mg VSS-d	6.5	3.1 (1.8)	3.94	3.7
Y	mg COD/mg COD	0.100	0.027*	0.045*	0.035
Y	mg VSS/mg COD	0.070	0.019 (0.002)	0.032 (0.0007)	0.025
Ks	mg COD/L	100	49 (19)	90 (13)	50
Smin	mg COD/L	-	-	-	4
b	1/d	0.20	-	0.0064	0.006
Methanosarcina					
μm	1/d	0.46	0.44*	0.53*	0.500
k	mg COD/mg COD-d	4.6	8.6*	8.9*	8.8
k	mg COD/mg VSS-d	6.5	12.2 (5.5)	12.7	12.5
Y	mg COD/mg COD	0.100	0.051*	0.060*	0.057
Y	mg VSS/mg COD	0.070	0.036 (0.013)	0.042 (0.008)	0.040
Ks	mg COD/L	100	280 (77)	320 (100)	280
Smin	mg COD/L	-	-	-	70
b	1/d	0.20	-	0.098	0.1

*calculated from reported/measured values

Digester stability under each simulation scenario was determined by calculating the acetate capacity (ACN) number. The ACN has been proposed and employed as a means of quantifying digester stability (Conklin et al. 2006; Chapman et al. 2007; Zahller et al. 2007) and it is defined as the ratio of maximum acetate utilization rate to acetate production rate. Higher ACNs indicate a greater degree of acetate utilization capacity in the digester, and, consequently, a greater degree of digester stability. ACNs less than 1.0 indicate the acetate utilization capacity of the digester biology has been exceeded and that digester failure would occur if the loading rate is sustained.

SIMULATION SCENARIOS

A generic plant model was created and executed in order to obtain two state variable streams for thickened solids –one of lower COD and one of higher COD. Different sets of inputs (including wastewater characteristics, primary clarifier solids capture, and thickening performance) were used to obtain these digester feed streams –a low-COD stream of 54 g/L and a high COD stream of 88 g/L. The thickened solids streams were used in subsequent models that included only the anaerobic digester and were aimed at investigating aceticlastic predominance. For steady-state simulations, several model runs were for performed for each feed stream to investigate the role of SRT –over the range of 6 to 30 d– on the growth and predominance of *Methanosaeta* and *Methanosarcina*. For the dynamic simulations, the competitive aceticlast model was used to evaluate the performance and stability of several digester configurations during a simulated peak loading event. A seven day peak event with 1.60 peaking factor (PF) was simulated; the event included three days of PF = 1.75 and four days of PF = 1.50. The peak loadings were simulated by increasing the flow while holding the state variable concentrations of the 54 g COD/L digester feed stream constant. The following digester configurations were simulated: 20 d SRT (competitive and lumped), 10 d SRT, 8 d–12 d SRT staged, and 20 d SRT digester augmented with *Methanosarcina* seed via diversion of 15% of the average thickened solids flow through an 8 d SRT digester and return of 8 d SRT digester contents to the main 20 d SRT digester.

RESULTS AND DISCUSSION

Figure 1 shows the aceticlastic biomass growth as a function of SRT under 54 g COD/L feed stream. The competitive aceticlastic model predicted *Methanosarcina* predomination for SRTs below 15 d, a mixed aceticlastic population between 15 and 17 d SRT, and *Methanosaeta* predominance for SRTs greater than 17 d. Aceticlastic predominance trend was unaffected by the strength of the digester feed stream as increasing the feed COD to 88 g COD/L resulted in identical patterns (data not shown).

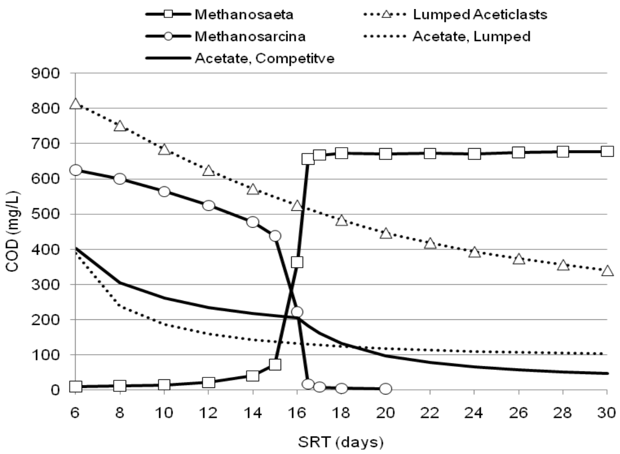

Figure 1. Aceticlastic biomass and acetate concentrations for steady-state simulations employing competitive and lumped aceticlastic kinetics with 54 g COD/L digester feed

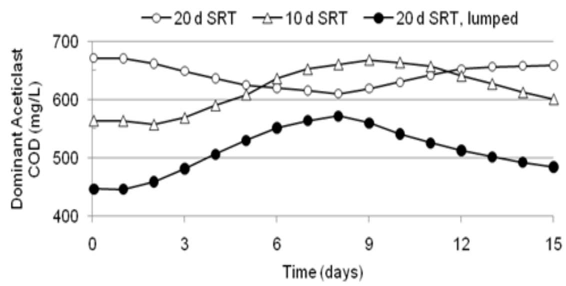

Figure 2. Concentration of dominant aceticlastic biomass concentration during peak event for selected simulations

As expected, aceticlastic biomass concentration increased proportionately to the digester COD loading. For the competitive aceticlastic model, predicted acetate concentration ranged from approximately 400 mg/L at 6 d SRT to 50 mg/L at 30 d SRT (Figure 1). The acetate concentration for the lumped aceticlastic model followed a similar curve; however, acetate concentration approached 100 mg/L instead of 50 mg/L at the upper end of SRT range. Figure 2 shows the predicted concentration of the dominant aceticlastic methanogen present in the 20 d SRT, 20 d SRT lumped, and 10 d SRT digesters during the peak event. Due to the higher growth rate associated with the dominant aceticlasts in the 20 d SRT lumped and 10 d SRT digesters, aceticlastic COD increases during the peak event. In the 20 d SRT lumped digester, the aceticlastic inventory is greater and associated K_s and S_{min} are lower than the 10 d SRT digester. Therefore, the peak acetate concentration was greater for the 10 d SRT digester than for the 20 d SRT lumped digester (data not shown). In the 20 d SRT competitive digester, the low μ_m and k associated with the dominant *Methanosaeta* population resulted in partial washout of aceticlastic biomass.

Despite lower SRTs, the *Methanosarcina*-dominated digesters had greater stability indices than *Methanosaeta*-dominated digesters of twice the SRT. The ACNs for low-SRT *Methanosarcina*-dominated digesters ranged from approximately 2.0 at 6 d SRT to 3.0 at 14 d SRT. *Methanosarcina* washout was predicted below 6 d SRT. The ACN for moderate-SRT digesters ranged from 1.5 at 18 d

SRT to 2.4 at 30 d SRT for the *Methanosaeta* kinetics employed in the base completive model. Bioaugmenting a *Methanosaeta*-dominated primary digester with a *Methanosarcina*-enriched slipstream (15% of the average digester feed) enhanced stability of a 20 d SRT primary digester during a representative peak week event and a 24 d SRT primary digester during transition to *Methanosarcina* dominance where the SRT instantaneously changed and maintained at 12 d SRT.

CONCLUSIONS

The integrated activated sludge-anaerobic digestion model of the BioWinTM wastewater process simulator was modified to include two groups of aceticlastic methanogens representative of Methanosaeta and Methanosarcina. Using this competitive aceticlastic framework, Methanosarcina predominance was predicted for SRT <15 d. Digester feed concentration (54 and 88 g COD/L) had negligible impact on predominance or digester stability. Even with lower SRTs the Methanosarcina-dominated digesters had greater stability indices than Methanosaeta-dominated digesters, yet the advantages of operation to select for Methanosarcina predominance must be evaluated with attention to solids destruction, trace metal bioavailability, and pathogen indicator reduction. Bench- or demonstration-scale study is recommended before decisions regarding the practice of low-SRT mesophilic digestion in a conventional complete-mix continuous-feed single-stage mode.

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COUPLED PROCESS OF NUTRIENT REMOVAL AND BIOGAS PRODUCTION USING *CHLORELLA VULGARIS*

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ABSTRACT

Due to increases in industrialization and in urbanization rates, there have been significant impairments in key nutrient cycles, affecting both ecosystems and human well-being. Nutrient pollution influences atmosphere, groundwater, and surface waters; as a result, create risk for environmental health, public health and economy. Urban sewage is rich in nutrients such as nitrogen (N) and phosphorus (P). These nutrients may cause eutrophication in receiving water bodies, if not removed. Microalgal nutrient removal is a significant alternative for biological wastewater treatment, considering their high nitrogen and phosphorus requirements. Apart from high nutrient uptake capabilities of microalgae, photosynthetic carbon-dioxide abatement during treatment aids reduction of greenhouse gas concentrations. Moreover, these systems are beneficial in terms of nutrients recycling and conversion into microalgal biomass, which, in turn, is a beneficial resource for biofuel production. In this study, a semi-continuous photo-bioreactor was operated for investigation of nutrient (N and P) removal efficiency of unialgal culture, Chlorella vulgaris. Biogas production from biomass obtained from semi-continuous photobioreactor was also investigated via Biochemical Methane Potential (BMP) assay. Maximum N and P removal efficiencies of 99.6% and 91.2% were achieved in the photobioreactor. Results of BMP study revealed that the maximum biogas production yield was 442 ml biogas / g VS.

Key words: *Wastewater, Algae, Nutrients, Photo-bioreactor, Biogas.*

INTRODUCTION

Any ecosystem service is directly affected by nutrient balance, adequacy and availability, which regulate the life on Earth. Key nutrient cycles including nitrogen and phosphorus have been significantly altered by anthropogenic activities since 19^{th} century. Increased atmospheric carbon dioxide concentrations due to fossil fuel consumption is an example to the negative feedback of human manipulation on ecosystems (IPCC, 2007). This increase causes elevation in global temperatures and uncontrolled sequestration of carbon-dioxide on ecosystems. These manipulations adversely affect not only ecosystems, but also human well-being, having adverse effects on environmental health, public health and economy (Berhe et al., 2005)

Eutrophication is one of the direct consequences of human manipulation on nutrient cycles. It is a phenomenon defined as “an increase in the rate of supply of organic matter in an ecosystem” (Nixon, 1995). Discharge of domestic sewage, which introduces high levels of N originating from human wastes and P originating from detergents, to water bodies are main causes of eutrophication (Girard, 2009). In aquatic environments, eutrophication causes algal blooms, oxygen depletion, increase in undesired vegetation, loss of plant beds, fish, coral reef and other species. Eventually, the water bodies become unavailable to utilize for agricultural, recreational, industrial and drinking purposes (Carpenter et al., 1998).

Wastewater produced by communities contains nutrients and compounds which may have triggering and toxic effect on aquatic flora growth. These chemicals may also cause mutations or may be carcinogenic. In order to prevent deteriorations in public health and environment, it is necessary to separate abovementioned constituents before they reach natural environments (Tchobanoglous et al., 2003). Growth of algae is an alternate method for biological wastewater treatment, considering their high nitrogen and phosphorus requirement for nucleic acids, phospholipids and protein syntheses. (Zhou, 2010). It has been reported that microalgal species such as *Botryococcus*, *Chlamydomas*, *Scenedesmus* and *Chlorella* have high potential of nutrient removal. *Chlorella vulgaris* has been reported to utilize nitrogen and phosphorus from industrial, agricultural and municipal wastewaters, when they are used as medium source of nutrients. Several studies have been conducted to investigate nutrient removal potential of *C. vulgaris* (See Table 1).

Table 1: Wastewater treatment studies using Chlorella vulgaris

Wastewater Type	**Cultivation Mode**	**Nitrogen removal efficiency**	**Phosphorus removal efficiency**	**Reference**
Steel making plant industry effluents	Batch	100 % NH_4^+-N 50 % NO_3^--N	N/A	Yun et. al. (1997)
Digested Dairy Manure	Semi-continuous	99.7 % NH_4^+-N 89.5 % TN	92.0 % TP	Wang et. al. (2010)
Undigested Dairy Manure	Semi-continuous	100 % NH_4^+-N 93.6 % TN	89.2 % TP	
Wastewater before primary settling	Batch	82.4 % NH_4^+-N 68.4 % TN	83.2 % TP	Wang et al. (2010)
Wastewater after primary settling	Batch	74.4 % NH_4^+-N 68.5 % TN	90.6 % TP	
Effluent from aeration tank	Batch	62.5 % NH_4^+-N 50.8 % TN	4.69 % TP	
Centrate from sludge centrifuge	Batch	78.3 % NH_4^+-N 82.8 % TN	85.6 % TP	
Municipal Effluent	Batch	98.1 % NH_4^+-N 90.9 % TN	90.0 % TP	Li et al., (2013)
Municipal Effluent	Semi-continuous	98.4 % NH_4^+-N 93.6 % TN	91.8 % TP	
Municipal Effluent	Continuous	98.3 % NH_4^+-N 95.5 % TN	90.6 % TP	

Biomethane production from microalgal biomass has received attention, since biogas obtained from anaerobic digestion can be used for electricity generation (Holm-Nielsen et al., 2009). Due to the fact that production of microalgae does not interfere with food demand like other energy crops such as sugar cane and canola, its utilization as an energy crop is advantageous (Mussgnug et al., 2010). In addition, biomass residues after anaerobic digestion can be converted into fertilizers. Utilization of these fertilizers provides sustainable agriculture and reduce production costs of microalgae. Microalgal technology also aids sequestration of atmospheric carbon dioxide, while producing valuable end products (Skjånes et al., 2007).

Several microalgal species have been studied as feedstocks for biomethane production. These feedstocks include mixed culture of *Scenedesmus spp.* and *Chlorella spp.*, the mixed culture of *Scenedesmus spp.*, *Chlorella spp.*, *Euglena spp.*, *Oscillatoria spp.*, and *Synechocystir sp.*, the culture of *Scenedesmus sp.* alone, and together with either *Spirulina sp.*, *Euglena sp.*, *Micractinium sp.*, *Melosira sp.*, or *Oscillatoria sp.* Table 2 provides a summary of biomethane production studies using microalgae.

Since cellulose and lignin contents of microalgae are almost zero, anaerobic process stability and digestion efficiency are high. However, production cost of methane is still higher than other feedstocks. Therefore, integrated wastewater treatment and biomethane production, which is process first discussed by Oswald and Gotaas (1957), can be the most feasible approach to reduce production cost (Harun et al., 2010).

Table 2: Biomethane production studies using microalgae

	HRT (days)	Biogas Yield (mL/g VS)	Methane Content (%)	Reference
Mesophilic Digestion				
Algae Only	28	418.3	73	Chen (1987)
Algae Only	30	412.0	61.1	Golueke et al., (1957)
50/50 Sludge/Algae	28	290.9	64	Chen (1987
Algae (*Scenedesmus* spp. and *Chlorella* spp.) + Waste paper	10	100-140	N/A	Yen and Brune, (2007)
Arthrospira platensis		481 ± 13.8	61	Mussgnug et al., (2010)
Chlamydomonas reinhardtii		587 ± 8.8	66	
Chlorella kessleri		335 ± 7.8	65	
Dunaliella salina		505 ± 24.8	64	
Euglena gracilis		485 ± 3	67	
Scenedesmus obliquus		287 ± 10.1	62	
Zea mays		653 ± 37.7	54	
Thermophilic Digestion				
Algae Only	30	493.2	62.1	Golueke et al., (1957)
50/50 Sludge/Algae (40˚C)	28	449.5	66	Chen (1987)
50/50 Sludge/Algae (55˚C)	28	299.7	62	Chen (1987)

MATERIALS AND METHODS

Microalgae

Unialgal culture of *Chlorella vulgaris* (CCAP 211/11B) was obtained from Culture Collection of Algae and Protozoa, England.

Anaerobic Seed

Mixed anaerobic cultures were obtained from the anaerobic sludge digesters of Greater Municipality of Ankara Tatlar Domestic Wastewater Treatment Plant. Characterization of the seed culture is given on Table 5.

Batch Cultivation Medium

Enhanced Bold's Basal medium (3N-BBM+V) was used for batch cultivation of *C. vulgaris*. The content of the medium is as follows (g/L); $NaNO_3$: 0.75, $CaCl_2{\bullet}2H_2O$: 0.025, $MgSO_4{\bullet}7H_2O$: 0.075, $K_2HPO_4{\bullet}3H_2O$: 0.075, KH_2PO_4: 0.175, NaCl: 0.025, Na_2EDTA: 0.0045, $FeCl_3{\bullet}6H_2O$: $5.84x10^{-4}$, $MnCl_2{\bullet}4H_2O$: $2.46x10^{-4}$, $ZnCl_2$: $3x10^{-5}$, $CoCl_2{\bullet}6H_2O$: $1.2x10^{-5}$, $Na_2MoO_4{\bullet}2H_2O$: $2.4x10^{-5}$, Vitamin B1: 0.0012, Vitamin B12: 0.00001.

Wastewater

Wastewater used during semi-continuous cultivation studies was obtained from primary clarifier effluents of Greater Municipality of Ankara Tatlar Domestic Wastewater Treatment Plant located in Ankara, Turkey. Wastewater fed to the photobioreactor was collected as five different batch on January 1st, February 1st, April 1st, April 16th and April 18th, 2013. Each batch was screened through a sieve with pore size of 3 mm, in order to remove larger particles, prior to storage at 0^oC. Wastewater characterizations and feeding cycles for which they are used are given on Table 3.

Table 3: Wastewater Characterization

Constituents (mg/L)	TAN	NO3-N	PO4-P	TN	tCOD	sCOD	Feeding Cycle #
January 1st	25.1 ± 1.01	< 0.1	4.91 ± 0.03	29.4 ± 0.82	351.1 ± 2.81	82.2 ± 0.0	1
February 1st	31.9 ± 1.32	< 0.1	5.3922 ± 0.02	36.9 ± 0.66	368.4 ± 7.96	84.95 ± 1.06	2-4
April 1st	28.8 ± 0.23	2.3 ± 0.08	1.8678 ± 0.01	35.1 ± 1.79	337.2 ± 1.39	73.0 ± 1.34	5-11
April 16th	20.6 ± 0.18	4.4 ± 0.12	1.5 ± 0.01	23.9 ± 1.24	253.2 ± 8.44	65.5 ± 1.99	12-16
April 18th	20.8 ± 0.41	1.5 ± 0.06	1.79 ± 0.0	25.3 ± 1.24	266.6 ± 4.29	67.1 ± 0.28	16-18

Basal Medium

The composition of basal medium (BM) used in the experiments was as follows (concentrations of the constituents are given in parentheses as mg/l): NH_4Cl (1200), $MgSO_4 \bullet 7H_2O$ (400), KCl (400), $Na_2S \bullet 9H_2O$ (300), $CaCl_2 \bullet 2H_2O$ (50), $(NH_4)_2HPO_4$ (80), $FeCl_2 \bullet 4H_2O$ (40), $CoCl_2 \bullet 6H_2O$ (10), KI (10), $MnCl_2 \bullet 4H_2O$ (0.5), $CuCl_2 \bullet 2H_2O$ (0.5), $ZnCl_2$ (0.5), $AlCl_3 \bullet 6H_2O$ (0.5), $NaMoO_4 \bullet 2H_2O$ (0.5), H_3BO_3 (0.5), $NiCl_2 \bullet 6H_2O$ (0.5), $NaWO_4 \bullet 2H_2O$ (0.5), Cysteine (10), $NaHCO_3$ (6000). This BM contained all the necessary micro- and macro-nutrients required for an optimum anaerobic microbial growth (Demirer et al., 2000).

Analytical Methods

TSS, VSS, tCOD, sCOD and TKN values were determined according to Standard Methods (APHA, 2005). TN, TAN (NH_4^+-N + NH_3-N), NO_3^-–N, PO_4^{3-}- P analyses were using Lovibond test kit vials Vario 535560, Vario 535600, Vario NitraX 535580, Vario 515810 respectively (Aqualytic, Germany). Optical density of any sample was measured using macro-cuvettes and spectrophotometer (HACH, DR 2800) at 685 nm wavelength with 1cm light path. The optimum wavelength value for measurement was determined by reading optical density values at different wavelengths within the range of 450 to 800 nm. 685 nm was found to reveal the highest absorbance value within the specified wavelength range. Since absorbance values below 0.1 and above 1 are not reliable sample dilution was made if necessary. Light intensity in culture medium was measured using PAR device (Li-Cor, 250 A) and DO values in photobioreactors were measured using Dissolved Oxygen Meter (Extech, 407510A).

During BMP test, gas production of each reactor was measured by water displacement method (Demirer and Chen, 2008). Gas composition analysis was performed by a gas chromatograph (GC) (Agilent 6890N) equipped with a thermal conductivity detector and capillary column CP-Sil 8 (CP8752, Varian) to detect CH_4 content. The temperatures of the oven, injector and detector were 45, 100 and 250°C, respectively. Helium was employed as a carrier gas at pressure of 4.11 psi.

Experimental Sets And Procedures

Batch Cultivation Photobioreactor (BCP)

Microalgal culture was cultivated in a 3300 L cylindrical bubble column reactor with 3000 ml of working volume. Reactor is constructed with 0.3 cm thick glass. The diameter of the reactor is 8 cm. The BCR is capped with a glass stopper with a tube for gas exit. An aeration tube with inner diameter of 0.5 cm is submerged into the reactor through the stopper and is connected to an air pump (RESUN AC-9602). Gas inlet and outlet of the reactor are equipped with 0.2 μm syringe filters. The BCP was operated in sterile conditions with 16 h : 8 h day – night cycle. Day cycle was obtained with eight 18 W cool-white fluorescent lamps (OSRAM, L 18W/685) in a cabin isolated from ambient light using black curtains. The closest pair of lamps, which provided light intensity of 120 $\mu mol/m^2 \cdot s$ was, 10 centimeters away from one side of the reactor. At the opposite side of the reactor, light intensity was 100 $\mu mol/m^2 \cdot s$. These light intensity values are within the optimum range for *Chlorella vulgaris* cultivation (Filali et al., 2011). BCP was continuously aerated with 0.5 vvm (volume air per volume broth per minute) air, in order to supply necessary carbon dioxide for growth and adequate mixing for light-dark cycle achievement. Temperature was 28 ± 2 ^{0}C in culture broth. Initially, pH was set to neutral.

Semi-Continuous Cultivation Photobioreactor (SCP)

In order to obtain microalgal biomass for BMP studies and determine nutrient removal potential of *Chlorella vulgaris*, a SCP for wastewater treatment was designed. The reactor has 40 L inner volume with length, width and height values of 32 cm, 25 cm and 50 cm respectively. The maximum working volume of the photobioreactor is 35L. SCP was equipped with two identical air pumps (RESUN 9602, PRC), each connected to the smallest surface of a pair of spargers with dimensions of 25 cm x 2 cm x 2 cm. Light was provided to SCP with eight cool-white 18 W fluorescent lamps (OSRAM, L 18W/685), placed four by four on largest surfaces of the photobioreactors. The distance between each lamp and the photobioreactor surface is 5 centimeters. Lamps are 8 cm away from and parallel to each other and symmetrically aligned at each surface of the photobioreactor, providing 150 µmol/m^2.s PAR at the surface and 80 µmol/m^2.s in the center of the photobioreactor, when filled with water.

The SCP was continuously illuminated for massive amounts of biomass production, enhancing continuous photosynthesis throughout the day. Aeration was also continuously supplied with 0.5 vvm air. pH was tending to elevate up to alkaline levels, therefore pH was lowered down to 6.0 ± 0.5 using 37% HCl and its increase above 9.3 was avoided, in order to prevent decrease in carbon dioxide uptake capacity and escape of ammonia by stripping. SCP was operated between temperature values of 24.8 ^{o}C and 29.6 ^{o}C.

SCP was started with 0.5 L microalgal culture and 3.5 L wastewater. Characteristics of the inoculated culture broth is given on Table 4. For the first four cycles, photobioreactor was operated in fed-batch mode. Afterwards, operation mode was switched to semi continuous. Rather than setting hydraulic residence time and performing feeding / wasting operation on diurnal basis, feedback from the reactor was gathered periodically to determine optimum time for wasting and feeding. That is, soluble nitrogen (TAN and NO_3^--N) concentrations in the reactor were measured frequently as a feedback from the system, since wastewater obtained were N-limiting. When a minimum of 75% soluble nitrogen removal was achieved on mass basis, photobioreactor was fed with fresh wastewater. Wasting and feeding volumes were determined not only considering the feedback, but also providing a relatively constant ratio between microalgae and soluble nitrogen on a mass basis, at the beginning of each cycle.

Table 4: Culture broth characteristics

NO_3^--N (mg/L)	**PO_4^{3-}-P (mg/L)**	**sCOD (mg/L)**	**OD (Abs.)**
19.6 ± 0.94	44.2 ± 1.1	149.5 ± 0.7	3.92 ± 0.006

In addition to optical density and soluble inorganic nitrogen species, PO_4^{3-}- P concentrations in the reactor at the beginning and end of each cycle were determined.

BMP Assay

Effluents of SCP were collected at the end of each cycle, centrifuged at 4000 rpm for 30 minutes. The recovery efficiency was calculated measuring optical densities of the effluents and final supernatants and found out to be over 90%. Characteristics of microalgal slurry are given on Table 5.

Table 5: Anaerobic seed and microalgal slurry characterizations

Parameter	**TS (mg/L)**	**VS (mg/L)**	**VS (%TS)**	**tCOD (mg/L)**
Anaerobic Seed	38900 ± 566	13300 ± 0.0	32.6	19762 ± 12
Microalgal Slurry	33250 ± 70	27950 ± 70	84.1	42943 ± 285

Reactors of 100 mL total volume and 71 mL effective volume were used in the experiments. The test reactors were seeded with 8 mL of microalgal slurry and 16 mL of concentrated anaerobic seed sludge (Table 6). All reactors were completed up to effective volume with distilled water. Control reactors were run without any algal biomass but seed sludge. In order to investigate the effect of BM supplementation, test and control reactors with identical COD values were operated with BM addition. After addition of all the constituents, effective volumes of the reactors were purged with nitrogen gas for 3 minutes and headspaces were purged for an additional minute. Reactors were capped with rubber septa and placed in a constant-temperature room at 35±1°C for batch mode incubation. Daily gas production was measured and gas compositions were analyzed.

Table 6: BMP assay reactor configurations

Code	C1	C2	A1	A2
Microalgal Slurry (mL)	0	0	8	8
BM	-	+	-	+
tCOD (mg/L)	4454	4454	9292	9292
VS (mg/L)	2997	2997	6146	6146

RESULTS AND DISCUSSIONS

Batch Cultivation of *Chlorella vulgaris*

Unialgal culture of *Chlorella vulgaris* had cultivated in 3NBBM + V medium for 56 days in batch mode. Correlation of TSS with optical density values was determined. TSS values were estimated further in semi- continuous cultivation studies using Equation (1), which represents the relationship between TSS and OD.

$$[\mathrm{TSS\ (mg/L)}] = 203.77\ [\mathrm{OD_{685}\ (Abs.)}]\ ;\ R^2 = 0.998 \qquad (1)$$

Semi Continuous Cultivation of *Chlorella vulgaris*

In order to produce microalgal biomass in massive amounts for BMP studies and to determine nutrient removal potential of the culture, semi- continuous cultivation reactor had been operated for 21 days. During the first four cycles with fed- batch operation, N/TSS_{algae} ratio was 0.18, 0.22, 0.18 and 0.18 respectively. When semi- continuous cultivation was started, N/TSS_{algae} value was fixed at 0.13.

Initial optical density in the reactor was 0.7 during the first cycle and decreased to 0.5 by the second cycle. Then, initial optical densities per cycle gradually increased up to 0.7 at the beginning of cycle 10. Starting from cycle 11, nutrient concentrations of the fed wastewater decreased. As a result, lower optical density value corresponded to the constant N/TSS_{algae} ratio. Until cycle 10, final optical density of each cycle had a tendency to increase compared to the previous cycle. Maximum optical density value was observed at day 10 as 1.472, at the end of cycle 8 (See Figure 1a).

Since N/TSS_{algae} values were taken into account for determination of the wastewater amount to be fed in SCP at the beginning of each cycle, daily volume of added wastewater varied in relation to the optical density reached at the end of the previous cycle. Without altering the ratio, daily wastewater volume and effective reactor volume were changed. Although wastewater volume changed between 8.5 L and 14.5 L, effective reactor volume was kept constant at 25L (See Figure 1b).

Since TAN, which is converted into NO_3^--N in the SCP, cannot be considered as treated, nitrogen removal efficiencies were calculated by taking into account the difference between sum of TAN and NO_3^--N concentrations in influent wastewater and effluent from each cycle. Ortho-P removal efficiencies were also calculated, considering influent concentration in wastewater and effluent of each cycle. As shown in Figure 1c, nitrogen removal efficiencies were above 80%, except for cycles 4, 5, 7 and 10. However, the removal efficiencies in these four cycles were acceptable in terms of feeding protocol. In order to completely remove nitrogen fed to the SCP in each cycle, N/TSS_{algae} ratio was reduced from 0.18 to 0.13. Then, cycle duration was increased. Maximum N removal efficiency of 99.6% was achieved at the end of cycle 9. When wastewater strength decreased, removal efficiencies were over 90%, with the maximum value of 92.5% at cycle 18.

Phosphorus removal efficiencies were unclear for the first four cycles, due to the interference of culture broth (3N BBM + V) with wastewater phosphorus concentrations (See Table 4). When this effect disappeared, the wastewater phosphorus concentrations in primary clarifier effluents of treatment plant started to decrease. Therefore, remaining phosphorus from previous cycles interfered with phosphorus removal efficiency calculations, until the phosphorus content in the reactor became lower than the concentration in feeding wastewater, which corresponds to cycle 13. As shown in Figure 1d, phosphorus removal efficiency in SCP was over 80% afterwards. Maximum phosphorus removal efficiency of 91.2% was observed at the end of cycle 17.

Nutrient removal efficiencies observed in this study are in consistency with similar studies. For example, ammonium and phosphorus removal efficiencies of high rate algal ponds were reported as 89% and 49% respectively (Green et al., 1995). Li et al. (2013) conducted batch, modified semi-continuous and continuous cultivation experiments of *Chlorella vulgaris* in municipal effluent. It was found that ammonia-N, total nitrogen and total phosphorus can effectively be removed by 98.0%, 90.3 – 93.6% and 89.9 – 91.8% respectively.

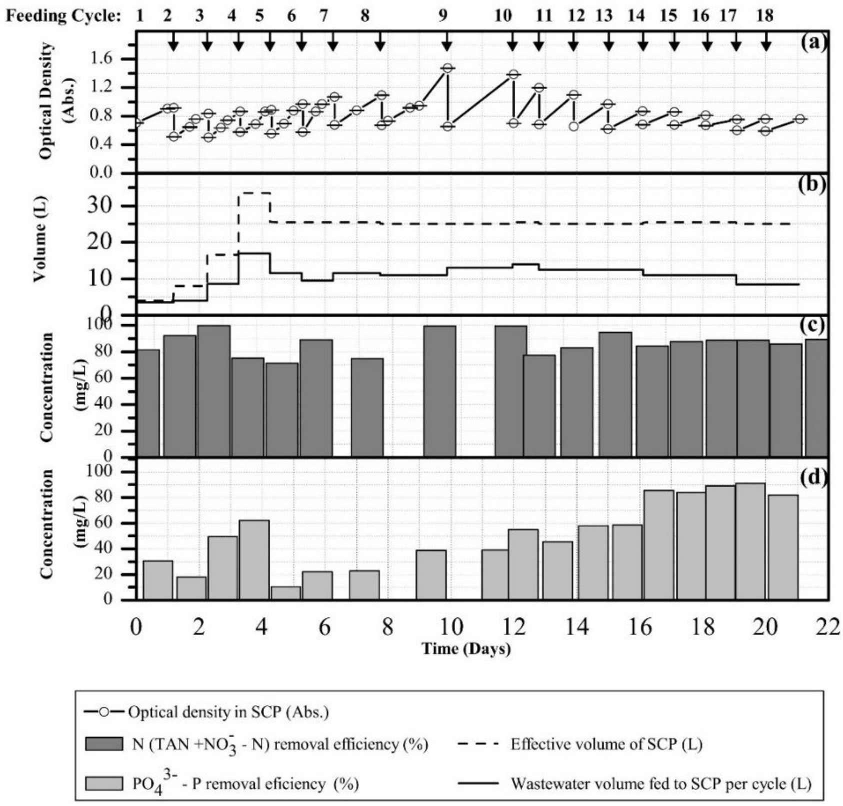

Figure 1. SCP Operation Kinetics and Nutrient Removal Efficiencies: (a) OD variations in SCP; (b) Fed wastewater volume and effective volume variations in SCP; (c) N removal efficiency of SCP per cycle; (d) P removal efficiency of SCP per cycle.

BMP Assay

Four batch reactors were operated for BMP test of raw microalgae for 66 days. Reactors were evaluated in terms of biogas production potential, biogas and methane yields. Gas production values were calculated by subtraction of cumulative biogas volume produced in control reactors with or without BM supplement. It can be seen from Figure 2 that the majority of biogas produced within first 30 days in each reactor. Until Day 25, there was no difference between reactors A1 and A2, in terms of biogas production. Afterwards, in Reactor A1, biogas production was further observed, whereas there was no significant change in cumulative biogas production data of A2, which was supplemented with BM. In A1, total of 99 mL biogas was produced, whereas 74 mL biogas was generated in A2, which is 25.1% less than observed in A1.

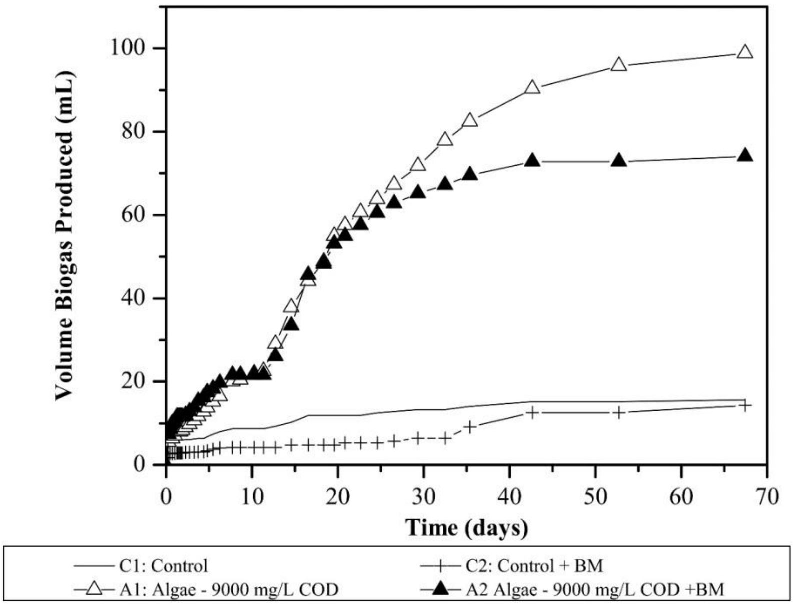

Figure 2. Cumulative biogas production values of BMP assay reactors

In order to determine methane production yields of reactors, methane contents were determined on percentage basis. Measurements were performed at Day 28, 35 and 56; started after the headspaces of reactors were washed with produced biogas; that is, when produced biogas volume exceeded three-folds volume of headspace. Figure 3 depicts methane contents of microalgal slurry reactors.

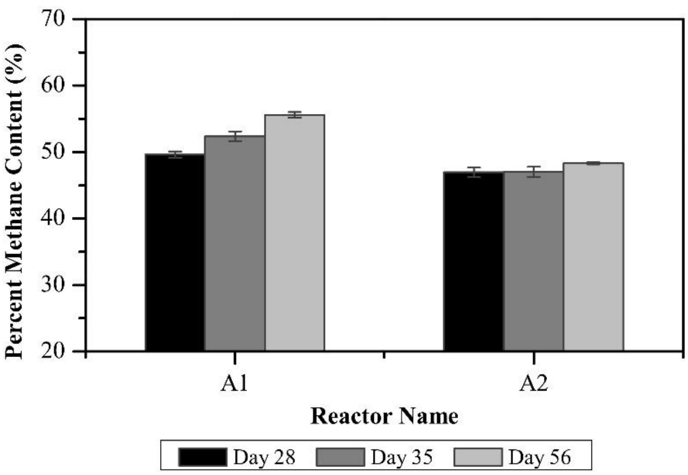

Figure 3. Methane contents of test reactors

As can be seen from Figure 3, methane contents of reactors were varying between 64% and 46%, although methane contents of produced biogas were not constant in any reactor. This fact shows that methanogenic bacteria activity did not have a constant rate and can be a result of consecutive ammonia inhibition and acclimation at various concentrations and time increments. Maximum methane content in these reactors was recorded at Day 56, as 55.59 ± 0.43% in Reactor A1 and 48.31 ± 0.16% in A2.

Table 7: Biogas and methane yields of test reactors

	A1	**A2**
Biogas Yield (mL/g VS added)	442	331
Methane Yield (ml CH4 / g VS added)	188	110

As shown on Table 7, maximum biogas production yield of 442 mL/ VS added was observed in reactor A1, which had the lowest initial COD content of 9000 mg/L and contained no BM. BM had an inverse effect on biogas production yield in for the reactor with same COD value. Same relation was not observed for methane yields, which were calculated using methane contents of the rectors. The maximum methane yield of 188 ml CH_4/ g VS was also observed in Reactor A1, with no BM addition. It can be clearly seen from Table 2 that these findings are in consistency with literature.

CONCLUSION

In this study, semi- continuous nutrient removal potential from primary clarifier effluents of domestic wastewater treatment plant, using microalgae was investigated. In the test runs, it was found that 99.6% of inorganic nitrogen and 91.2% of inorganic phosphorus present in domestic wastewater can be removed by *Chlorella vulgaris.*

Apart from successive nutrient removal potential of *Chlorella vulgaris*, it was also revealed that harvested microalgae from wastewater treatment systems can be converted into bioenergy via biomethane production. Results of this study showed that 442 ml biogas / g VS can be obtained by anaerobic digestion of *Chlorella vulgaris*.

Regarding outcomes of the present study, stress on ecological integrity due to nutrient discharge can be successfully eliminated using microalgal nutrient removal systems. In addition, produced biomass can be used as a renewable energy source.

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III International Conference
„ECOLOGY OF URBAN AREAS“ 2013

INFLUENCE OF ECOLOGICAL FACTORS TO PLANTS GROUPS IN INUDATION

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ABSTRACT

Rivers inundations different from each other in ground looking, looking of mechanical and mineralogical characteristics of soil, hydrological regime, so there are various plant groups in that area. Because of big demands for water, there are Populus nigra associations (section Aigeiros), where they can use not only water from rainfalls, but also underground water and water from floods. That area belongs to alluvial-hygrophilic forests.

Key words: *ecological factors, inundation, hydrological regime, alluvial hygrophilic vegetation.*

INTRODUCTION

River inundations differ from each other in ground looking, mineralogical and mechanical characteristics, hydrological regimes and plant associations that are located there. Dominating process of inundation creating is process of fluvial sedimentation which is closely related to river tractive force. There are three different genetic parts in river inundation depending on its transmission power such as coastal, central and pre-terracal part. Each of these genetic parts has its own soil distribution, specific hydrological regime and special forms of plant associations. So, there are hydromorphic soils formed on alluvial deposits that are characterized by associations of alluvial forests that can use rainfalls and underground waters. Ecological conditions of these sites in river inundations are under great influence of human factors (embankments, reclamation, etc). The aim of this scientific paper is to consider influence of the most important factor – water regimes – on vegetation in river inundations that can be naturally or artificially formed.

MATERIAL AND RESEARCHING METHOD

Researching of water regimes on river inundation sites was performed many times: on river Tamis (Herpka I., et. al,(1987.), Ivanišević P., et al, (2005.)) on the grounds that are under direct river influence and on the river Danube that is protected with ground embankments (Letić Lj. et al., (2013.). There are detailed dates analyzes in the paper that are collected at object "ameliorative system Lok", management unit Titel, which is located on the right bank of the Danube river, that is protected from floodwaters with ground embankment. Image 1 – this area presents place which is located between embankment and ameliorative channel "Lok" and it covers surface of about 47.0 ha. This ground is under the influence of inside and outside waters.

During high water levels of the river Danube underground waters cause very high soil humidity. Amelioration of these locations and with building of drainage system can improve conditions here – as a result, there are good conditions for agricultural and forest plants. Ameliorative system "Lok", Watermanagement company "Šajkaška" Novi Sad, drain mentioned locations with its channel net and pumping station that gives spare water to the river Danube back. The location is presented with place that is located between embankment and ameliorative channel “Lok” and covers the whole surface of about 47 ha with very specific micro-relief.

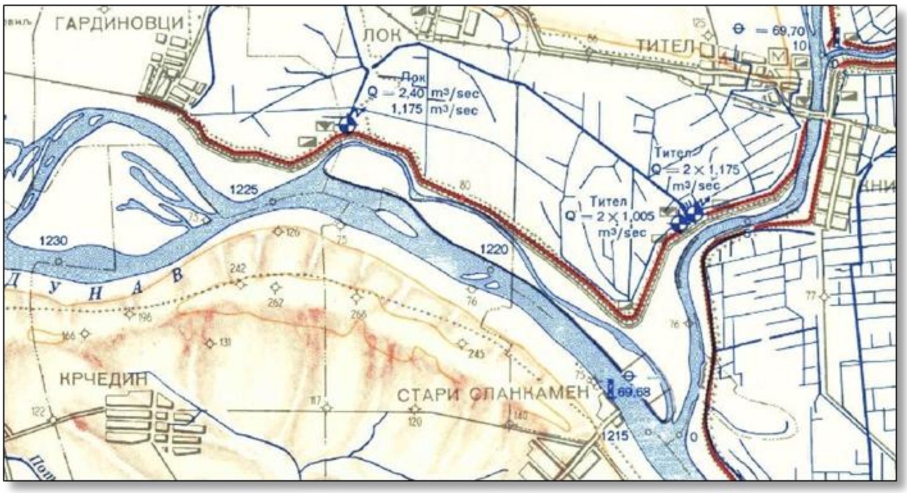

Image 1. Ameliorative area Lok, MU Titel

Research of the location includes dates analyzes that are calculated with different methods: pedologic, hydrological, ecological, and each of these was performed in lab and presented due to graphic analyzes.

RESULTS OF RESEARCH

Position of researched location determine its hydrological characteristics that are a bit corrected with building of ameliorative system “Lok”. Floods on inundation area in case of high Danube water level is eliminated by embankment building and its underground and inside waters in ameliorative object collected with net of drainage system go to the pumping station over the embankment. In this way protected locations in the river inundation are free of very high humidity soil during spring-summer period and it’s especially important within years with high level waters.

At researched areas of ameliorative system “Lok”, there are three specific soil parts such as fluvisol, humofluvisol and humogley that are formed at protected area of the river Danube and they differ from each other in relief and particularly in hydrological characteristics Galić Z., et al.,(2013.). After building of protecting embankment there are no floods on these grounds and, as a result, dominating process of fluvial sedimentation was stopped forever – therefore ecological and productive characteristics of the soil were completely changed.

Water regime at the researched location was determined on indirect way – there are dates of Danube water level and dates about water level at channel net of ameliorative system “Lok”. There are analyzed water levels at the nearest hydrometric profile (Slankamen) and water levels were recorded from list of activities from pumping station “Lok”, that determine underground water levels at researched areas. Water level analyze of the river Danube and water level analyze in ameliorative channel includes period of time between 2009 and 2013, but there are accepted dates that are related to the most important 2010, a year with the highest level of water.

From hydrological point of view, it was very bad year, where water levels of the river Danube reached values close to 77.00 mnm, and water level in channel net of system Lok was between 71 and 71.50 mnm (it was achieved due to temporary work of pumping station) with an average value of about 71.06 mnm during vegetative season. These values are a bit higher than projected water level, that shouldn’t be more than 70.90 mnm Letić Lj., et al., (2013.).

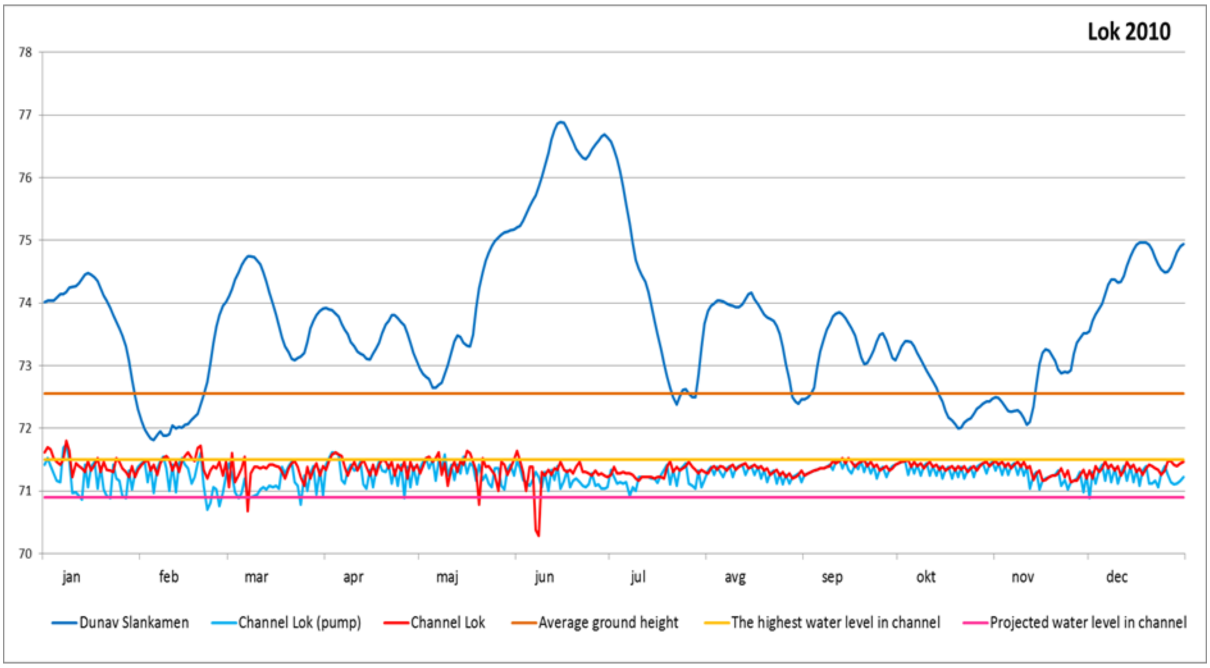

Diagram 1. Level of water Danube (Slankamen) and water level in ameliorative channel Lok for 2010.

As for previously presented values of water level in net of channel system, which determine underground water level and average values of analyzed forest areas, it can be said there are good conditions for root system development of Populus species, and it should be also emphasized that height of pedologic active profile should be about 1.2 meters Herpka I., (1979., 1987.). Besides, period of flooding for typical sites of Populus species is about 80 days Ivanišević P., et al., (2005.). So, grounds that satisfy the condition are located at 72.06 mnm height and that is minimum for Populus growing (Populus x euroamerikana sp.), which is determined by average value of water level in channel net during vegetative season, diagram 1. Under the lowest level for planting of EAPopulus species, there is zone of increasing water level which is suitable for Salix species growing that should be located between the highest water level in channel of about 71.5 mnm and the average value of water level in channel of about 71.06 mnm, and till the projected water level in channel of about 70.90 mnm, respectively. Ground height that is marked as minimum for Salix species (DGV) is located at the height that is close to highest water level in channel (71,5 m.n.m.), and under it there is zone with cane where dominates stagnant water.

Table 1: distribution of researched inundation areas for “Lok”, heights and surfaces

Height above sea		71,5	71,75	72,0	72,25	72,5	72,75	73,0	73,25	73,5	73,75	74,0	74,25	74,6
surfaces	F $10^3 \cdot m^2$	1,9	23,8	78,9	81,9	771,2	75,7	59,3	29,8	16,5	12,5	6,9	4,2	0,7
	ΣF $10^3 \cdot m^2$	1,9	25,7	104,6	186,5	263,7	339,3	398,7	428,5	445,0	457,5	464,4	468,6	469,3

On the base of dates from table 1, from the whole surface of researched location the greatest part of ground is suitable for growing of Euroamerican Populus, that is about 79 %, but on the other hand, some grounds with higher water level are more suitable for Salix specie growing – that is about 21 % and just 0.5 % belongs to marshy land that characterizes species that prefer high presence of water.

CONCLUSIONS

Due to analyze of available dates about relief and hydrological factors on researched areas of Lok location, it should be deduced:

- from three different soil fractions (fluvisol, humofluvisol, humogley) that are formed in protected area of inundation zone of the river Danube, which differ from each other in ground looking and especially in hydrological characteristics, fluvisoil is the most important, not only as the most widespread, but also in its ecological and productive characteristics.
- ground of researched area MU "Lok", from hydrological regime point of view in protected area of inundation zone of the river Danube belongs mainly to Populus nigra species sites (secc. Aigeiros), so it is suitable for Populus species growth (Populus x euroamericana sp.) with about 78.6 %, but on the other hand, some sites with higher water level are more suitable for growth of Salix species and they cover 20.9 % from the whole surface. Just about 0.5 % is marshy land covered with cane vegetation.
- development of EA Populus species in analyzed ecological conditions serves to regulate inside and outside waters of analyzed areas due to net of ameliorative channels

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THE UNIQUE AND UNUSUAL PHYSICO-CHEMICAL CHARACTERISTICS OF ORGANIC EMERGING CONTAMINANTS

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ABSTRACT

The paper presents unique and unusual physico-chemical characteristics with special focus on pseudo persistency, partition coefficients and negative effects of chemical cocktails of emerging contaminants (EmC). Unusual and unexpected physical and chemical characteristics of EmC need additional investigation of the occurrence, fate, behavior and ecotoxicology effects on the environment and human health. Within the international NATO Project ESP.EAP.SFP 984087 the screening and target analysis were performed in samples of Danube surface water and wastewater discharged directly into Danube which is the fundamental basis for the broader knowledge of the newly properties of EmC. More than 150 different EmC, priority and hazardous substances and toxic residues of metals were registered. Based on target analysis, predicted environmental concentration (PEC) and predicted no effect concentration (PNEC) were used in prioritization process of EmC in accordance with EU Water Framework Directive.

Key words: *emerging contaminants, chemical cocktails, pseudo persistency.*

INTRODUCTION

Increasingly sensitive analytical techniques have detected the presence of previously unregulated organic emerging pollutants in actual or potential sources for production of drinking water worldwide. The term ‘emerging contaminants’ is generally used to refer to such compounds/contaminants often previously not considered or known to be significant to surface, ground and waste water (in terms of distribution and/or concentration) but which are now being more widely detected and seeks for the significant research. These groups of contaminants which belong to the group of EmC have negative effects to all environmental compartments as well as could be ecotoxic to human population.

For EmC there is short definition previously unknown or unrecognized mystery pollutants, to recent time ignored environmental contaminants. EmC are generally not included in the legislation but not really than new, and upcoming priorities – future candidates for routine monitoring. Emerging contaminants are ubiquitous, persistent/pseudo-persistent and biologically active molecules that occur in the environment as a result of natural, industrial and human activities. EmC low doses and pseudo-persistency effect are recognized as a powerful chemical and eco stressors on total biosphere with unknown toxicology implication, fate, behavior, distribution and partitioning as well as transport through all environmental media.

EmC are mostly present in waste, surface and receiving water bodies (Grujić Letić et al., 2012, Loos et al., 2010, Milić et al., 2012). The most common mechanism for EmC is input into the environment through the wastewater discharges, application of sewage sludge, landfill leachate, accidents and other ways.

The dominant physicochemical characteristics particularly specific for EmC are: stable structure, low/non degradability, hydrophilicity and lipophilicity (Log Kow in the range of 0.03 – 9.2), bioconcentration/bioaccumulation and interaction with protein, toxicity, acute, but rather chronic effect. Most of the molecules of EmC are endocrine disruptors, with suspected teratogenic, mutagenic and carcinogenic consequences in low and sub low doses. Low doses effect with non-monotonic response and toxic effects are observed in the picomolar to nanomolar range. EmC are volatile/non/semi volatile compounds, polar/nonpolar molecules, with short half-lives. EmC can be neutral, acidic or alkaline molecules and in ionic or zwitter ionic states. Their main physical and chemical properties are characterized by some experimentally or mathematically derived constants of: protonation (Log pKa) in range of 9.6 – 2.5, octanol–water partition coefficient (Log Kow) in range 0.35 – 9.2 and solubility (Sw) in range from $1*10^6$ mg/l to 0.02 mg/l (Vojinovic Miloradov et al, 2013). Physicochemical properties of EmC (solubility, ad/absorbability, biodegradability, beside others) vary greatly depending on different molecular structures, number of asymmetric C atoms and stereochemistry. For most EmC, there is currently little information about their potential toxicological consequences on ecosystems, particularly from long-term low-level environmental exposure. The fate and the transport of EmC in natural aquatic media are practically unknown, especially in context of water/soil/sediment distribution and partitioning processes. These processes are in the intensive phase of research. In rare literature references it could be found the unique and specific constants as: the sorption removal of EmC are quite low (<20%), compounds with Kd>500 L/kg (Log Kd>2.7) potentially tend to adsorb onto sludge and particles, Log Kd values for most of selected EmC substances are less that 2.7 confirming their low tendency to adsorb (Verlicchi et al., 2012). The value of EmC/pharmaceuticals molecular charge at pH 7 provides information about its potential to create electrostatic interactions with the negatively charged soil/sediment surface. Sorption of EmC compounds is in general pH dependent. Attempts to correlate biodegradation removal of EmC to its molecular structure demonstrate that a large set of emerging organic chemicals including type of esters, nitrile and aromatic alcohols may increase biodegradability while aromatic amines, iodide, nitro- and azo- groups increase the persistency of the compound. The long and highly branched side chains (i.e. ranitidine/pharmaceutical) could provide EmC compounds more persistent as well as complicated aromatic ring structure (i.e. diazepam) and halogen group.

Especially specific and unique physico-chemical characteristics of so called chemical cocktail effects complicates the explanation of toxicological effects of EmC because of synergistic, antagonistic and catalytic interactions of simultaneously present EmC in real biological fluids. Every day, the cells are exposed to a large number of chemicals coming from many different sources; pharmaceuticals, PCPP products, toys, cosmetics, electronic equipment, indoor air, dust, additives, food and many others which are the components of the chemical cocktails/mix. An increasing amount of well documented studies suggests that these chemicals, in combination, can have severe effects on animals, nature and on humans, too. Currently, risk assessment and current EU-regulation of chemicals is generally carried out by a “substance by-substance approach”. However, we seriously underestimate the risk of chemicals, if we do not address the effects caused by simultaneous exposure to multiple chemicals from multiple sources. Multiple human exposures to EmC may start at conception and may be combined with a cocktail of other chemicals present in the environment. The effects of exposure to these mixtures are difficult to understand due the complexity and specificity of the situation during a period of special vulnerability and sensitivity of population (new born babies, adults, sick and alter population), but can not be denied. Another very serious threat is development and spread of bacteria, viruses and other microbes resistant to the antibiotics present in the environment, with possible unpredictable important consequences.

In this paper we would like to emphasize the new phenomena of effects of low doses, pseudo-persistency and negative effects of chemical cocktails of EmC. Two screening campaigns in the river Danube in the vicinity of Novi Sad have been performed within the NATO Project ESP.EAP.SFP 984087 in order to determine occurrence of EmC, priority and hazardous substances of interest for Danube basin and to proceed with target analysis of Danube surface water and wastewater discharged directly into Danube, which is the fundamental basis for the broader knowledge of the newly properties of EmC.

Low - dose effect and non-monotonic dose response

At the beginning of 21 century, a "low dose" effect was proposed based on studies which showed that hormonally active environmental emerging agents were causing a variety of adverse effects, mainly reproductive and developmental, at "low doses." There are two major characteristics of endocrine disrupting chemicals (EDCs), low dose exposures and non-monotonic dose response curves (NMDRCs). Natural hormones act at extremely low serum concentrations. EDCs can act in nanomolar to micromolar range, which is the same concentration level in which active EmC were found in surface and wastewaters, and potentially in drinking water (Vojinovic Miloradov et al, 2012).

NMDRCs present an important challenge to traditional approaches in regulatory toxicology, which assume that the dose response curve is monotonic. There is now substantial evidence that low doses of EDCs have adverse effects on human health as well as on wildlife. The traditional thinking in toxicology do not recognize the effects occurring at "low doses." It is claimed that "low dose" effects are occurring at levels comparable to those to which humans are being exposed. According to the definition “low dose” effects could be defined as specific phenomena that occur in the range of human exposures or effects observed at doses below concentration level till now are used for traditional toxicological studies.

What is NMDRS? Non-monotonic dose response curves, defined as a nonlinear relationship between dose and effect were the slope of the curve changes sign somewhere within the range of doses examined. The number of active molecules in picomolar and nanomolar concentrations is in the ranges from $6.023*10^{11}$ to $6.023*10^{14}$, respectively. These concentrations of EmC are stoichiometric equal and correspond to the biological concentration of hormones.

Persistency and Pseudo-persistency

Persistency in abiotic matrices (soil, water, sediment) is determined by the rates of the chemical removal by physical, biological and chemical processes, Vrem= - dc/dt. Chemical processes of removal include abiotic degradation processes like hydrolysis, direct/indirect photolysis and oxidation/reduction reactions. Microbial degradation is basic and the most important process of biotic degradation. Standardized test methods are available for most but not all degradation processes. Long life of “overall persistency” is based on chemical fate modeling.

EmC which are continually released to aquatic environment are attributed as pseudo – persistent even if their half-lives are short. Pseudo – persistency is the consequence of the constant supply of EmC which are continually replenished in environment, especially in aquatic media, i.e. receiving water or open aquatic bodies.

Toxic effects of EmC in very low doses and the phenomena of pseudo-persistency are particularly important for continual, multigenerational exposure of aquatic organisms.

Thermodynamic kinetic equilibrium processes within domain of pseudo persistency phenomena could be presented by mathematical relation in which the rate of input of EmC (*Vin*) is considerably higher than the rate of observed EmC output (*Vout*) i.e. *Vin*>>*Vout*, i.e. *Cin*>>*Cout* (mol/L).

Chemical cocktails of emerging pharmaceuticals

As the world’s population is growing and ageing, more people can afford medical treatment and new treatments are developed, the amounts of EmC/pharmaceuticals can be expected to increase rapidly. EmC/Pharmaceuticals entering the environment persist there and their residues are presently found in drinking water. They are found in fish where they may accumulate. The presence of different EmC/pharmaceuticals contributes to the increasing multiple chemical cocktail that today’s population is exposed to. Vulnerable populations are exposed with possible important consequences for life.

The effect that the chronic exposure to environmental EmC/pharmaceuticals adds to the effects of other chemicals in the cocktail is still not studied. The different chemicals might have potential synergistic effects (1+1=3). Extremely sensitive groups in this respect are fetuses, sick and older population. The fate, behavior and toxic consequences of chemical cocktails are still unknown.

Detection of EmC

Although the concentration levels of EmC are very low, they are detectable in wastewater, surface and raw water due to sophisticated analytical equipment UPLC tandem double MS or UPLC-TOF-MS/MS for organic emerging substances. For emerging ions analyses of metals AAS or electrochemical analyzer are used, while anions were analyzed with electrochemical analyzer or HPLC. For determination of EmC in modern approach two types of analysis are recommended, screening and target analysis. For screening and semi-quantitative analysis is preferable GC-MS, and for target and quantitative analysis performed after screening analysis, LC-MS/MS should be used or any other more sophisticated equipment.

Screening analysis of the Danube surface water and wastewater

The most frequently compounds occurring in studied water samples were phthalates, PAHs, terpenes and fatty acids. Special groups detected in all waste and river water samples were terpenes like nerol, citronellol, menthol, ionone and other compounds like camphor, ethyl citrate or methyl jasmonate that could occur in cosmetics, care products, and home cleaning products. Wide variety of hormones, derivatives of benzene and polycyclic aromatic hydrocarbons (PAHs) were detected in many studied water samples.

Presented study of the surface water quality was performed for the first time in Novi Sad and its surroundings, where municipal and industrial wastewaters are directly discharged, without any treatment, into the Danube River.

CONCLUSIONS

Emerging contaminants, EmC, are pollutants with growing concern of their occurrence in environment, toxic effect, distribution, transport and fate with very low concentrations in wastewater, surface water, groundwater or drinking water resources with possible negative effects on humans and aquatic ecosystem. The research progress has been made regarding the information, data monitoring and knowledge of the specific physico-chemical characteristic as the low doses effects, NMDR, pseudo-persistence, chemical cocktails which causes shifting in a concept of specific physico-chemical characteristics of EmC in process of environmental protection. Results of analysis of screening and target campaigns demonstrated that phthalates, PAHs, terpenes and fatty acids belong to the most frequently occurring compounds in wastewater and Danube surface water near Novi Sad. According to screening and target analysis, PEC/PNEC ratio and process of prioritization are in progress. These research activities have been conducted for the first time on the Danube river in the vicinity of Novi Sad.

ACKNOWLEDGEMENT

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III International Conference
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OPTIMIZATION OF THE GREEN-PROCESS OF AMMONIA REMOVAL FROM WASTEWATER USING NANOPOROUS SORBENT

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ABSTRACT

The use of process simulation for simplification, modeling and performance optimization of ion exchanging process for wastewater ammonia removal, using synthetic zeolites as a adsorbent, is described in this paper. The process simulator SuperPro Designer was used for this purpose. A model was designed for this environmental process using the simulator SuperPro Designer with operating settings for treating of 50 m^3/h wastewater containing ammonium at concentration of 45 mg/l. The main objective is to optimize the plant dimensions and decrease the operating costs through changing the operating parameters, in order to achieve more sustainable environmental process for tertiary wastewater treatment. For this purpose we developed several simulations. For constant operating settings of the plant we optimize the plant dimensions, and further for this setup we optimize the cycle time of each column, reaching high efficiency, maximum annual operating time, and 96% ammonia removal. When defining the standard conditions of the plant model, in order to decrease the operating cost, simulations were made on the change of the composition of regeneration solution, using mixture of cheaper and efficient components.

Key words*: process design and optimization, wastewater treatment, ion exchange, SuperPro Designer*.

INTRODUCTION

The global industrial development requires environmental technologies aimed to reduce environmental impact and increase efficiency. Hence, the problem of modeling environmental processes becomes a big challenge. Today, process simulators are big engines which can be used in each phase of the development of the project, and together with including of the engineer intuition we can get the right solution for one process. During process development, process simulation software is used to perform material and energy balances, estimate the size of equipment, calculate demand for utilities as a function of time, asses the environmental impact, etc.

Synthetic zeolites are adsorbents that has been known for their ability to remove ammonium from polluted waters. The adsorption capacity of zeolite and its chemical regeneration for ammonium removal was investigated in several studies (Kazemian, H.,1993; Rahmani, A. R.,. Mahvi A.H. and Mesdaghinia A.R., 2004). Usually, the service cycle is a down flow packed bed column followed by chemical regeneration (usually by NaCl). When applying the ion exchange technique where regeneration is included, ammonium is first separated from the wastewater flow during the loading phase by filtering it through a column packed exchanger. As the exchanger becomes saturated with ammonium ions, the exchanger is regenerated chemically by passing a salt solution through the column. The ammonium ions are exchanged by cations such as sodium ions, and the ammonium ions thereby become displaced. The regeneration phase results in a concentrated effluent stream of ammonium chloride (chemical regeneration). The ion exchange process may be followed by ammonia stripping when the brine solution is recovered, and the ammonia gas may be sorbed in sulfuric or nitric acid (Liberty at al., 1981). The major drawback of this process is the high cost of the chemical regeneration stage and disposal of the concentrated ammonium-sodium brain produced (Ori Lahav and Michal Green. 1981). For this reason the ion exchanging technique has not been extensively used for primary ammonia removal. The technique has, however, been investigated as an alternative to conventional biological nitrogen treatment (nitrification-denitrification) when the BOD/N ratio, wastewater temperature, or nitrogen concentration are low. In order of developing more sustainable environmental processes, the process of wastewater ammonia removal through ion exchanging columns was used as a representative example for economic optimization of environmental process. For this environmental process a model was designed using the process simulator SuperPro Designer with certain equipment dimensions and operating settings for treating of 50 m^3/h wastewater containing ammonium at concentration of 45 mg/l. The main objective is to decrease the operating costs through changing the operating parameters, in order to achieve more sustainable environmental process for tertiary wastewater treatment.

MATERIALS AND METHODS

Description of the process

The main goal of the development of suitable simulation models is to conduct a transparent environmental processes analysis. The general focus is on the process of tertiary wastewater treatment as an addition to already existing wastewater treatment plant in city of Skopje with already known effluent quality and quantity (Stefan Kuvendziev et al., 2010). The additional equipment for ammonia removal through process of ion exchange is showed in Figure 1.

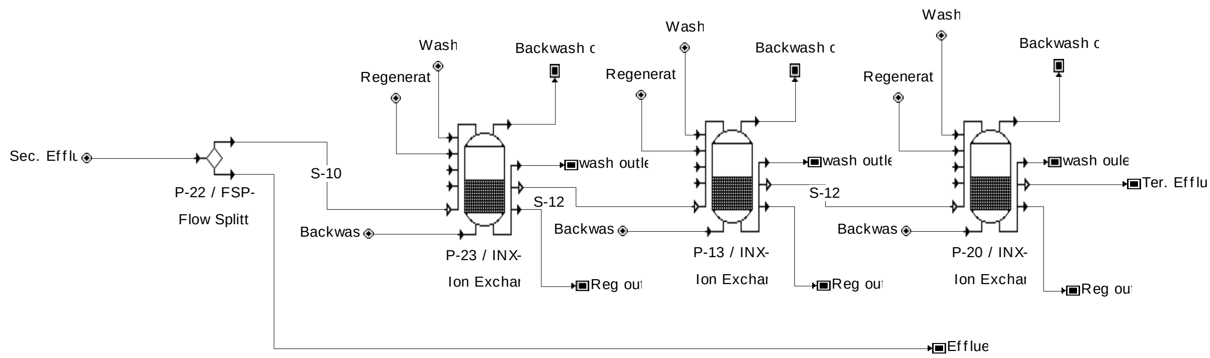


Figure 1. SuperPro Designer scheme of the process of ion exchange

The flow sheet is developed by putting together the required unit procedures, and joining them with material flow streams. This process starts with continuous effluent feed stream, which represents the effluent sewer from the secondary wastewater treatment plant. This stream is characterized with effluent flow of 50 m^3/h and ammonia concentration of 45 mg/l. During the planning of this model, other effluent quality characteristics are not taken into consideration, under assumption that the effluent water is already prepared for the ion exchanging columns. After the flow splitting, the secondary effluent continues in the first ion exchanging column (P- 23/INX101) where ammonia removal is up to 50%. The ion exchanging columns although are embedded in one contuous process, they work in batch or semi- continuous mode, including several operations in one procedure. The operations and their schedule included in each column are showed in the next figure (see Figure 2):

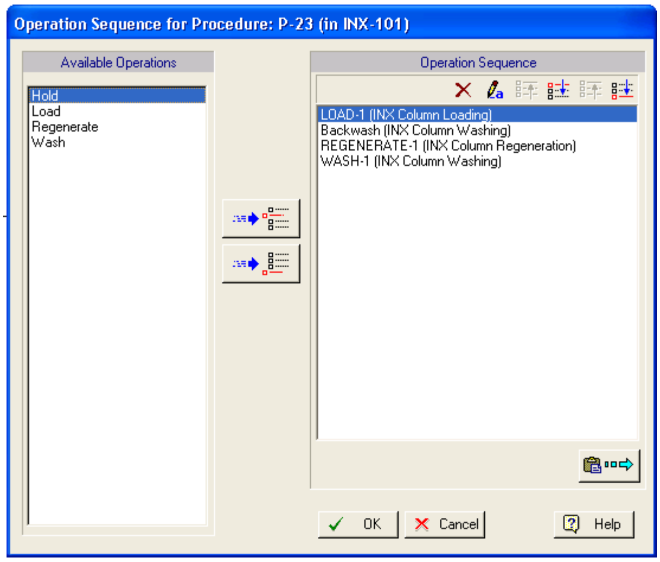


Figure 2. Operations and their schedule in the procedure P-23/ P-24/ P-25

The breakthrough time in the ion exchange columns can be defined by the binding capacity of the sorbent or by the service volume. In our model, the breakthrough time is defined by the binding capacity of the natural zeolite of 1 g/l ion mass. In the second column (P-24/INX102) ammonia removal reaches up to 83% (see Figure 3), and in third ion exchanging column, the ammonia removal is set up to 96%. Each column has a volume of 1.96 m^3, and out of the performed simulations, the highest load uptake was recorded in the first column and the least load was adsorbed by the third column.

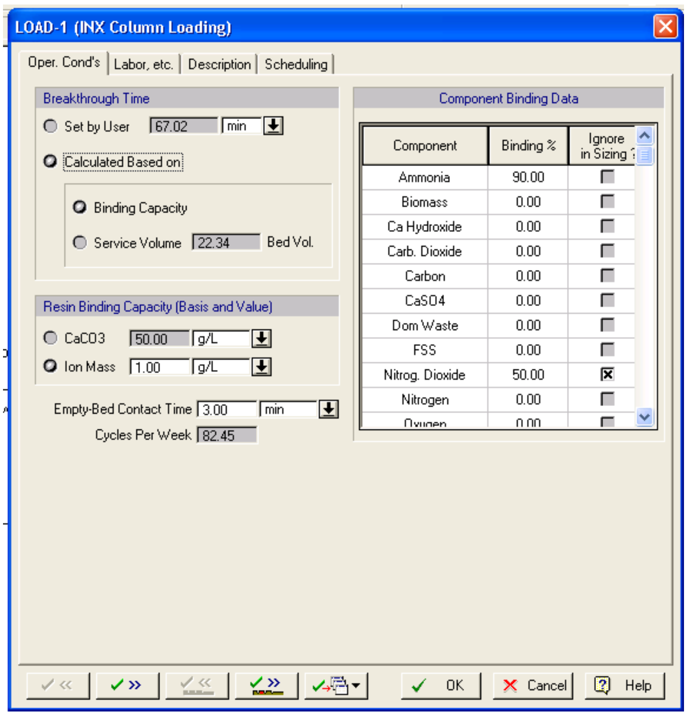


Figure 3. Review of the operation window LOAD-1 in SuperPro Designer

The simulation report produces a clear overview of the results regarding the material balances for each material component in the system, total material balances, and material balances for each flow separately and in total. A binary system, consisting of ammonia and water, was established as an inlet stream of the experimental system (Table 1; Table 2).

Table 1: Composition of the feed of the column

Secondary Treated Effluent			
Component	Flowrate (kg/batch)	Mass ratio (%)	Concentration (g/l)
Ammonia	8.16763	0.0050	0.046420
Water	163344.33529	99.9950	928.354297
Total	163352	100	

Table 2: Composition of the treated effluent

Tertiary Treated Effluent			
Component	Flowrate (kg/batch)	Mass ratio (%)	Concentration (g/l)
Ammonia	0.00229	0.0000	0.000014
Water	163344.33529	100.0000	994.684420

RESULTS AND DISCUSSION

In this environmental process, the key parameters that are important to manipulate in SuperPro Designer for accruing optimal operating and economic results are the type and quantity of regeneration solution, type of sorbent, optimal dimensions of the equipment and the right scheduling of the procedures, which give us maximum batches per year for minimal resources used.

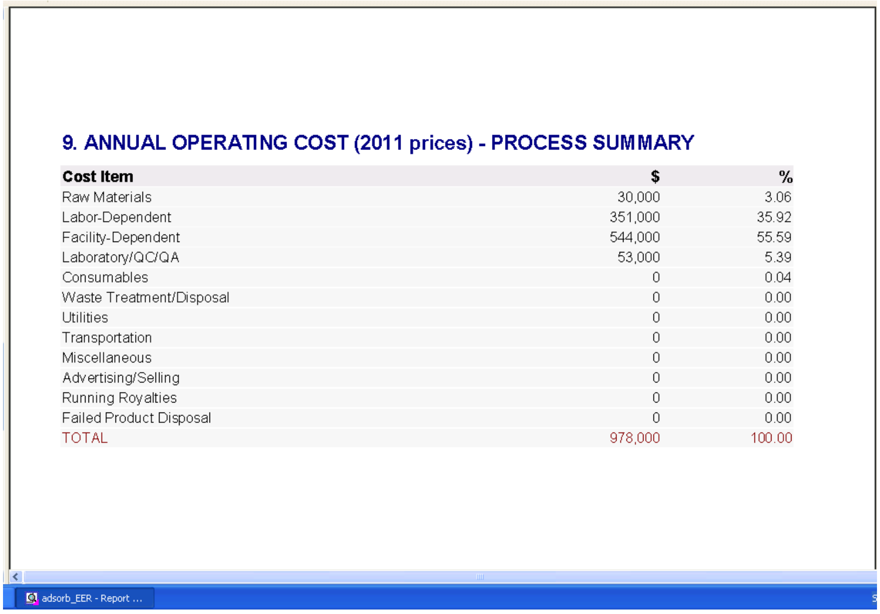
This process simulation tools enable users to readily experiment with options that have the potential of increasing the efficiency and reducing the resources. The base case process already operates at its maximum efficiency (imposed by volume of the columns). Consequently, the only option to increase efficiency is by reducing or changing the type of the regeneration solution as it represents the biggest operating cost. The simulations are done on constant inlet flow, constant equipment dimensions and settings.

According to available literature (Ødegaard, H. 1992) regarding regeneration solutions for zeolites, the conventional NaCl solution can be replaced with solution of NaOH or changed into mixture of these two regeneration solutions. The purchase price of the NaOH is twice lower than the NaCl. According to the first column the consumption of regeneration solution is shown in Table 3:

Table 3: Composition of the regeneration solution for the INX- 101

Regeneration Solution Consumption NaCl+ NaOH			
Component	Flowrate (kg/batch)	Mass ratio (%)	Concentration (g/l)
Water	7685.41447	90.0000	940.96072
Sodium Chloride	853.93494	10.0000	104.55119

After simulation is done the next simulation report (see Figure 4) of economic evaluation of the process is exported:

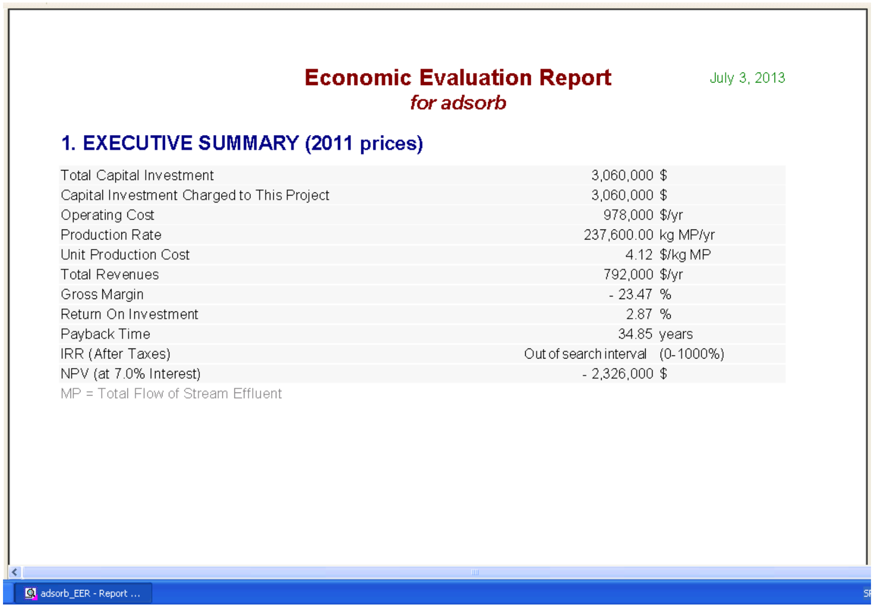


9. ANNUAL OPERATING COST (2011 prices) - PROCESS SUMMARY

Cost Item	$	%
Raw Materials	30,000	3.06
Labor-Dependent	351,000	35.92
Facility-Dependent	544,000	55.59
Laboratory/QC/QA	53,000	5.39
Consumables	0	0.04
Waste Treatment/Disposal	0	0.00
Utilities	0	0.00
Transportation	0	0.00
Miscellaneous	0	0.00
Advertising/Selling	0	0.00
Running Royalties	0	0.00
Failed Product Disposal	0	0.00
TOTAL	978,000	100.00

Figure 4. Annual operating cost in the economic evaluation report in SuperPro Designer

From the evaluation report, the executive summary of the process can be mark off with separation of the expenses and other economic predictions, such as payback time, return of the investment etc (Figure 5).



Economic Evaluation Report
for adsorb

July 3, 2013

1. EXECUTIVE SUMMARY (2011 prices)

Total Capital Investment	3,060,000	$
Capital Investment Charged to This Project	3,060,000	$
Operating Cost	978,000	$/yr
Production Rate	237,600.00	kg MP/yr
Unit Production Cost	4.12	$/kg MP
Total Revenues	792,000	$/yr
Gross Margin	- 23.47	%
Return On Investment	2.87	%
Payback Time	34.85	years
IRR (After Taxes)	Out of search interval	(0-1000%)
NPV (at 7.0% Interest)	- 2,326,000	$

MP = Total Flow of Stream Effluent

Figure 5. Executive summary of the economic evaluation report in SuperPro Designer

For the next simulation the composition of the regeneration solution is changed with a mixture of 5% NaCl and 5% NaOH solution. This is shown in Table 4:

Table 4: Composition of the regeneration solution after changes made

Regeneration Solution Consumption NaCl+ NaOH			
Component	Flowrate (kg/batch)	Mass ratio (%)	Concentration (g/l)
Sodium Chloride	426.83656	5.0000	52.25957
Sodium Hydroxide	426.83656	5.0000	52.25957
Water	7683.05801	90.0000	940.67221

After performed simulation, the results were exported through the economic evaluation report (see Figure 6), in order to conduct comparative analysis. As a result, operating cost is decreased, but further optimizations can be performed in the field of Labor depended costs and Facility depended costs (electricity etc.).

9. ANNUAL OPERATING COST (2011 prices) - PROCESS SUMMARY

Cost Item	$	%
Raw Materials	17,000	1.74
Labor-Dependent	351,000	36.41
Facility-Dependent	544,000	56.35
Laboratory/QC/QA	53,000	5.46
Consumables	0	0.04
Waste Treatment/Disposal	0	0.00
Utilities	0	0.00
Transportation	0	0.00
Miscellaneous	0	0.00
Advertising/Selling	0	0.00
Running Royalties	0	0.00
Failed Product Disposal	0	0.00
TOTAL	965,000	100.00

Figure 6. Annual operating cost in the economic evaluation report in SuperProDesigner

CONCLUSION

Out of the performed simulations it can be concluded that through changing the composition of the regeneration solution, the cost for raw materials can be decreased for 43%. This will influence the final payback time and return of the investment. Process simulation can play an important role throughout the life-cycle of process development and optimization. We conclude that the new regeneration solution is suitable for the existing treatment plant. Performed simulations suggest that the ion exchanging columns reach optimum operating costs when applying a mixture of regeneration solutions.

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INFLUENCE OF PROCESS PARAMETERS ON AERATION ENERGY CONSUMPTION IN AEROBIC BIOLOGICAL TREATMENT OF MUNICIPAL WASTEWATER

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ABSTRACT

Urban areas produce a relatively large amount of urban waste water. Municipal wastewater are typical composition and is usually processed by mechanical, chemical-physical and biological processes. Most treatment plants for municipal wastewater has a biological aerobic treatment by which naturally removes pollutants from the water, but also consumes the largest amount of energy during the entire treatment process. Of the total energy required for wastewater treatment, energy consumption in the process of aeration in biological treatment is 50 to 90%. This paper discusses the optimization of aeration in terms of energy consumption. Controlled process parameters significantly can reduce the energy consumption and to provide the required amount of dissolved oxygen required for aerobic biological treatment of wastewater in urban areas.

Key words: *aeration, power consumption, processing, municipal wastewater.*

INTRODUCTION

Domestic waste water is tap water or natural water of consistent quality which is used for cooking, washing and sanitation needs in the household. In addition to mineral and organic components that were already present in the water which use the waste water formed, it still contains a significant amount of human excrement, paper, soap and other detergents, food waste, mineral waste and a number of other waste materials. Most of the pollutants of domestic wastewater is organic and due to its high energy value is subject to the action of saprophytic micro-organisms or microorganisms that feed on dead organic material. Because this wastewater to microbial degradation and may have an unpleasant odor. For domestic wastewater settlements or a negligible share of industrial wastewater containing a significant proportion of waste water from a variety of institutions and public institutions, often being referred to as sanitary sewage. If a village or city influenced its advanced industrial production and if the industrial waste water (with some degree of processing) are discharged into the city sewer system and interfere with domestic or sanitary sewage, then the mixture thus formed is called communal or municipal wastewater.

Before discharge to receiving waters should be municipal wastewater treated in an appropriate manner. The task of wastewater treatment is not only to break down pollutants, and to those in the natural recipients dropped in another form, but that the appropriate procedure eliminates pollutants from wastewater. After removal of suspended and colloidal dispersed particles can be deposited, the remaining colloidal particles and dissolved organic substances must be removed from the water in secondary purification, which is usually performed biological treatment processes. The task of biological treatment is to get as much as possible to remove biodegradable organic compounds. Biological treatment processes are basically the same as the self-purification processes in natural waters. They take place in the biological activity of aerobic and anaerobic microorganisms. For aerobic biological treatment is necessary to provide sufficient oxygen and efficient contact of oxygen, organic compounds and microorganisms. Usually the introduction of oxygen through the air, although

it is possible to enter technical and oxygen. Operation which is performed introducing air or oxygen in the water is called aeration.
As in all technical processes and the process of aeration in the aerobic biological wastewater treatment process parameter selection is of utmost importance. This paper discusses the influence of process parameters on aeration energy consumption in aerobic biological treatment of municipal wastewater.

IMPACT ON EFFICIENCY PARAMETERS AERATION PROCESS WITH BIOLOGICAL TREATMENT OF MUNICIPAL WASTEWATER ACTIVATED SLUDGE

In the biological treatment of municipal wastewater activated sludge for the introduction of air into the pool bioaeration used aeration or deep pressure and surface or mechanical aeration, and the combination of these two procedures - combined aeration. Aeration efficiency depends on several factors: structural solutions and distribution vendors, bioaeracionog basin geometry and composition of the water to be purified. For a surface aeration using mechanical turbine intake of oxygen in the water depends on the shape and diameter of the turbine, the peripheral speed and the depth of immersion of the turbine, and the composition of the wastewater. Increase the speed turbines increases oxygen supply.

Typical process parameters for different aeration systems are:
- The introduction of oxygen capacity, kg / h
- Load the aeration basin organic substances reduced to a unit volume pool kgBOD$_5$ / (m^3 · day)
- Load of sludge, ie. ratio of organic substances and dry mass of sludge kgBOD$_5$ / (kgSM · day)
- Duration of aeration, h
- The amount of sludge to be recycled from the secondary sedimentation tank in bioaeration pool, %, and
- The effect of reducing the required amount of biochemical oxygen %.

Depending on the type of treatment process with activated sludge systems are following the application of aeration:
- Aeration and recirculation,
- Contact stabilization (biosorption, regeneration sludge)
- Kraus (Kraus) process,
- Gradually adding wastewater
- Gradually add air
- Systems with complete mixing,
- Extended aeration,
- Systems with deep manhole.

Contact process is very effective for wastewater treatment, with a greater proportion of organic pollution in the form of fine suspended and colloidal particles. In smaller villages away from the central plant for wastewater treatment is often used with the extended aeration process. In areas where land prices are high use systems with deep manhole in the biological treatment of municipal wastewater with activated sludge. Plant type deep shaft was developed in England and is used in areas where land prices are high. Most plants of this type are located in Japan, and their application in the U.S. and Canada is booming. The advantages of deep shaft are low operating and labor investment, low requirements for the occupation of land and well withstand high organic load.

In depth aeration, the choice of placement and type of air distributor is of paramount importance for successful process of wastewater treatment. There are certain criteria relating to the method and installation location dealer in bioaeration pool. Dealers can be placed over the entire surface of the bottom bioaeracionog pools, only one of his side or at a certain height from the bottom. Schedule distributor must be such as to provide the required amount of oxygen to all parts of the basin. It is often more immersed air distributors placed at the entrance of the pool due to increased oxygen demand in this area. Figure 1. describes different ways of setting up and connecting the aeration panels at the bottom of the bio-aeration basin in order to provide more efficient enrichment of water with oxygen.

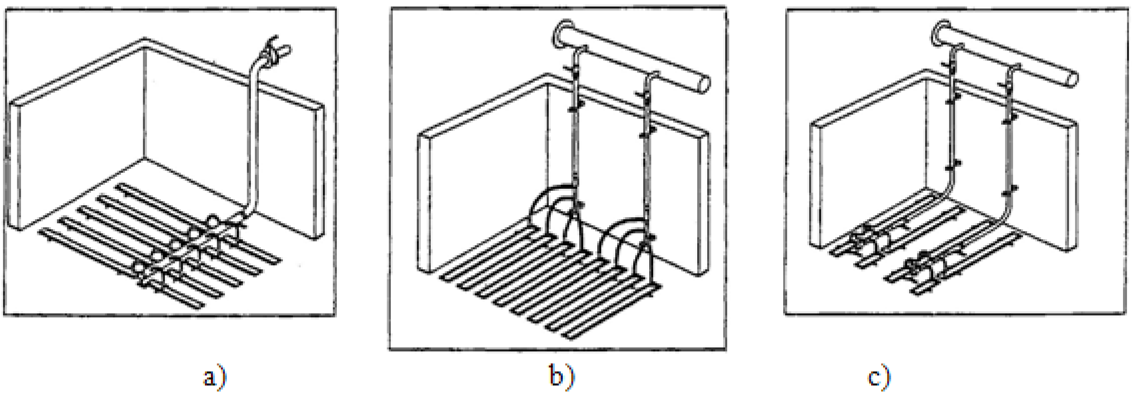

Figure 1. The positioning and supply air panel group air distributors:
a - horizontal connection, b - vertical integration, c - central connection [1]

It is advisable that before entering the engineering and construction of wastewater treatment perform analysis and comparison of aeration systems in terms of efficiency, energy efficiency and capacity introduction of oxygen and only then to the consideration of other relevant factors make multi-criteria optimization, and came to the selection of an appropriate solution . Main technical characteristics that define the efficiency of the aerator with blowing air (air distributors) in the process of deep aeration are: standard input capacity of oxygen, the actual capacity of the introduction of oxygen, the specific capacity of the oxygen entering, standard efficiency of oxygen transport, the actual efficiency of oxygen transport, energy transport efficiency standard oxygen, the actual energy efficiency of transport of oxygen and pressure drop by one distributor of air.

Standard efficiency of oxygen transport is expressed as a percentage and is defined by the ratio of the standard input capacity of oxygen and the total flow of oxygen which causes aeration device. For a given construction distributor of air standard efficiency of oxygen transport function of the depth at which the dealer is located and the resulting flow of air or oxygen. Due to the longer contact time between the liquid and gas phases with increasing depth of immersion distributor of air and reducing air velocity increases and the value of the indicators.

The actual efficiency of oxygen transport as a standard efficiency of oxygen transport is expressed as a percentage and is defined by the ratio of the actual capacity bringing the total flow of oxygen and oxygen is supplied to the aeration device.

Standard energy efficiency of oxygen transport is the ratio of the standard input capacity of oxygen and engaged power required to drive the aeration device. In addition to standard defines the actual energy efficiency of oxygen transport, which is the ratio of actual oxygen input capacity of engine power required to drive the aeration device.

Specific energy consumption is an indicator of air distributors, which takes into account the organic load of wastewater (expressed in kWh per kg of organic load expressed as BOD_5).

In addition to these basic indicators of air distributors there are a number of parameters relevant for the selection of appropriate vendors that provide data producers. Selection of air distributors can be carried out according to the specific capacity of the introduction of oxygen that can be carried by some distributors, which like the previous parameters (indicators) Function of immersion and flow of air through the distributor.

To select the compressor plant and the entire system for air supply (oxygen) for aeration important indicator of the pressure drop that is implemented on one distributor of air. Distributors manufacturers this parameter usually given in the form of a chart, where the pressure drop increases with increasing of the input current of air.

To be able to define the technical indicators of air distributors is necessary to first determine the volumetric ratio of the oxygen in the water. Volumetric coefficient of oxygen transport is the product of the coefficient of the oxygen in the water and the surface area of contact of air and water in the process of aeration.

The chart (Figure 2.) shows the dependence of specific capacity of oxygen entering the air flow and thickness setting distributor of air, and the chart (Figure 3) shows the dependence of the pressure drop on the air flow and the type of distributor.

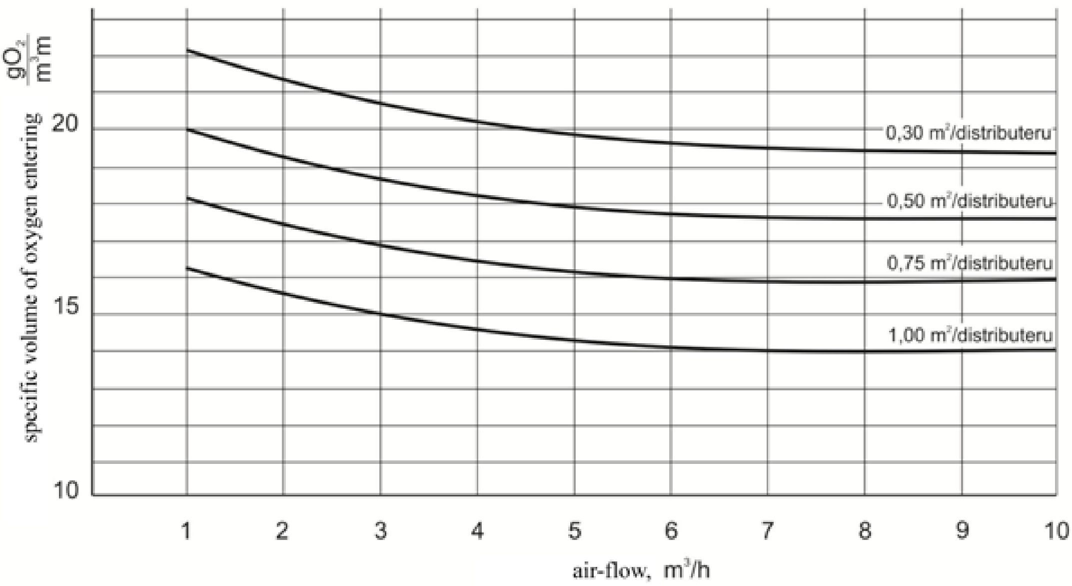

Figure 2. Dependence of specific capacity of oxygen entering the air flow and density setting air distributors [2]

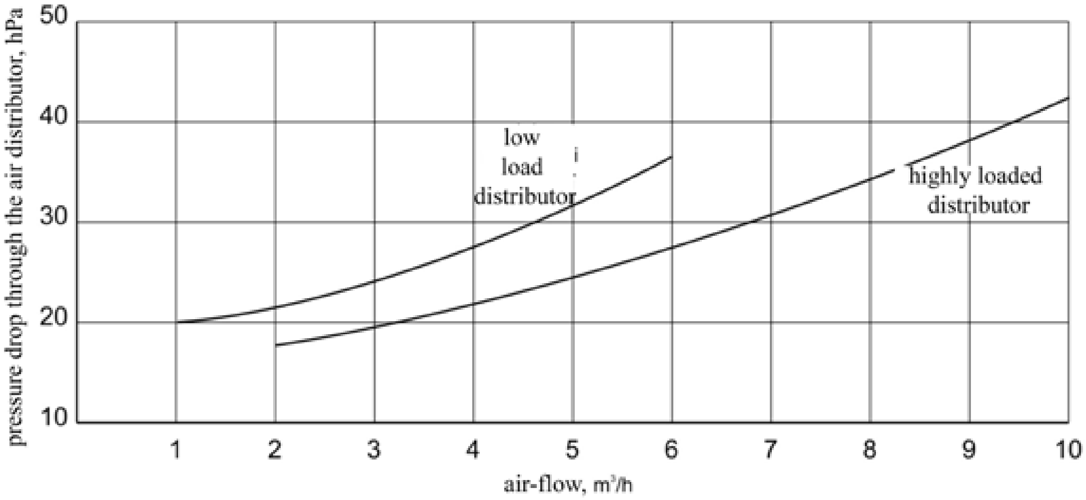

Figure 3. Dependence of the pressure drop due to the resistance of the air distributors of air flow and type of distributors [2]

CONTROLLING THE AMOUNT OF AIR IN THE AERATION SYSTEMS

The concentration of dissolved oxygen in bioaeration pool size from which to manage the process of aeration. Aerators should be entered as the air (oxygen) in the waste water as needed to maintain the desired concentration of dissolved oxygen in bioaeration pool.

The main task of managing the process of aeration is to provide the necessary concentration of dissolved oxygen and minimum energy consumption for the air supply in bioaeration pool. Automatic control of aeration process regulates the amount of air using a computer or controller to meet the changing needs for oxygen and maintain the required concentration of dissolved oxygen in the water. Basic characteristics of automatic control aeration are providing integrity and continuity of the process, increase process reliability and reduce operating costs.

Manual control of the aeration process is usually done when a constant flow of air, which leads to bioaeration pool, and when in the course of biological treatment varies not required concentration of dissolved oxygen in the water. In systems for biological treatment of waste water in which the changes occur once or twice daily, or weekly or seasonal applied manually manage the process of aeration. In this case, the air flow is adjusted so that they are satisfied and most intense oxygen demand in the future. In this way, wasting energy, because during the process most of the time provides more oxygen than needed. In practice, a large number of plants for biological treatment of waste water is no change in the mode, and is used to manually control the process of aeration. The plants for biological treatment of waste water in which the manual control can not maintain the required concentration of oxygen dissolved in the appropriate time period and certain parts of the aeration basin requires the application of automatic control.

Automatic control of dissolved oxygen in the water is the only way in practice to meet the demands for oxygen and therefore reduce energy consumption and reduce the number of problems resulting from aeration. The amount of energy needed for aeration process is 50 to 90% of the total energy required for biological treatment of water, so that the application of automatic control systems can achieve significant energy savings. For plant wastewater treatment needs for the amount of air that is introduced into the water is not constant, but typically ranges. Manual regulation of the process of aeration can meet some minor variation application for dissolved oxygen, but in most cases these variations are very large so manual control is not producing the desired results. Compared to manual control automatic control of dissolved oxygen in the water can save 25 to 40% of energy. Dependence of the concentration of dissolved oxygen in the effluent of the ways to manage the process of aeration is given in Figure 4.

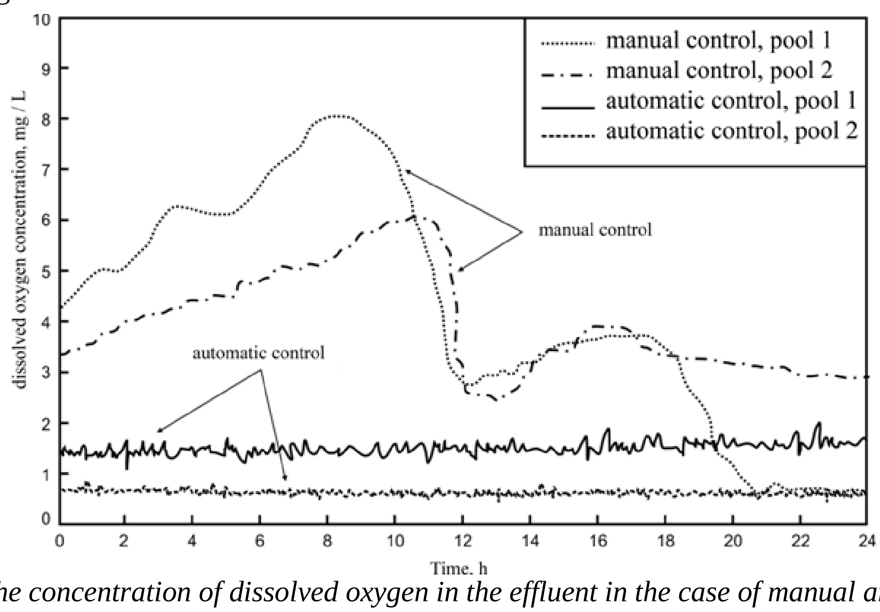

Figure 4. The concentration of dissolved oxygen in the effluent in the case of manual and automatic control of aeration process [3]

Comparison of energy consumption for the manual and automatic control process of introducing air into the wastewater by the distributor of air is shown in Figure 5.

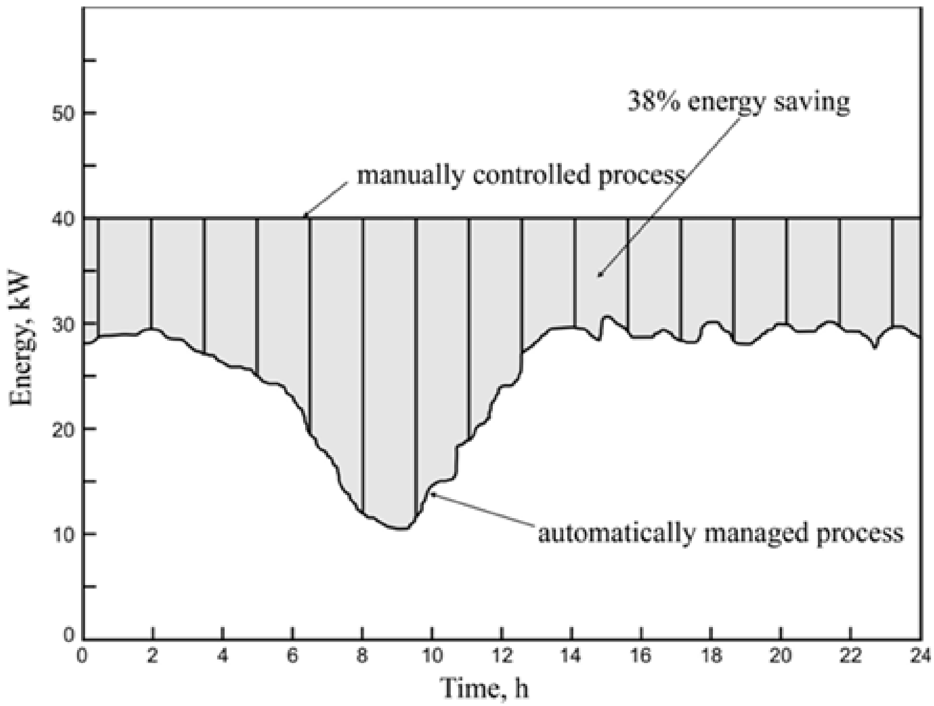

Figure 5. Comparison of energy consumption for the manual and automatic control of aeration process [3]

In sharp increase air flow through the openings distributor efficiency of the oxygen decreases and reduces the efficiency of the aeration process due to increased pressure drop through the air distributor. Therefore, it is necessary to gradually reduce the air flow to meet the demands for oxygen, and in order to maintain maximum efficiency of the oxygen in the aeration process.

CONCLUSION

Improves aeration process parameters significantly can reduce the energy consumption and to provide the required amount of dissolved oxygen required for aerobic biological treatment of wastewater in urban areas.

By proper selection of process equipment for aeration to provide optimal working conditions, as well as lower operating costs of facilities for biological wastewater treatment in general.

Municipal wastewaters are typical composition and is for design of their processing is necessary to pay attention to:

- The quantity of water to be treated,
- The required quality of treated water,
- Available space for construction,
- Choose the type of treatment process with activated sludge and on the basis of the aeration system,
- Selection of appropriate equipment and devices,
- The way of the process parameters of aeration, and others.

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NATURAL REMOVAL OF SELECTED EMERGING POLUTANTS DUE TO THE RIVER BANK FILTRATION

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ABSTRACT

Riverbank filtration (RBF) systems are particularly well suited for providing better water quality than direct withdrawal from the surface water. During the underground passage, a series of physical, chemical, and biological processes take place, improving the quality of the surface water, substituting or reducing conventional drinking water treatment. Under appropriate circumstances (several dozen feet of unconsolidated, unfractured porous media) reliable RBF systems can remove microbial pathogens, organic contaminants (including taste and odor causing substances and DBP precursors), emerging pollutants, turbidity, and other substances. Among emerging pollutants, a particular attention focuses on pharmaceuticals because they may exert their activity at the low concentration levels (ng/L range). In Europe, many different pharmaceutical active compounds, used as human and veterinary drugs, are susceptible to reach every environmental medium. The relatively recent awareness of pharmaceutical products (PPs) impact on environment is reflected in literature since the 1990s through the exponentially increasing number of studies concerning this emergent class of water pollutants. The aim was to study the occurrence and behavior of selected pharmaceuticals and their residues during passage through the riverbed and aquifer sediments.

Key words: *River bank filtration, emerging pollutants, removal, pharmaceuticals, environment.*

INTRODUCTION

Alluvial aquifers are widely used as a groundwater source in many countries, mainly due to their high yield potential, proximity to demand areas, their ease, and economy of extraction. During this process, known as riverbank filtration (RBF), a reduction in the concentration of pollutants is achieved by physical, chemical, and biological processes that take place, between the surface water and groundwater, and with the substrate. The processes which take place in an aquifer are numerous and diverse. In addition to convective transport of solutes, the various groups of processes include: dispersion processes, solid/liquid phase exchange processes, and degradation processes (processes which lead to the "disappearance of a certain substance from both the liquid and solid phases of the aquifer) (Dimkić et al., 2008.). In addition to the removal of pollutants (particles, microorganisms, organic, and inorganic compounds, etc.) there are two most significant advantages of RBF. The first advantage is related to the fact that the flow through the aquifer surves as a barrier against concentration peaks that may result from accidental spills of pollutants. The second is the regulation of the temperature variations in the river water: during winter, when air temperatures are low, the filtered water is usually warmer than surface water, and *vice versa*. The lowest variation in temperature improves the quality and further processing of the bank filtrate (Hiscock et al., 2002.).
In Republic of Serbia raw water for drinking water production is generated mainly by bank filtration of surface water, within the city boundaries.

Surface water represents the recipient for substantial quantities of wastewater from urban centers. Since a significant quantity of pharmaceutically active components reaches the surface waters, a number of pharmaceutical residues have been detected in measurable, but low concentrations in groundwater (Grujić et al., 2009, Radović et al., 2012).

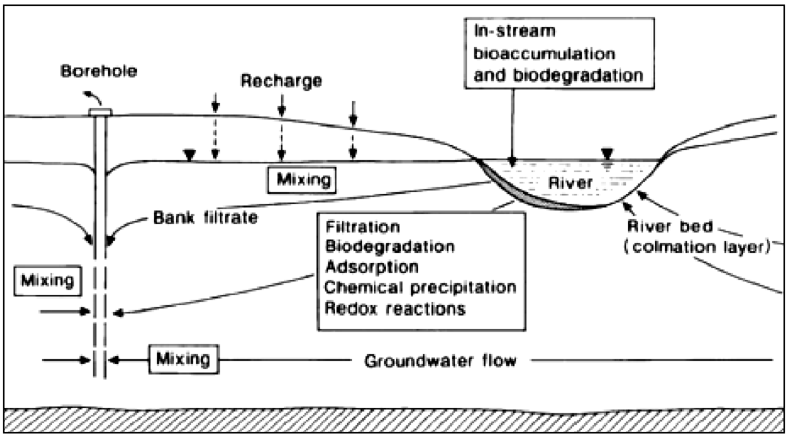

Figure 1. Basic scheme of riverbank filtration and main attenuation processes (Hiscock et al., 2002.)

Since several pharmaceutical residues are not completely removed during conventional wastewater treatment, or as it is case in the Republic of Serbia, where only15 % of wastewater is treated (RSO Serbia), they most definitely reach the receiving surface water systems (Heberer, 2002a, Radjenović et al., 2009). Effects and behavior of the large number of trace pollutants, including pharmaceutical residues and metabolites in the aquatic environment and in groundwater in particular are relatively unknown (Schwarzenbach et al. 2006, Loos et al. 2010). The pharmaceuticals carbamazepine, trimethoprim and 4-formylaminoantipyrine, 4-FAA, and 4-acetylaminoantipyrine, 4-AAA (metamizole metabolites), have widely been used in Serbian medical care system (Terzić et al., 2007, Grujić et al., 2009.). They are excreted after ingestion either in their original form or as metabolites after biotransformation.

METHODS

Field site

The Morava River is 185 km long and flows through the most fertile and densely populated area of Central Serbia, called a Morava river valley, or Pomoravlje. The studied field site is located at Morava River, Danube tributary, 1 km before the confluence. Groundwater sampling sites cover groundwater source system Ključ near Morava river bank from 1 monitoring well and 1 piezometer. The second groundwater transect on drainage system Ključ - Morava, is the alluvial plain of the Velika Morava, built of polycyclic fluvial- lacustrine and alluvial deposits, Quaternary (eopleistocen - Holocene). Thickness of gravel in the area of the groundwater source is from 6 to11 m. Thickness of Quaternary deposits is about 15 to 20 m. Thickness of gravel in the area of the groundwater source is from 6-11 m. Monitoring well (GW Vb-2) with accompanying piezometer (GW Vb-2-P1) was used to investigate the hydrochemical composition of the freshly infiltrated water and to study the elimination of organic micropollutants in the colmation layer. Monitoring well (GW Vb-2) was used for observation of the groundwater at 12 meters below terrain elevation, at a distance of 30 m from the Morava River shoreline (shoreline moves slightly over the year). Accompanying piezometer (GW Vb-2/P1) was used for the observation of the groundwater at 11 m below terrain elevation. Piezometer (GW Vb-2/P1) is at approximately the same distance from Morava river shoreline as the corresponding well.

Figure 2. Locations of monitoring well and sampling site on Morava River, groundwater source "Ključ"

Sampling and analysis

Water sampling from surface water and monitoring wells was conducted periodically between July 2010 and December 2012. Analysis for redox potential, pH, O_2, temperature and electric conductivity were carried out in the field by The SEBA Multiparameter Sensor MPS-D (RS 232). The measurements in monitoring wells were made with probe immersed into the water to the level of filter design, and in piezometers the probe was dived to the filter structure after throwing at least three volumes of water from the piezometers using peristaltic pumps. Samples for cation analysis were preserved with addition of concentrated nitric acid (HNO_3). Alkalinity samples were collected in glass bottles that were carefully filled to the tip of the bottle, to avoid any air entrapment. Samples were stored at 4°C, and complete water analysis was generally performed 24 to 48 hours after sampling.
Water samples for pharmaceutical residue analysis were collected as grab samples, in 1 l bottles, and refrigerated at 4 °C without preservatives until they were processed, usually 24 to 48 hours after sampling. The selected pharmaceuticals were analyzed by solid phase extraction (SPE) followed by liquid chromatography-tandem mass spectrometry analysis (LC–MS^2) according to a method described in the literature (Grujić et al., 2009).

RESULTS AND DISCUSSION

Based on the experimental results pharmaceutical concentration of in the Morava River and accompanying drainage wells and piezometers were calculated.

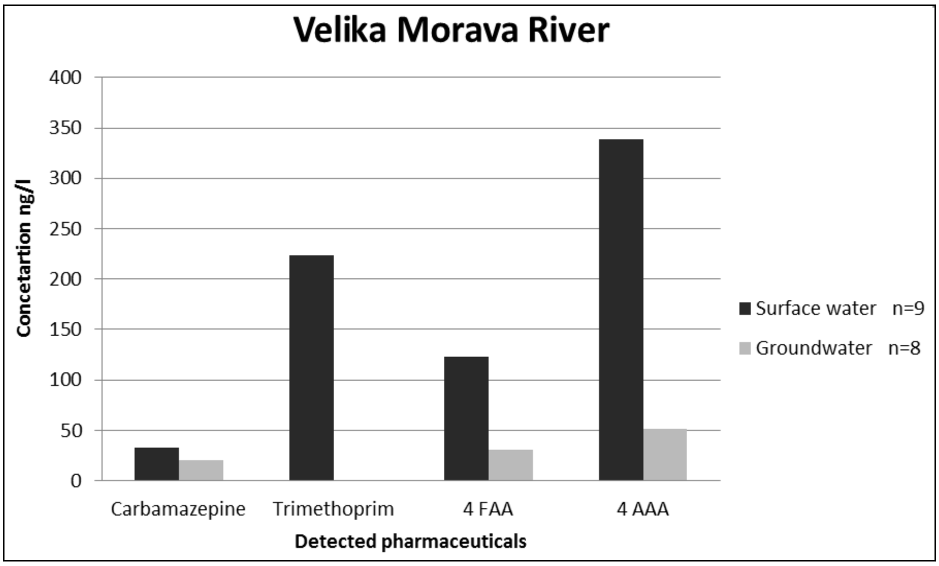

Figure 3. The results for selected pharmaceuticals concentration in the River Velika Morava, the monitoring well Vb-2 and piezometer Vb-2-P2

Conclusion emerges that a significant decrease in pharmaceutical concentrations in surface water is a results of a flow through the river bank and bank filtrate all the way to the drainage wells and piezometers. It is evident that riverbank filtration can help utilities in various ways.

CONCLUSIONS

There are numerous advantages to using riverbank filtration as a water treatment technology. Based on the analyses it can be concluded that a significant decrease in pharmaceutical concentrations in surface water results from the flow through the river bank and bank filtrate all the way to the drainage wells and associated piezometers. RBF improves water quality and may lower down other accompanying water treatment costs and expenses. This type of process combines the removal of particles, turbidity, pathogens, natural organic matter, organic and inorganic chemicals, peak smoothing in spills, temperature equalization, and reduction in DBP formation, improvements in taste and odor, and biochemical stabilization of water. As surface water seeps through sediment and aquifer, water undergoes a diversity of natural attenuation processes, significantly improving water quality, without the need for processing chemicals, and resulting, in ideal cases, in a high quality of natural groundwater. However, polar persistent organic substances are often not completely removed during underground passage. Elimination rates of these substances vary with residence time and length of subsoil passage, and often depend on the underlying redox medium. Overall, underground passage of water improves raw water quality and makes drinking water more acceptable for the consumer. The benefits of underground passage, which are less recognized, include avoided medical costs and a longer life span. It is evident that riverbank filtration can help utilities in various ways. On the basis of a comprehensive evaluation of available data, it is obvious that water quality is improved and subsequent treatment steps can be replaced or at least supported, leading to lower water treatment costs.

ACKNOWLEDGEMENTS

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GROUNDWATER ARSENIC CONTAMINATION IN ZRENJANIN AREA

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ABSTRACT

Groundwater arsenic contamination is one of the biggest public health problems in the world. Arsenic (As) occurs naturally as an element, ranks as the 20th most occurring trace element in the earth's crust. Arsenic is constantly present over decades in drinking water supply systems of the city of Zrenjanin in Vojvodina region, Serbia. People in this affected area have chronically been exposed to drinking arsenic contaminated wells water. There are serious health problems related to the consumption of groundwater with extremely high arsenic concentrations. In the observed area, the origin of groundwater arsenic is discussed for a long time. Arsenic contamination is understood to be of geogenic origin released from soil under conditions conducive to dissolution of arsenic from solid phase on soil grains to liquid phase in water, and percolation of fertilizer residues might have played a modifying role in its further exaggeration. The research analyzes data on the concentrations of arsenic from the 2003, 2006, 2007 and 2011. It will be observed and discussed the vertical fluctuations of arsenic concentrations during these years. The paper is aimed at determining the major source of arsenic in groundwater.

Key words: *arsenic, groundwater, contamination, arsenic origin.*

INTRODUCTION

City of Zrenjanin is situated on the western edge of the region Banat in province of Vojvodina with an altitude ranging from 77-97 meters. Zrenjanin is positioned at 20°23' east longitude and 45°23' north latitude. Most of the population and the economy of the city is supplied with water from shallow (30-75 m) and deep (90-135 m) aquifers, which are characterized by high mineralization, a high content of iron, ammonia, manganese, sodium, organic matter, arsenic, unbalanced organoleptic properties. The water is oxygen-poor and loaded with dissolved sulfur hydrogen and methane. The main groundwater aquifers in Zrenjanin have extremely adverse physical characteristics according to the strategic development material focused inter alia on the quality of groundwater/ drinking water (The Council for the strategic development of the Municipality of Zrenjanin, 2005). Water supply of the City of Zrenjanin is based on utilization of groundwater from the two main aquifer with the wells located northwest of the city with a total of 35-40 wells. In Zrenjanin groundwater directly engages the pipeline system and it supplies the population as drinking water. The groundwater only passes through the microbiological treatment before enters the pipeline system.

A rapid growth in research on arsenic occurrence and behavior in the drinking water has occurred over the last decade. Today, groundwater arsenic contamination have been recognized and documented in numerous countries across the world. From all sources, As in drinking water has the greatest influence on the human population and their health (Habuda-Stanić and Kuleš, 2002). The presence of arsenic in groundwater sources at concentrations greater than 50 mg/l was confirmed in Argentina, Bangladesh, Chile, China, Hungary, Romania, Taiwan, Vietnam, USA…

The aim of this study was to explore the major source of the groundwater arsenic based on the collected data. It will be discussed the vertical fluctuations of arsenic concentrations during observed period of time.

THEORY

Arsenic occurs naturally as an element, ranks as the 20th most occurring trace element in the earth's crust (NRC, 1977) and is widely distributed in the environment. Arsenic (As) is a naturally occurring contaminant found in many groundwaters. It generally occurs in two forms (valences or oxidation states): pentavalent arsenic (also known as As(V), As(+5), or arsenate) and trivalent arsenic (also known as As(III), As(+3), or arsenite). In natural groundwater, arsenic may exist as trivalent arsenic, pentavalent arsenic, or a combination of both. Although both forms of arsenic are potentially harmful to human health, trivalent arsenic is considered more harmful than pentavalent arsenic. Trivalent arsenic is generally more difficult to remove from drinking water than pentavalent arsenic. Trivalent arsenic can be converted to pentavalent arsenic in the presence of an effective oxidant such as free chlorine. In natural waters arsenic is most often found in the form of $H_2AsO_4^-$, $HAsO_4^{2-}$, H_3AsO_3 and $H_2AsO_3^-$.

Redox potential and pH are the main factors which influence the form of arsenic in the water (Habuda-Stanić and Kuleš 2002). Under oxidized conditions, $H_2AsO_4^-$ is dominant at low pH (less than about pH 6.9), whilst at higher pH, $HAsO_4^{2-}$ becomes dominant (H_3AsO_4 and AsO_4^{3-} may be present in extremely acidic and alkaline conditions respectively). Under reduced conditions, at pH less than about pH 9.2, the uncharged arsenite species H_3AsO_3 will predominate (Smedley et al. 2002). A predominance of molecules and ions of arsenic depending on the pH of the water is shown on figures 1 and 2.

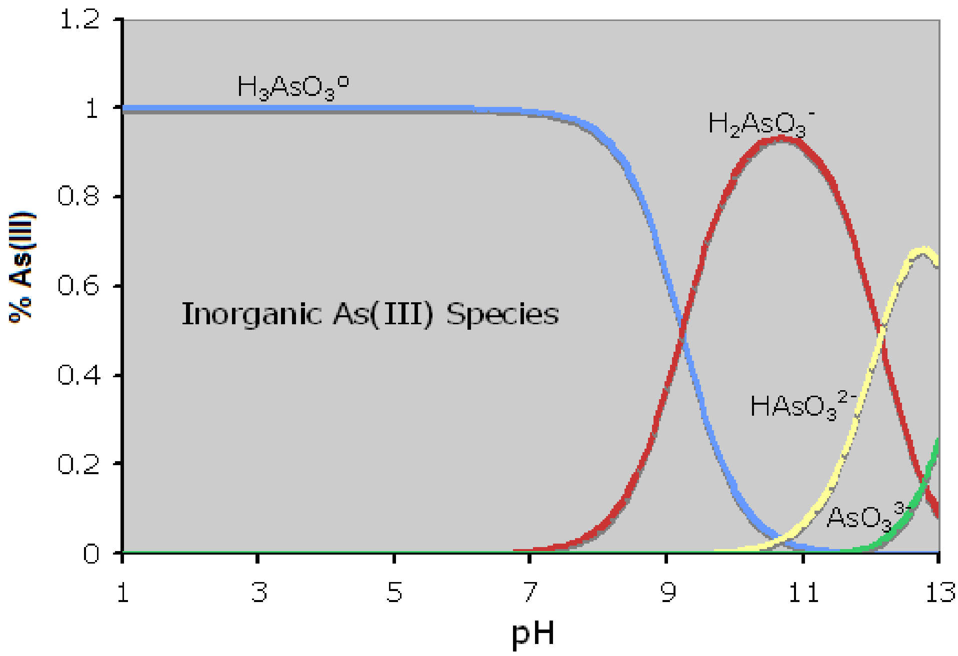

Figure 1. Stability and speciation of As (III) compounds in water depending on the pH of the water (B. Jovanović et al., 2011)

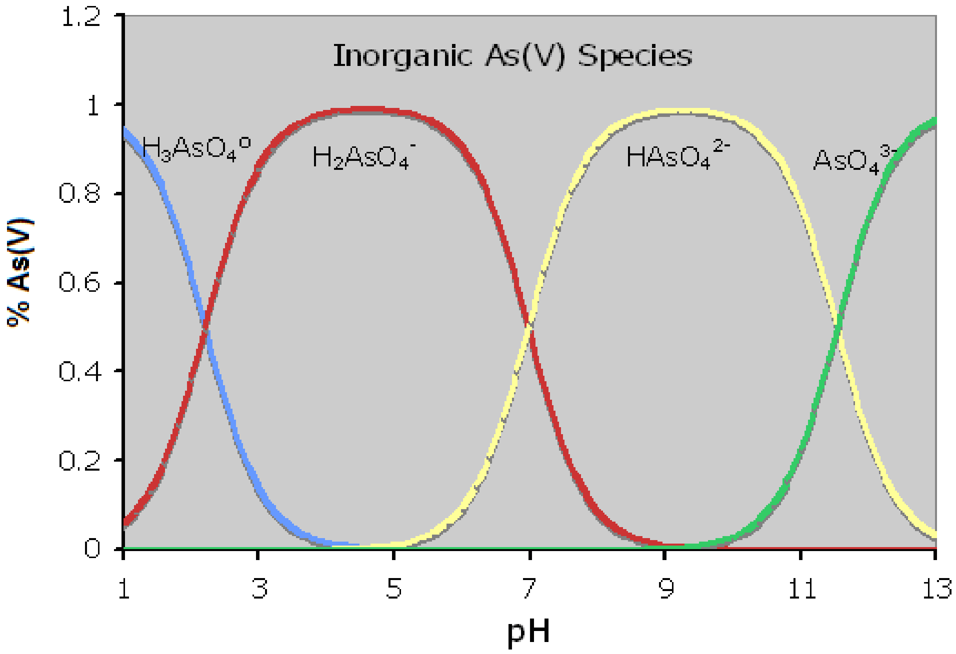

Figure 2. Stability and speciation of As (V) compounds in water depending on the pH of the water (B. Jovanović et al., 2011)

Under natural conditions, the greatest range and the highest concentrations of arsenic are found in groundwater as a result of the strong influence of the water–rock interactions and the favorable physical and geochemical conditions in aquifers for the mobilization and accumulation of arsenic. Arsenic is particularly mobile at pH values typically found in groundwater (pH, 6.5–8.5) under both oxidizing and reducing conditions (IARC, 2004).

Equations (1-3) are representing oxide reduction potential of As (III):

$$H_3AsO_3 + H_2O \rightarrow H_3O^+ + H_2AsO_3^- \quad (1)$$

$$H_2AsO_3^- + H_2O \rightarrow H_3O^+ + HAsO_3^{2-} \quad (2)$$

$$HAsO_3^{2-} + H_2O \rightarrow H_3O^+ + AsO_3^{3-}. \quad (3)$$

Equations (4-6) are representing oxide reduction potential of As (V):

$$H_3AsO_4 + H_2O \rightarrow H_3O^+ + H_2AsO_4^- \quad (4)$$

$$H_2AsO_4^- + H_2O \rightarrow H_3O^+ + HAsO_4^{2-} \quad (5)$$

$$HAsO_4^{2-} + H_2O \rightarrow H_3O^+ + AsO_4^{3-}. \quad (6)$$

Inorganic arsenic compounds are classified by the International Agency for Research on Cancer (IARC) in Group 1 (carcinogenic to humans) on the basis of sufficient evidence for carcinogenicity in humans and limited evidence for carcinogenicity in animals (WHO, 2011). There are numerous data on the relationship between the risk of cancer and drinking water with high content of arsenic, but has not yet assessed the risk caused by low concentrations of arsenic in water. Considering all the uncertainties related to the risk assessment, the World Health Organization in 1993 recommended the maximum permissible concentration (MPC) of arsenic in drinking water of 10 mg / l. Recommendations from these have been adopted in the legislation of the Republic of Serbia in the By-law on the hygiene of drinking water (Official Gazette of Republic of Serbia, No. 42/98 and 44/99).

METHODS

Until recently, As was often not on the list of constituents in drinking water routinely analyzed by national laboratories, water utilities and non-governmental organizations and so the body of information about the distribution of As in drinking water is not as well known as for many other drinking water constituents (Smedley and Kinniburgh, 2002). Indeed, As is now recognized as the most serious inorganic contaminant in drinking water on a worldwide basis. In the city of Zrenjanin arsenic is analyzed once a year.

The presence of high arsenic concentrations in drinking water doesn't indicate any change in taste, odour or visible appearance of water. So, it is difficult to detect it without complex analytical techniques.

Total water arsenic was determined using the HG-AAS technique (Perkin–Elmer 1100 atomic absorption spectrometer equipped with a MHS-20 hydride generation system, Perkin–Elmer Corp., Norwalk, CT, USA). Reagents of analytical grade or higher quality were used. Hydride generation was performed using a 3% (w/v) NaBH4 in 1% NaOH (both Merck suprapur; Merck, Darmstadt, Germany) solution. The radiation source was a hollow cathode lamp of arsenic (Perkin–Elmer) used at a wave length of 193.7 nm and a spectral slit width of 0.7 nm. Hydride generation (HG) was performed with 0.6% $NaBH_4$ dissolved in 0.5% NaOH and 5 mol/dm^3 HCl. The hydrides were then transported to a heated quartz cell and the atomic absorption of the analyte was measured. By analyzing 4 series of 10 repeated analyses of blank samples and calculating the three standard deviation of these responses a limit of detection of this method was 0.5 mg/l and limit of quantification was 2 mg/l. Recovery of standards was 80–120% (D. Jovanović et al., 2012).

FINDINGS

In this research were analyzed data on the concentrations of arsenic from the 2002-2003, 2006, 2007 and 2010-2011. Water sampling and analyses were performed at the Institute of Public Health in Zrenjanin. In the folowing tables 1-4 will be reperesented the concentrations of groundwater arsenic.

Table 1: Arsenic concentrations ($\mu g/l$) in drinking water in the city of Zrenjanin and in the nearby villages from April 2002 to March 2003

Town and nearby villages	April	May	June	July	Avg.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Melenci	**235**	**230**	**140**	**80**	**70**	**110**	**230**	**349**	**260**	**260**	**275**	**340**
Taraš	**240**	**230**	**120**	**90**	**70**	**250**	**260**	**344**	**320**	**250**	**275**	**290**
Jankov Most	**85**	**70**	**70**	**60**	**40**	**75**	**60**	**72**	**50**	**50**	**70**	**48**
Mihajlovo	**70**	**65**	**60**	**30**	**95**	**110**	**95**	**92**	**80**	**70**	**85**	**95**
Elemir	**85**	**55**	**50**	**35**	**40**	**17**	**150**	**224**	**140**	**210**	**205**	**190**
Klek	**65**	**85**	**50**	**30**	**60**	**90**	**70**	**96**	**70**	**65**	**80**	**75**
Zrenjanin-source	**75**	**105**	**165**	**-**	**55**	**54**	**60**	**85**	**46**	**60**	**95**	**120**
Zrenjanin-network	**95**	**80**	**100**	**60**	**60**	**75**	**75**	**70**	**70**	**200**	**85**	**90**
Aradac	**120**	**100**	**70**	**40**	**95**	**90**	**45**	**-**	**155**	**42**	**130**	**90**
Lazarevo	6	8	5	5	5	5	8	5	4	4	8	5

B. Despotovac	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Lukićevo	< 2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ečka	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Lukino Selo	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Stajićevo	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Belo Blato	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Botoš	8	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Tomaševac	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Orlovat	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Perlez	4	5	2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Knićanin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Farkaždin	18	20	13	15	11	8	13	10	12	10	30	30
Čenta	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

Analysis of drinking water indicate multiple higher concentrations of arsenic in the city, at the source and in the network, also in a populated area Aradac and Klek, and all the villages north of the city: Melenci, Elemir, Taraš, Mihajlovo and Jankov Most. Monthly monitoring of arsenic reveals that the concentration varies to a lesser extent, depending on the season, but the higher levels are held throughout the year. The detected concentration range up to 340 μg / l (in the Taraš and Melenci), which is 34 times higher concentration than maximum allowable concentration (MAC). Other places in the municipality, that are located south of the city, have a lower content of arsenic in drinking water, mainly within the allowed limits.

Based on continuous monitoring of water quality over a period of a year, it has been concluded that drinking water in the city of Zrenjanin and nearby villages is not hygienically correct and its quality does not match the current standards. Water cannot be considered as health safely and is reasonable to argue that has increased potential health risk, especially in the presence and content of arsenic in drinking water in the city and some nearby settlements. In 2004 Provincial Sanitary Inspection banned for drinking and cooking water from Zrenjanin due to multiple exceeded concentrations of arsenic (Law on waters 2010). The ban is still in force.

Table 2: Arsenic concentration in groundwater wells (May - Juny 2003)

Well no.	As (μg/l)	Well no.	As (μg/l)
2	**130**	21	**220**
3	**160**	22	**220**
6	13	23	**195**
7	**95**	24	**180**
8	**105**	31	**22**
9	**95**	34	**166**
10	**83**	35	**180**
11	**26**	37	**140**
12	**205**	38	**152**
14	5	39	**47**
15	9		

In the most wells arsenic concentration values are several times larger than the limits prescribed by the regulations. The mean value is 117 μ g / l, while the maximum is 220 μ g / l, which is 22 times higher than the permissible value. In only two wells (no. 14 and 15) found arsenic concentrations are below the limit values. These concentrations are low because they are extracting the water from shallow aquifer.

Table 3: Arsenic concentration in drinking water in the city of Zrenjanin and in the nearby villages in 2006 and 2007

Town and nearby villages	2006.god As (μg/l)	2007.god As (μg/l)
Melenci	**230**	**230**
Taraš	**270**	**270**
Elemir	**70**	**130**
Zrenjanin-source	**83**	**105**
Zrenjanin-network	**140**	**92**
Lazarevo	7	5
B. Despotovac	<2	<2
Lukićevo	<2	<2
Ečka	<2	<2
Stajićevo	<2	<2
Belo Blato	<2	<2
Botoš	<2	<2
Tomaševac	<2	<2
Orlovat	<2	<2
Perlez	<2	<2
Knićanin	<2	<2
Farkaždin	**20**	**17**
Čenta	<2	<2

As in the analysis from 2002 and 2003, it can be seen that in places where it was previously determined a high content of arsenic, elevated values remain constant over a period of several years. Also, in places south of Zrenjanin concentrations remain low, below the allowable limit. In the city itself, at the source and the central network distribution, the values are in a lesser extent which vary depending on the group of wells that are currently in use and the points on the network from which the sample was taken.

Table 4: Arsenic concentration in groundwtare wells (October 2010 - July 2011)

Well no.	October,2010	January,2011	April,2011	July,2011
3	**187**	**170**	**155**	**102**
4	5	5	7	40

For this analysis were taken two typical wells which are located at depths of two aquifers. Groundwater of those aquifers is abstracted to supply the population as drinking water. The well no.3 is located at a depth of 98-118 m while the well no.4 is at a depth of 36-61 m. It can be seen that the deeper aquifer has increased concentrations of arsenic while in shallow aquifer arsenic is under the allowable limit.

DISCUSSION

Smedley and Kinniburgh (2002) outline that the reducing conditions observed in Bangladesh/West Bengal and Viet Nam aquifers are similar to those in the regions of Taiwan, China, northern China and Hungary that suffer from high levels of arsenic in groundwaters. That also stands for the city of Zrenjanin, because it is situated on the Panonian basin like the Hungary and has the same geological characteristics. Arsenic contamination is understood to be of geogenic origin released from soil under conditions conducive to dissolution of arsenic from solid phase on soil grains to liquid phase in water, and percolation of fertilizer residues might have played a modifying role in its further exaggeration (Ghosh and Singh, 2009).

Smedley et al. (2002) studied the geochemistry of arsenic in groundwaters from Quaternary loess aquifers, which were high in arsenic, in an area thought to spread over 106 km2 in La Pampa province, central Argentina. Dissolved arsenic ranged from 4 to 5300 μg / l, with 73% of samples exceeding 50 μg/l. The conclusions drawn for La Pampa province may be applicable elsewhere in determining which regions are vulnerable to arsenic and related water-quality problems: “Under oxidising conditions, vulnerable aquifers potentially occur where several important criteria coincide: semi-arid climatic conditions with limited recharge where high-pH groundwater can be generated; young (Quaternary) sediments or volcanic sediments; and slow groundwater-flow conditions. Such aquifers are likely to have been poorly flushed over the geologically-short timescale since deposition and hence will have had little opportunity for removal of trace elements such as arsenic from the aquifer.” Similar conditions exist in the Lagunera and Sonora regions of Mexico and in the Atacama Desert, Chile (Smedley and Kinniburgh, 2002). Table 5 summarizes the geological characteristics of the regions of the world with naturally elevated levels of arsenic in the drinking-water.

Table 5: Regions of the world with naturally elevated levels of arsenic in groundwater (IARC, 2004)

Country/region	Affected area (km^2)	Potentially exposed population	Arsenic concentration (μg/l)	Environmental conditions
Bangladesh	118 849	$\sim 3 \times 10^7$	< 0.5–2500	Hollocene alluvial/deltaic sediments; abundance of organic matter; strongly reducing, neutral pH, high alkalinity, slow groundwater flow rates
India/West Bengal	38 865	6×10^6	< 10–3200	Same as Bangladesh
Viet Nam	-	-	-	Pleistocene and Holocene sediments; strongly reducing conditions
China/Taiwan	4 000	$\sim 10^5$	10–1820	Coastal zones, sediments, including black shales; strongly reducing, artesian conditions, some groundwaters contain humic acids
China/ Xinjiang, Shanxi	38 000	~500	40–750	Holocene alluvial plain; reducing
Thailand	100	1.5×10^4	1 – < 5000	Dredge quarternary alluvium; oxidation of disseminated arsenopyrite due to mining

Mongolia/ Inner Mongolia	4 300	10^5	< 1–2400	Holocene alluvial and lacustrine sediments; strongly reducing, neutral pH, high alkalinity, some groundwaters contain humic acids
Argentina/ Chaco-Pampean Plain	106	2×10^6	< 1–7550	Holocene and earlier loess with rhyolitic volcanic ash; oxidizing, neutral to high pH, high alkalinity; groundwaters often saline
Northern Chile/ Antofagasta	35 000	5×10^5	100–1000	Quaternary volcanogenic sediments; generally oxidizing, arid conditions, high salinity
Bolivia		5×10^4	-	Same as Argentina and Northern Chile
Mexico	32 000	4×10^5	8–620	Volcanic sediments; oxidizing, neutral to high pH
Germany/ Bavaria	2 500		< 10–150	Mineralized sandstone
Hungary, Romania/ Danube Basin	110 000	4×10^5	-	Quaternary alluvial plain; reducing conditions, some high in humic acid
Spain	-	$> 5 \times 10^4$	< 1–100	Mineralization; alluvial sediments
Greece	-	1.5×10^5	-	Mineralization; thermal springs; mining
Ghana	-	$< 1 \times 10^5$	< 1–175	Sulfide mineralization, particularly arsenopyrite; gold mining
Canada/Moira Lake, Ontario	100	-	50–3000	Mine tailing; ore mining
Canada/British Columbia	50	-	0.5–580	Sulfide mineralization in volcanic rocks; neutral to high pH groundwater
USA/Arizona	200 000	-	< 1300	Alluvial basins, some evaporites; oxidizing, high pH
USA/ California	5 000	-	< 1–2600	Holocene and older basin-fill sediments; internally drained basin, mixed redox conditions, high salinity
USA/Nevada	1 300	-	< 2600	Holocene mixed aeolian, alluvial and lacustrine sediments; mainly reducing, some high pH, some with high salinity due to evaporation

CONCLUSION AND IMPLICATION

Alluvial environment in the examined area is mostly characterized by reducing conditions, which cause high arsenic concentrations in groundwater. In these environments, aquifer sediments do not allow air to enter (the aquifer) and coupled with the fact that recent sediments contain organic matter (which uses available oxygen), result in the development of reducing conditions (Smedley and Kinniburgh, 2002). In these environments, reducing conditions result in increased concentration of arsenic in solution, which are dominated by As^{3+} species (Duker et al., 2005). Another factor which is affecting the concentration of groundwater arsenic in the city of Zrenjanin and nearby area is a slow groundwater flow rate.

Problems with the water supply of the city of Zrenjanin and nearby villages are not solved through decades therefore the population of this locality are long-term exposed to health risk and suffering. The results show that the quality of drinking water in Zrenjanin mainly depends on the geological structure of the soil. This is the real state of the geochemical properties of the area on which Zrenjanin area is situated. The concentration of arsenic is highly elevated in the deeper soil layers, while in the shallow aquifer they are below the limit values. Thus, highly concentrations of arsenic in groundwater are of geological origin with spread out resulting from the mobilization under natural hydro-geologic conditions.

There are no great vertical fluctuations in the concentrations of arsenic from this area. From the places where it was previously determined a high content of arsenic, elevated values remain constant over a period of several years. In the villages south of the city of Zrenjanin, As concentrations remain low probably due to different geological structure of the land.

The groundwater sources in the city of Zrenjanin and nearby locations were found to have natural arsenic contamination problems. There is a great concern about the potential effects of arsenic pollution on human health and environment. Arsenic poisoning through drinking water is not instantaneous but accumulative nature. It is demonstrated that long-term exposure to arsenic through drinking water is associated with increased risk for skin, lung, bladder and kidney cancer and skin lesions.

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SORBENTS WITH MAGNETISM FOR FACILE SEPARATION HEAVY METALS FROM THE REACTION SYSTEMS

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ABSTRACT

Magnetic sorbents (NFeOs-nanofericoxides) based on the magnetic properties NFeOs and manufactured for easy removal of heavy metals from the reaction system. Some of them were prepared by modifying the chemistry surface of magnetic NFeOs with functional groups other materials including chitosan, Sphaerotilus natans, alginic acid, humic acid, amino acids and polyacrylic acid and carboxymethyl-beta-cyclodextrin. Others have obtained encapsulation of magnetic NFeOs with poly (3,4-ethylenedioxythiophene) and SiO_2. Zeolites, multi-layer carbon nanotubes, mesoporous molecular sieves and graphite nanolayers also selected as the base for magnetic supports NFeOs. Available composite magnetic adsorbents show satisfactory adsorption of toxic metals from aqueous solutions.

Key words: *sorption, magnetism, heavy metals, supports NFOs.*

INTRODUCTION

The removal of heavy metals, such as mercury, lead, thallium, cadmium and arsenic, from natural waters has attracted considerable attention because of their adverse effects on environmental and human health. Enhancement of sorbent materials into nanoporous structures has shown to significantly improve their performance in metal removal when compared to conventional sorbent beds. However, such nanomaterials still suffer from issues involving mass transport of large water volumes through the materials. A dispersible sorbent with a large surface area and suitable chemistry would be very advantageous for the removal of heavy metals from aqueous solutions (Fryxell et al., 2000; Fryxell et al., 2002; Fryxell et al., 2004).

THEORY

Iron oxide nanoparticles are highly dispersible in solutions. With particle sizes of less than 40 nm, they offer a large surface area and super paramagnetic properties; they are attracted to a magnetic field but do not retain magnetic properties when the field is removed, making them highly useful in novel separation processes. Specifically, unmodified maghemite (ç-Fe_2O_3) was reported for successful capturing of Cr (VI), while magnetite (Fe_3O_4) nanoparticles modified with an oleic acid ligand were reported for capturing As (III) and As (V), both by exploiting a strong reactivity between iron oxides and metal species. Attachment of undecanoic acid on ç-Fe_2O_3 nanoparticles and chitosan on Fe_3O_4 nanoparticles resulted in magnetic sorbent materials effective for the capture of Cd and Cu, respectively (O’Handley, 2000).

METHODS

Based on the magnetic characteristic of some NFeOs, composite sorbents with magnetism were fabricated for facile separation from the reaction systems. Some of them were synthesized by modifying the surface chemistry of the magnetic NFeOs with other materials of functional groups, including chitosan (Chang and Cheng, 2005), Sphaerotilus natans (Guan et al., 2007) alginic acid (Jeon et al., 2007), humic acid (Liu et al. 2008), amino (Huang and Chen, 2009), poly-acrylic acid (Mandavian and Mirrahimi, 2010) and carboxymethyl-beta-cyclodextrin (Badruddoza et al., 2011). Others were obtained by encapsulating magnetic NFeOs with poly (3,4- ethylenedioxythiophene) (Shin and Jang, 2008), hydrogel (Tang and Wang, 2010) and SiO_2 (Wang et al., 2010). Several porous materials such as zeolite, multiwall carbon nanotube, mesopore molecular sieve, graphene nanosheets were also chosen as the substrates for supporting magnetic NFeOs (Hua et al., 2012).

A novel magnetic nano-adsorbent has been developed by covalently binding polyacrylic acid (PAA) on the surface of Fe_3O_4 nanoparticles, followed by amino-functionalization using diethylenetriamine via carbodiimide activation (Huang and Chen, 2009). PAA coated magnetic iron oxide nanoparticles (m-PAA-Na) were successfully prepared by coprecipitation, followed by modification with 3-aminopropyl triethoxysilane and acryloyl chloride (Mandavian and Mirrahimi, 2010). The surface of the modified nanoparticles was further modified by graft polymerization with acrylic acid (Hua et al., 2012).

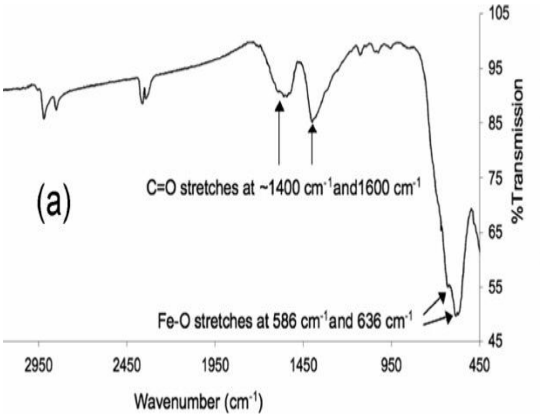
Zeolite is also an excellent host for NFeOs encapsulation. Oliveira et al. (2004) combined NaY zeolite with magnetic iron oxides to fabricate a magnetic adsorbent. The NaY zeolite:iron oxide magnetic composites were prepared at a weight ratio of 3:1, which was chosen to keep a relatively high content of iron oxide and thereafter to avoid the decrease in adsorption capacity of the composites. They were available by precipitation of iron oxides or hydroxides onto the zeolite surface.

Shin and Jang (2007) provided a facile synthetic route for the fabrication of magnetic nanoparticle – PEDOT core–shell nanostructures. It was achieved by inducing ferric cations onto the magnetic nanoparticles (MNPs) with a partial etching process followed by seeded polymerization.

RESULTS AND DISCUSION

Superparamagnetic iron oxide (Fe_3O_4) nanoparticles with a surface functionalization of dimercaptosuccinic acid (DMSA)

Yantasee et al., (2007) shown that superparamagnetic iron oxide (Fe_3O_4) nanoparticles with a surface functionalization of dimercaptosuccinic acid (DMSA) are an effective sorbent material for toxic soft metals such as Hg, Ag, Pb, Cd, and Tl, which effectively bind to the DMSA ligands and for As, which binds to the iron oxide lattices. The nanoparticles are highly dispersible and stable in solutions, have a large surface area (114 m^2 /g), and have a high functional group content (1.8 mmol thiols/g). They are attracted to a magnetic field and can be separated from solution within a minute with a 1.2 T magnet. The chemical affinity, capacity, kinetics, and stability of the magnetic nanoparticles were compared to those of conventional resin based sorbents (GT-73), activated carbon, and nanoporous silica (SAMMS) of similar surface chemistries in river water, groundwater, seawater, and human blood and plasma. DMSA Fe_3O_4 had a capacity of 227 mg of Hg/g, a 30-fold larger value than GT-73. The nanoparticles removed 99 wt % of 1 mg/L Pb within a minute, while it took over 10 and 120 min for Chelex-100 and GT-73 to remove 96% of Pb. (see also Figure 1 and Figure 2).



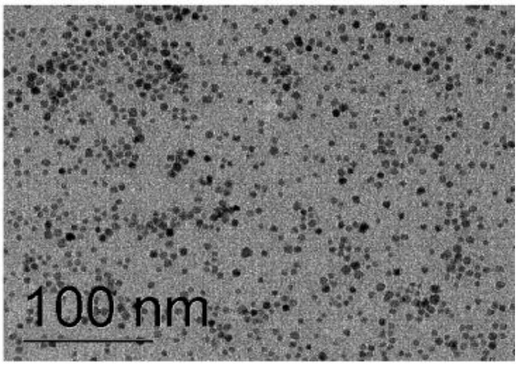


Figure 1. IR spectrum of DMSA modified Fe_3O_4 Figure 2. TEM image of DMSA modified Fe_3O_4 (Yantasee et al. 2007)

Surface modification of magnetic NFeOs by amino group

Surface modification of the magnetic NFeOs is believed to prevent their aggregation (Illes and Tombacz, 2003, 2006) and air oxidation (Maity and Agrawal, 2007) in aqueous system. A novel magnetic nano-adsorbent has been developed by covalently binding polyacrylic acid (PAA) on the surface of Fe_3O_4 nanoparticles, followed by amino-functionalization using diethylenetriamine via carbodiimide activation (Huang and Chen, 2009) (see also Figure 3).

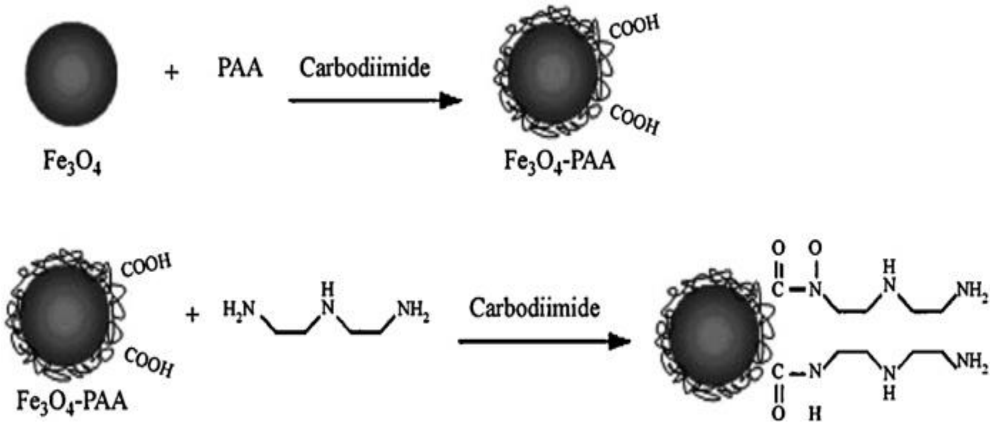


Figure 3. Scheme for the binding and amino-fictionalization of PAA on Fe_3O_4 nanoparticles as a novel magnetic nano-adsorbent for both metal cation and anions (Hua et al.2012)

Adsorption of Cu (II) and Cr (VI) ions obeyed the Langmuir isotherm equation. The maximum adsorption capacities and Langmuir adsorption constants were 12.43 mg/g and 0.06 L/mg for Cu (II) ions and 11.24 mg/g and 0.0165 L/mg for Cr (VI) ions, respectively. With the size ranging from 10 to 23 nm, the magnetite nanoparticles exhibited super-paramagnetism above 300 K, and the saturation magnetization was 57.1 emu/g at 300 K. m-PAA-Na could adsorb Cu2+, Pb2+, Ni2+and Cd2+ well, and higher pH resulted in its higher chelation tendency. The amount of adsorption increased with the increase in tempera-ture for all the metals (Hua et al., 2012).

Supporting magnetic NFeOs with zeolite

Zeolites offer an attractive and inexpensive option for the removal of organic and inorganic contaminants. Natural zeolites are of low cost and can function as cation exchangers for metallic contaminants. The adsorption capacity of zeolite results from their high surface area and net negative charge on their channel structure, which attracts and holds cations such as heavy metals. For example, NaY zeolites with pore diameter of 0.78 nm possess large surface area and high cation exchange capacity could serve as adsorbent for heavy metals. Fe oxide in the composites had a smaller particle size (ca. 25 nm for pure Fe oxide and ca. 16 nm for the composite). Due to the presence of 26% (w/w) of iron oxide, the composite showed decreased BET surface area (381 m^2/g) and micropore volume (0.148 cm^3/g) compared with the pure NaY. Zeolite (568 m^2/g and 0.267 cm^3/g). The immobilized NFeOs are mainly present as maghemite along with some goethite. Upon controlled H_2 treatment the iron oxides can be reduced to metallic iron and the composite magnetization increased. The adsorption of Cu^{2+}, Cr^{3+} and Zn^{2+} from aqueous solutions on the 3:1 zeolite:Fe oxide composite was studied, and the adsorption capacity were in the order of $Cr^{3+} > Cu^{2+} > Zn^{2+}$ (Hua et al., 2012).

Coating magnetic NFeOs with PEDOT

Poly (3,4-ethylenedioxythiophene) (PEDOT) contains sulfur endowing two unpaired electrons. The thiol-functionalized polymer is readily conjugated with positively charged heavy metal ions according to the coordination formation. Therefore, PEDOT functionalized magnetic nanoparticles are regarded as an excellent candidate for efficiently separable and reusable absorbent for heavy metal removal by using an external magnetic field (Kang et al., 2005, Rossi et al., 2007, Liu et al., 2000). The amount of Ag^+, Hg^{2+} and Pb^{2+} uptake were ca. 27.96, 16.02 and 14.99 mmol/g, respectively. The adsorption rate was observed in the order of $Ag^+ > Hg^{2+} > Pb^{2+}$, in accordance with cation radius and interaction enthalpy values (Hua et al., 2012).

CONCLUSIONS AND IMPLICATIONS

Regeneration of metal-loaded NMOs is also an important feature to evaluate their repeatability in use and the possibility of recovering valuable metals from the eluates. In principle, the regeneration efficiency mainly depends upon the nature of metal adsorption, i.e., how metals interact with NMOs, as well as the components of the eluting reagents. Currently, studies on how to regenerate metal-loaded NMOs are limited as compared to the adsorption studies. This is partly because most of the available works focus on the performance of NMOs toward metal removal as well as the underlying mechanism. Comparatively, how to regenerate the used NMOs for multiple uses is ignored. More attention should be paid to the topic when we hope to promote environmental nanotechnology approaching to the practical application.

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INDICATORS OF HYDROGEN DEPOLARIZATION AND OXYGEN SURFACE POTENTIAL SEASONAL CHANGES IN URBAN RIVER WATER

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ABSTRACT

Hydrogen depolarization current seasonal change in urban river water influence between the river entrance in the town and exit, after evolved hydrogen pressure relaxation period is examined on the basis of correlation with: magnetic induction effective in electron spin resonance, ESR; oxygen surface depolarization potential; electrons density and temperature in chemisorbed gas bubbles.

Key words: *Urban zone of river water, Monitoring data, Electrical conductivity, Hydrogen reversible potentials, Hydrogen ions depolarization current, Oxygen surface depolarization potential, Magnetic induction change*

INTRODUCTION

In contact surface of oxygen specifically chemisorbed according to Langmuir adsorption isotherm, electron titrations enable hydrogen depolarization processes. The previous obtained results (Petar Ševaljević, 2012) indicate to the oxygen specific chemisorptions state seasonal changes to O_2^- on entrance and HO_2^- on exit from the urban zone. The reversible hydrogen depolarization processes in contact surfaces with speciffically chemisorbed oxygen steady state in double water film control:
- equal hydrogen electrical and oxygen chemical potential change free energies
- evolved hydrogen pressure equal to oxygen partial pressure in air
- hydrogen electrochemical potential calculated according to Nernst equation.

Using the method developed previously in the thermodynamic diagnostic of electron densities in gas bubbles, (Mirjana. M., Ševaljević, Stojan N. Simić and Petar V. Ševaljević, 2012), depending on oxygen chemisorptions equilibrium constant on the compressed and expanded gas bubbles, obtained according to Langmuir adsorption isotherm, the correlations are examined between :
- the total free energy change of hydrogen, oxygen, iron and amonium and reversible evolved hydrogen depolarization potential difference,
- as well as between the electric field change controlling hydrogen depolarization current in urban zoneand oxygen surface depolarization potential change are examined,

on the basis of river water seasonal quality monitoring database in the urban zone of the town Zrenjanin. Oxygen distribution between air and liquid according to Boltzmann law control reversible and irreversible processes, as well as quasi-reversible catalytic processes in presence of a transition complex of speciffically chemisorbed oxygen surface depolarization potential, $e\chi_{ePLTE}$, where: $h\nu = k_BT = e\chi_{ePLTE}$. Hydrogen depolarization current control the depolarisation pseudo-first order kinetic rate constants, $k_{H3O+,in}$, s^{-1} , $j = k_{H3O+} \cdot F$ and also electric field strenght in the contact surface of depolarizator , according to Ohm law for electrolytes, $j = \kappa \cdot \Delta E = \kappa \cdot \Delta U/d$, depending on water electric conductivity, κ. The main objective of present paper is the study free and delocaliesed electrons resonance electromagnetic quant energy absorption ESR ($h\nu = k_BT = e\chi_{ePLTE}$ and $g\mu_B(m_s - m_{0s})B = h\nu$) of hydrogen depolarization current and oxygen surface depolarization potential indicators O_2, NO, NO_2 and transition elements as Fe d-atoms (at μ_B=9,274E-24J/T and g=2, in contact surface determined to Perrine).

EXPERIMENTAL RESULTS

On the basis of the monitoring database of c_{O2}- oxygen molar concentrations, pH, electrical conductivity, κ and water temperature, Tw measured in the Institute of the Public health in Zrenjanin 2010 for the each month, the diagnostics of parameters is carried out (M. Ševaljević et al, 2012),, which enable the study of indicators of hydrogen depolarization and oxygen surface potential seasonal changes:

k_{H3O+}- hydrogen ions depolarization rate constant,

$\Delta U/d$ – electric field controlling hydrogen depolarizaion current density, i.e. potential difference gradient, ΔE^{θ}_{H2}–reversible hydrogen depolarization potential at δ -intermolecular distance calculated to Perrine, temperature, T_{ePLTE} and hydrogen isochoric delarization potentials , $\Delta\chi_{changes}$ (see table 4)

$\Delta[e]_{r\ in\text{-}out}$-electrons density change calulated for compressed gas bubbles and for expanded gas bubbles T_{eaq} -electrons hydration temperature, T_{ePLTE} -dehydrated electrons temperature, $\Delta\chi_{O2}$-oxygen surface depolarization potential,

$d \approx \lambda = \chi_{O2}/(j/\kappa)$- the layer depth of transition complex effective in catalytic quasi-reversible processes,

$\Sigma\Delta_{in\text{-}out}G^{\theta}_{indESR}$- iron and ammonium total Gibbs free energy changes as indicators of surface oxygen potential couple processes with reversible depolarized hydrogen (Mi9lan Pavlović, Miladin Ševaljević, Tatjana Nikolin , Mirjana Ševaljević , 2013)

j_{in}/j_{out}-hydrogen depolarization curent and $B^{\#}$ - magnetic field effective in indicators ESR

Table 1: River water monitoring data for the river water temperature, t_w , oxygen content, $\gamma(O_2)$, water pH for the two locations (input and output fom the town) and conductivity

The dates of input	t_w oC	Δt, °C	γ_{O2}m g/l	pH	*Output, date*	Tw °C	γ_{O2} mg/l	pH	t_{wPPV} ^{0}C	pH PPV	κ_{town} S/m, PPV
13.1.2010	5,4	-2,1	12,4	7,82	*13.1.2010*	5,5	12,7	7,85	*8*	*7,77*	*0,0424*
3.2.2010	1,3	-1,8	11,1	7,96	*3.2.2010*	1	9,1	7,87	*5,4*	*7,8*	*0,0589*
3.3.2010	8	-1,1	11,8	7,88	*3.3.2010*	7,8	11,7	7,85	*7,6*	*7,91*	*0,0775*
23.4.2009	9,5	0,1	7,1	7,74	*23.4.2009*	17,8	4,9	7,71	*18,1*	*7,05*	*0.082*
29.4.2010	16,8	2,7	9,2	7,48	*29.4.2010*	17,2	5,3	7,39		*7,58*	*0,051*
29.4.2011	12,5	7,9	8,8	7,44	*29.4.2011*	12,5	7	7,29	*17*	*8,03*	*0,14*
13.5.2009	19,5	-3,5	9,9	8,03	*13.5.2009*	19,5	4,9	7,82			
14.5.2010	18,5	0,8	7,8	7,41	*14.5.2010*	18,2	6,5	7,33		*8,08*	*0,05*
20.5.2011	18,3	-1,9	7,6	7,22	*20.5.2011*	18,4	5,4	6,99	*17,6*	*7,72*	*0,0533*
6.6.2010	24,4	5,2	5,7	7,49	*6.6.2010*	23,5	5,7	7,43	*25,1*	*7,81*	*0,0719*
1.7.2010	24,6	5,1	4,2	7,34	*1.7.2010*	23,3	6,4	7,18	*22,5*	*7,64*	*0,0963*
16.7.2009	26,9	-1,6	5,7	7,47	*16.7.2009*	26,3	5,2	7,55	*26,4*	*7,94*	*0,0564*
29.7.2011	23,6	-4	5,7	7,65	*29.7.2011*	23,1	3,6	7,72	*23*	*8,34*	*0,061*
13.8.2009	25,1	1,2	5,7	7,14	*13.8.2009*	25,7	4,8	7	*21,4*	*8,5*	*0,0419*
19.8.2010	26,3	1,3	5,8	7,82	*19.8.2010*	26,3	5,6	7,72	*25,8*	*7,76*	*0,0419*
30.8.2011	24,2	-4,5	4,3	7,12	*30.8.2011*	24,5	5,6	7,12	*25,1*	*8,15*	*0,0491*
15.9.2010	19,6	-1,6	6,8	7,43	*15.9.2010*	20	3,7	7,26	*24,2*	*7,63*	*0,058*
15.9.2011	23,3	-1,5	4,7	7,16	*14.9.2011*	24,4	3	7,03	*20,4*	*7,33*	*0,0584*
15.10.009	13,1	-6,6	8,7	7,87	*15.10.2009*	13,9	7,3	7,15	*12,1*	*7,65*	*0,0543*
4.11.2009	8,2	-4,6	9,2	7,74	*4.11.2009*	8	8,1	7,76	*8,8*	*7,79*	*0,0619*
2.12.2009	8,7	-2,4	10,1	7,94	*2.12.2009*	7,8	7,9	7,84	*9,9*	*7,6*	*0,0555*

Table 2: The hydrogen ions depolarization measured seasonal rate constant ,k depolarization current, j, measured el. conductivity,κ and corresponding potential gradient ΔU/d detm. acc.to Ohm's law

Month	$k_{H3O+, in}$, s^{-1} Eq.(4)	j_{in} A/m^2	$k_{H3O+, out}$ s^{-1}	$j_{, out}$ A/m^2	J_{in}/j_{out}	$\kappa_{,av,exPPV}$ S/m	ΔE =ΔU /d V/m
I-III	-6, 18E-6	-0,6	-4,7E-6	-4,54E-01	1,32E+00	0,0596	-10,0062
IV-V	-1,91E-5	-1,84	-3,9E-5	-3,8E+00	4,84E-01	0,0723	-25,4931
VI-IX	j_a-j_c=(1,36-1,73)E-5	-0,36	j_a-j_c=(2,36+1,73)E-5	3,95E+00	-9,11E-02	0,0614	-5,81515
X-XII	-1,9E-5	-1,83	1.94E-5	1,87E+00	-9,79E-01	0,0575	-31,887

Table 3: Intermolecular distance to Perine, δ used in the pressure determination, p and quasireversible hydrogen depolarization ΔE_{H2}^{θ} (p_{H2}=p_{O2}, ans $\Delta\varphi_{H2}$=-$\Delta\mu_{O2}$) and electrons density change $\Delta[e]_{r0}$

Month	δ m	$\ln p/p_0$	E^{θ}_{H2in} V	E^{θ}_{H2out} V	2F(E^{θ}_{in}-E^{θ}_{out})$_{H2}$ kJ/mol	$\Delta[e]_{rin-out}$ $molm^{-6}$	$\Delta[e]_{r,in-out}$ $molm^{6}$
I-III	5,01E-11	2,00E+00	*0,4555*	43,95	-1,93	1450	1450
IV-V	7,70E-11	2,00E+00	*0,49*	47,28	-3,86	4710	4710
VI-IX	9,25E-11	2,00E+00	*0,51*	49,21	0	-400	-400
X-XII	7,39E-11	2,02E+00	*0,484*	46,71	-1,93	-2040	-2040

Table 4: Oxygen molar concentrations, c, electrons hydration temperature, T_{eaq} , electrons temperature of phase transition latent heat of active centers, T_{ePLTE} and hydrogen isochoric polarizations, $\Delta\chi_{,changes}$

	$c_{O2, IN}$ mol/dm3	$c_{O2, OUT}$ mol/dm3	T_{eaqin} K	T_{eaqout}	$T_{e,in}$ K	$T_{e,out}$ K	$\Delta T_{e\ in-out}$ K	$\Delta\chi_{H2,in\ ePLTE}$, V	$\Delta\chi_{H2out\ ePLTE}$, V	$\Delta\chi_{H2in-out\ ePLTE}$, V
I-III	0,000368	0,00035	261,4	263,2	75,15	67,21	7,94	0,08	0,09	-0,01
IV-V	0,000263	0,00018	284,7	298,0	25,78	36,36	-10,58	0,28	0,20	0,08
VI-IX	0,000166	0,00016	308,5	310,4	47,70	54,72	-7,02	0,17	0,15	0,02
X-XII	0,000247	0,00019	286,2	292,3	15,88	26,58	-10,7	0,45	0,27	0,18

Table 5: The resonance wavelenght, λ depending chemisorptions oxygen potentials, χ in catalytic tzransition state, corresponding magnetization field, B and indicators of energy absorption total free energy change, $\Sigma\Delta_{in\text{-}o}G^{\theta}{}_{ind}$

Month	$\lambda_{in}=hc/F\chi_{ePLTE}$ mm	$\lambda_{in}=hc/F\chi_{ePLTE}$ mm	$B^{\#}(T,\chi)_{in}$ T	$B^{\#}(T,\chi)_{out}$ T	$\Delta B^{\#}_{\Delta\chi H2in/out}$ T	$\Sigma\Delta_{in\text{-}o}G^{\theta}{}_{ind}$ kJ/mol	
I-III	15,6	13,9	0,0185	0,0234	-0,0049	112,74	$\Delta G^{\theta}(N_2O_5)_c$-$RT_{eaq}/2$
IV-V	4,5	-6,2	0,225	0,115	0,11	-728,30	$\Delta G^{\theta}(Fe(CO)_5)$-$\Delta G^{\theta}(NH_2OH)_{aq}$
VI-IX	-7,3	-8,3	0,0835	0,065	0,0185	1175,52	$\Delta G^{\theta}(O_2^{+})_g$-$RT_{eaq}$
X-XII	2,8	-4,6	0,085	0,21	-0,125	18,55	$\Delta G^{\theta}(H^{+}/H_2)$ - $\Delta G^{\theta}(NH_3)_g$-$RT_0$

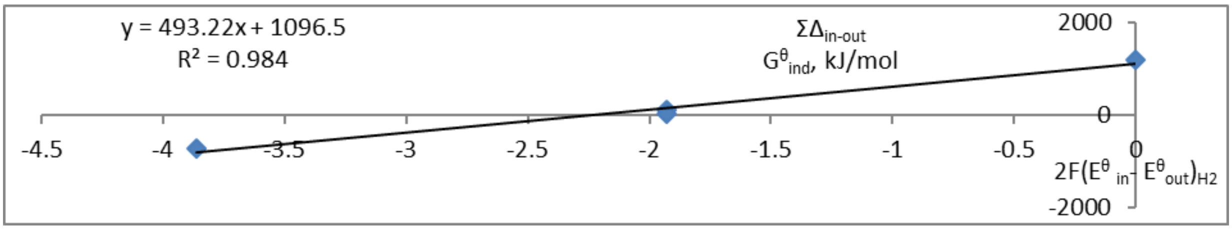

Figure 1. The functional dependence between total free energy changes, $\Sigma\Delta_{in\text{-}out}G^{\theta}{}_{ind\ ESR}$ *and reversible evolved hydrogen* $2F(E^{\theta}in - E^{\theta}out)_{H2}$ *electric potential difference in urban zone betwen input and output*

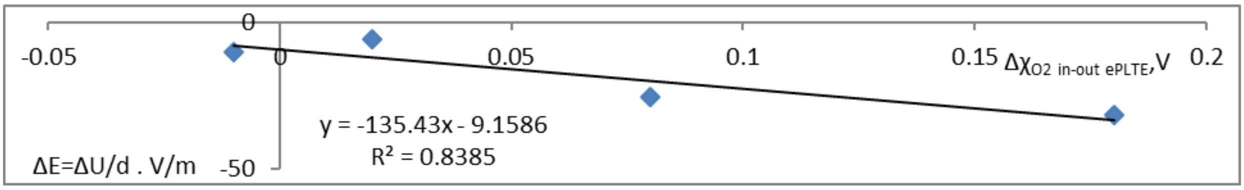

Figure 2. The functional dependence between electric field change, $\Delta E=\Delta U/d$, *V/m controlling hydrogen depolarization current in urban zone and oxygen surface depolarization potential change ,* $\Delta\chi_{\ in\text{-}out\ ePLTE}$

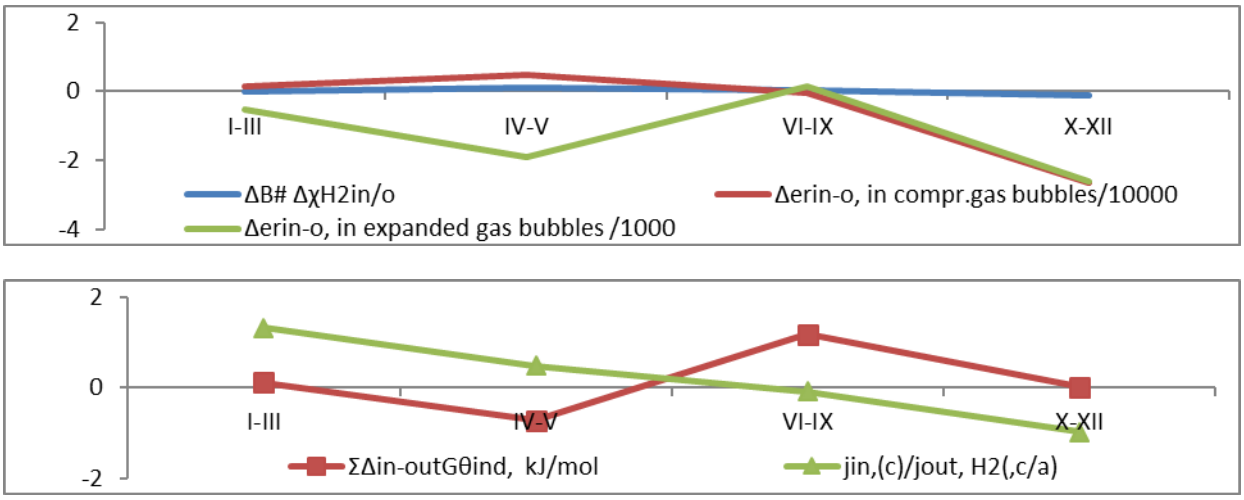

Figure 3. The correlation between the resonance magnetic induction change $\Delta B^{\#}$, *electrons density change Δ [e], depolarization current density ratio* j_{in}/j_{out} *, the indicators total free energy change* $\Sigma\Delta_{in\text{-}out}G^{\theta}{}_{ind}$

CONCLUSION

The conclusion remarks are as follows:
Obtained functional dependences with strong correlation coefficients confirm:

- The total free energy change of hydrogen, oxygen, iron and amonium, ΣΔin-outGθind, of moleculese effective in electron spine resonance, ESR is indicator of the reversible evolved hydrogen depolarization potential difference change, ΔE θ H2 (see Fig.1)
- Electric field change controlling hydrogen depolarization current in urban zone, i.e. of ΔE=ΔU/d=j/κ is indicator of oxygen surface depolarization potential change, Δχ in-out ePLTE (see Fig. 2)
- Seasonal magetic induction change between river input and output in urban zone correlate (see Fig. 3):
  - in winter to minimal negative value and the minimal electron density in expanded and maximal electron density in compressed gas bubbles and favored indicators oxidation in urban zone in maximum of hydrogen depolarization cathode current density ratio for river input and output
  - in spring maximal positive value and maximal electron density in compressed gas bubbles and to maximal affinity of indicators of the oxygen maximum surface depolarization potential and decreased hydrogen depolarisation cathode current in minumum of electron density in expanded gas bubbles
  - in summer to decreased positive value and decreased electron density in compressed and enhanced in expanded gas bubbles, in maximum of endothermic free energy of indicators of oxygen surface and hydrogen depolarization anode current
  - in autumn to opposite magnetic induction change relating to summer and maximal hydrogen depolarization anode current on river output influence to the favored dissolved oxygen chemisorption (see table 5) and to the the equilibrium electron density in compressed and expanded gas bubbles.

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INVESTIGATION OF POSSIBILITIES OF EAFD PRETREATMENT BY PELLETIZATION AND HEAT TREATMENT FOR ZINC VALORIZATION

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ABSTRACT

The importance of EAF dust preparation is essential, both for environmental and technological reasons. EAF dust represents very harmful waste due to very fine particles consisting of various metals and metal oxides. In this paper the process of EAF dust pretreatment is shown, which consists of raw pellets formation and their annealing. Also, the optimal composition of pellets and annealing parameters were determined based on different physical and chemical properties of pellets. Thus obtained pellets are intended primarily for melting in DC-plasma arc furnace.

Key words: *EAFD, hazardous waste, pellets.*

INTRODUCTION

Nowadays, an increasing quantity of steel is produced in electric arc furnaces (EAF), mostly because of potential of recycling various materials (scrap), easy adjustment to different kinds of steel and at the same time low environmental impact. The production of steel in EAF generates a by-product called EAF dusts. This dust is collected in bag house and quantity of approximately 15-20kg of the dust is produced per ton of steel product. The collected material – EAF dust (EAFD) contain mostly iron oxides, zinc and other heavy metal oxides including lead, chromium and cadmium. The phase identification of the EAFD samples indicates the presence of complex minerals such franklinite ($ZnFe2O4$), magnetite ($Fe3O4$), magnesium-ferrite ($MgFe2O4$), chromite ($FeCr2O4$), calcium-magnetite ($Ca0.15Fe2.85O4$), periclase (MgO), manganese oxide ($Mn3O4$), quartz ($SiO2$) and zincite (ZnO) [1-4]. Because the heavy metals contained in them tend to leach under slightly acidic rainfall conditions these dusts are considered toxic and hazardous products, and the disposal of these materials in landfill sited is regarded as an environmental hazard. The European Community Council Directive (91/156/CEE) requires control of harmful and toxic products quantity environmental concerns, among steelmakers all over the world, is treatment and disposal of dusts from the electric arc furnace [5].

It is expected that the volume of the dusts generated by EAF processes will continue to increase on the short and medium terms. EAFD is therefore interesting from different perspectives as hazardous waste material, or as a potential source of various metals (Fe, Zn, Pb) which could be then recycled. In developed countries, the processes treatment of the EAFD usually has a goal of recovering of zinc. Dust treatment processes may be classified as metal recovery from recycling, and may be grouped into pyrometallurgical and/or hydrometallurgical processes, chemical stabilization, vitrification or direct recycling back to the EAF. Pyrometallurgical process include following processes: rotary furnace (Waelz process), rotary hearth furnace (Kobelco, Inmetco), multiple hearth furnace (Paul Wurth PRIMUS), shaft furnace (Cupola oven, IS Zinc smelter, Mitsui), melting cyclone (VAI, HRD), plasma Furnace (Mintek), electrothermal (Toho). Hydrometallurgical processes include leaching in $NH4Cl$

(Ezinex, HST), leaching in H2SO4 (Recupac, HydroMet, ZincOx) and leaching in NaOH (Zimaval) [6-13].

According to the BREF document about the best available techniques (BAT) in metallurgy of nonferrous metals [14, 15], Waelz process is the most widely used method of treatment EAFD with high content of zinc (~32%).

Some dust treatment processes use pellets. Two basic processes for agglomeration are pelletization and briquetting. Accordingly, the objective of the present work was to study the behavior before and after annealing (mass loss, compressive strength after annealing, and zinc extraction efficiency) of EAF dust pellets of various diameters and compositions.

EXPERIMENTAL

Raw materials

Iron-bearing, raw materials are electro-arc furnace dust (EAFD), pyrite cinder and mill scale. Additives are: flux (lime), binders (cement, bentonite) and reducer (coke).

Raw materials were chemically and physically characterized. After that raw materials were mixed and pelletized. Pellets left to dry on air, and analyzed in relation to mass loss, compressive strength after annealing, and zinc extraction efficiency.

EAFD were generated in process of the electric arc melting steel scrap in plant Sirmium Steel d.o.o., Sremska Mitrovica.

Table 1: Chemical composition of EAFD, %

	Fe as oxids	Zn	Cr_2O_3	NiO	MnO	CaO	SiO_2	MgO	Al_2O_3	S	Pb	Cu	C	Cd
%	17.75	34.38	0.50	0.10	10.44	13.71	10.47	7.96	1.02	1.00	1.88	0.52	1.00	0.04

Pyrite cinder was generated in the production of sulfuric acid. Pyrite cinder for their contents belongs to the technogenic waste.

Table 2: Chemical composition of pyrite cinder, *%*

Element	Fe	Zn	Cu	Pb	Cd	Cr	As	Sb	Se	Al_2O_3	SiO_2	MgO	S
%	57.20	0.34	0.24	0.28	0.00	0.01	0.29	0.04	0.02	0.82	8.21	0.19	1.17

Mill scale was created in the process of hot rolling. It is common to mill scale after preparation (pelletization, sintering, oiling, etc.) returns in the steelmaking process.

Table 3: Chemical composition of mill scale, %

Fe	FeO	Fe_2O_3	MnO	CaO	SiO_2	MgO	Al_2O_3	C	Cr	Ni	Ignition loss	Average moisture
70.32	68.21	24.00	0.12	0.54	0.81	0.22	0.18	0.02	0.04	0.03	-2.65	0.895

The most common flux which was considered in this case is limestone. The addition of water to 70% in lime, lime milk is obtained, which serves as both flux and as a binder in the present case. Using lime milk reduces the total water consumption in the process.

Used limestone and coke were commercial grade.

Pellet preparation

Tests have begun weighing about 50 kg of material in relation that suits selected mixture presented in Table 4.

Table 4: Composition of pellets

	EAFD	Mill scale	Pyrite slag	Magnetite concentrate	Lime	Coke	Cement
P1	20	4	62	0	2	10	3
P2	20	4	42	20	2	10	3

As a binder for the pelletization process, 10% suspension of lime milk (1 kg lime in 9 dm^3 of water) was made. After measuring the amount of material for pelletization, powdery material has been manually homogenized for a period of 10 min, and then added in portion to the disc pelletizer where additional homogenization was made. Disc pelletizer is placed at an angle of 45 º with a speed of 15 r / min. Plate speed was determined by tachometer DTO6234, Velleman.

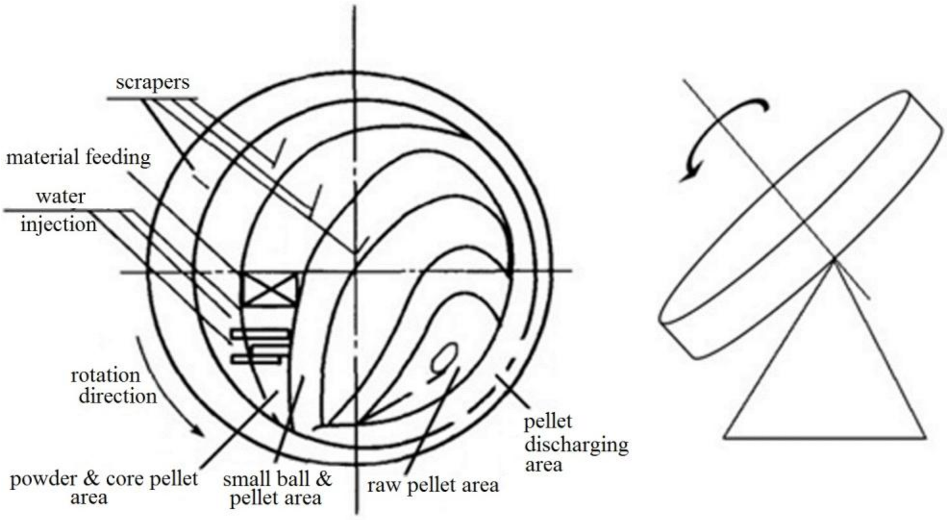

Figure 1. Disc pelletizer

After addition of the first portions of material in the device, it is approached adding lime milk to mixture. Once the entire amount of material is in the device move into pellets, new portion of material is added. Finished pellets are continuously subtracted from pelletizer disc. The procedure is repeated until the entire amount of materials is pelletized. Finished pellets were left to dry in the air for 48 hours, after which it was performed sieve analysis.

After determining the particle size distribution, obtained green pellets were analyzed for resistance to fall and the compressive strength.

Annealing

After analyzing the green pellets, annealing was started. Before annealing pellets were dried in a single layer at 105 º C. Fractions +4-10 mm is selected. Annealing was performed in a furnace Morgan type 1, at temperatures of 850-1200°C (P1) and 850-1150°C (P2), with a step of 50°C. Annealing time was 30min (P1) and 30, 60 and 90 minutes (P2).

Annealing was performed in previously weighed crucible. By adding measured amounts of pellets sufficient to fill crucible to the top. Crucible filled with pellets is placed in the furnace. After that, the furnace was closed and released into the operation. After reaching the desired temperature, furnace was turned off and the sample was left in the furnace until the furnace has cooled down to room temperature.

After the process of annealing was over, the sample was extracted from the furnace and was measured by weight loss, as shown in *Figure 3*. The theoretical weight loss for pellets of selected composition, taken at the loss of Zn, Pb, S, and C is 16.81%.

Obtained pellets annealed at each of the indicated temperatures were examined for the compressive strength. Mean value of compressive strength for each temperature is shown in table 7.

Chemical analysis

Chemical analysis of the products of annealing was performed using X-ray Fluorescence (XRF). Before testing the chemical composition, pellets are crushed, sifted by a sieve of 50 µm to give them the more homogenized structure, and therefore the testing was more accurate. The testing was done by The Niton XRF Analyzer XL3t.

RESULTS AND DISCUSSION

Table 5 : Sieve analysis results

Fractions, mm	P1 share, %	P2 share, %
-2.5	1.04	9.31
+2.5 -4.0	53.30	15.32
+4.0 -10.0	35.37	64.3
+ 10.0	6.49	1.79

Table 6: Resistance to fall test (a number of pellets that has remained whole)

Fractions, mm	Falling height, m					
	P1	P2	P1	P2	P1	P2
	1		1.5		2	
-2.5	10	10	10	10	10	10
+2.5 -4.0	10	9	9	6	6	3
+4.0 -10.0	5	1	4	0	0	0
+10.0	6	1	0	0	0	0

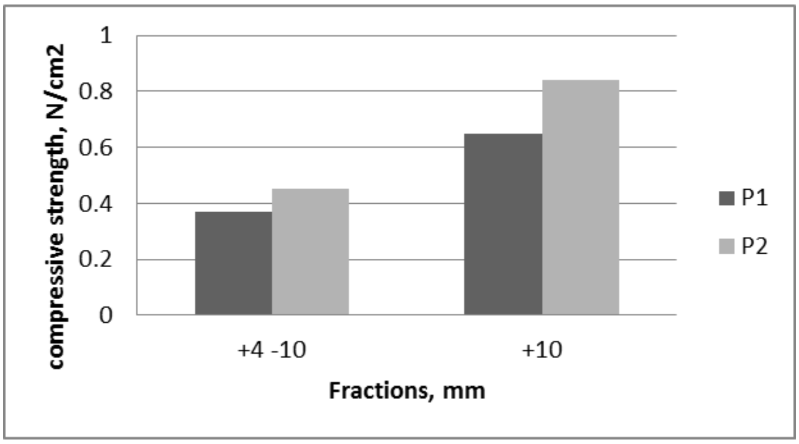

Figure 2. Compressive strength of green pellets

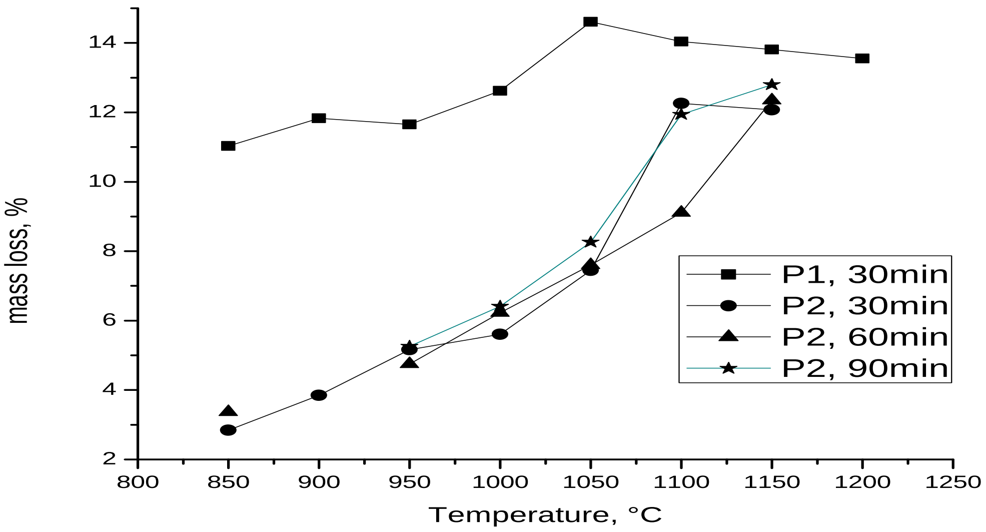

Figure 3. Mass loss due to annealing pellets

From the results in figure 3 we see that for pellets P1, weight loss increases up to 1100°C, which leads to weight loss in the amount of 87% of the theoretical value. By continuing to increase the temperature the mass loss is reduced. For pellets P2 was observed that with increasing temperature, the mass loss increases and reaches a maximum value for pellets annealed at 1150°C, 60min, when it comes to losing 74% of the theoretical value mass loss. Also it was observed that increasing the holding time results in an increased mass loss.

Table 7: Compressive strength of annealed pellets

Temperature, °C	<Rs>, N/cm^2			
	P1	P2		
	30 min	30 min	60 min	90 min
850	0.51	1.406	1.285	
900	0.34	2.308		
950	0.26	3.262	1.350	1.184
1000	0.51	1.182	1.552	1.695
1050	0.55	1.488	6.163	1.154
1100	1.32	4.061	4.442	6.230
1150	2.00	8.861	5.504	6.980
1200	1.06			

From the table 7, which shows the values of compressive strength, we see that the value for P1 pellets compressive strength increases with increasing temperature, and reaches a maximum at 1150°C. We see the same dependence for pellets P2, where for increasing temperature, the compressive strength of pellets increases, and reach a maximum value at a temperature of 1150°C for 30min, which is 8.861 N/cm^2. It is observed that the values for P2 pellets are greater than for P1 pellets for the same annealing conditions.

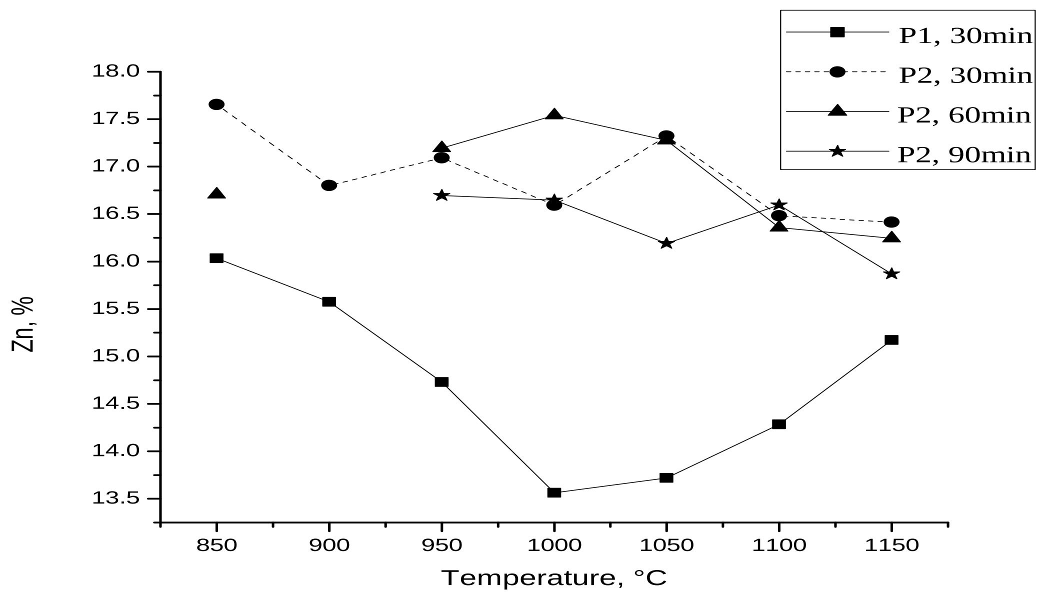

Figure 4. The dependence of Zn percentage in the pellets of temperature and annealing time

From the figure 4 we see for pellets P1 the largest decline (most Zn is evaporated) at a temperature of 1000°C, and at higher temperatures, increasing the amount of residual Zn in pellets. P2 pellets in their raw state contain 18.61% Zn. Depending on the annealing time, we notice a sharp decline at 850°C for 60 min annealing and at 900°C for 30min annealing. At higher temperatures for all times follow a uniform loss, while the biggest loss is observed at 1150°C for a hold time of 90 min and in the pellet lags 15.87% Zn.

CONCLUSIONS

Based on the results obtained by pre-treatment analysis of mechanical properties of raw pellets can be concluded that much better results are obtained with a mixture of P1 regarding for resistance to fall, while better results with pellet P2 in terms of compressive strength. P2 pellets have a maximum value of compressive strength of 8.861 N/cm^2, which is 4 times more than the compressive strength of pellets P1 under the same annealing conditions.

When annealing pellets P2 in stationary conditions and with process parameters studied, such as temperature, time, there is a slight extraction Zn (pellet P2 was allocated only 15% of the total Zn) from the pellets and a low level of transition to deposit. It is assumed that this phenomenon is due to the formation of the liquid phase and decreasing the evaporation and reduction of zinc and lead. Using plasma arc melting is possible to achieve better recycling results in valorization of Zn and Pb. Also, by using plasma arc melting variety of dispersed iron bearing raw materials could be successfully treated.

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THE POTENTIAL OF CARBON NANOMATERIALS FOR REMOVAL OF HEAVY METALS FROM WATER/WASTEWATER

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ABSTRACT

With the advent of nano science and technology in the last decade, research has been devoted to exploit unusual and unique properties of carbon nanomaterials (CNMs). The CNM can exist in several forms, such as single-wall carbon nanotubes (SVCNTs), multi-wall carbon nanotubes (MVCNTs), carbon beads, carbon fibers and nanoporous carbon. CNMs have been widely studied for potential use as catalyst supports for optical devices, computers and biochips. However, their sorption potential has not been studied extensively. CNMs are projected target materials who have unique surface morphology, therefore, may prove to be good sorbents.

Key words: *carbon nanomaterials, heavy metals, sorption.*

INTRODUCTION

Extensive industrialization and improper disposal are attributed to be a prime factor responsible for the release of heavy metals into the ecosystems. Once released, the heavy metals tend to bioaccumulate in higher trophic levels of the food chain. Almost all heavy metals are toxic to living beings and excessive levels are known to cause both acute and chronic toxicity (A Handbook of Community Water Supplies, 1990). Heavy metals cannot be degraded or destroyed; moreover, the natural process of metal mineralization is very slow. Hence, removal of heavy metals from water and wastewater is best accomplished by immobilization and concentration on suitable sorbents. The sorbed metals can be removed and reused as raw materials (Bansal and Goyal, 2005). Among many conventional methods that are being used for this purpose, sorption of heavy metal ions onto various solid supports (ion exchange resins, activated charcoals, zeolites and ion chelating agents immobilized on inorganic supports) is the most common route applied for decontamination of wastewater and industrial effluents because the employed sorbent can be easily regenerated and because it is highly effective and economical (Camel, 2003; Lemos et al., 2008). Moreover, solid sorbents can be easily incorporated into automated analytical procedures for preconcentration and determination of trace metal ions in natural waters (Dias et al., 2008). Thus, efforts dedicated to exploring new effective sorbents continue to grow. The carbonaceous materials have been proved to be effective sorbents for removal of metal ions as well as their complexes. Their large sorption capacity is linked to well develop internal pore structures, a large specific surface area, and the presence of a wide spectrum of surface functional groups (Vidic et al., 1997). Cadmium exposure may cause nausea, salivation, muscular cramps and anaemia. Extended exposure to cadmium may also cause cancer (Flick, et al. 1971). Lead poisoning is associated with gastrointestinal disorders, constipation, abdominal pain, and central nervous system effects (Ernhart, 1992). Exposure to nickel may cause cancer of lungs, nose and bones. Moreover, it may cause extreme weakness, dermatitis, headache, dizziness and respiratory distress (Kasprzak et al., 2003). Zinc toxicity from excessive ingestion is less common, however, it may cause damage to various systems in the human body (Lu and Chiu, 2006; Lu et al., 2006).

THEORY

With the emergence of nano science and technology in the last decade, research has been initiated to exploit the unusual and unique properties of carbon nanomaterials (CNMs). CNMs may exist in several forms, such as, single-walled carbon nanotubes (SWCNTs), multi-walled carbon nanotubes (MWCNTs) (See Figure 1.), carbon beads, carbon fibres and nanoporous carbon. CNMs have been studied widely for potential applications in catalyst supports, optical devices, quantum computer and biochips. However, their sorption potential has not been studied extensively. CNMs are engineered materials targeted to exhibit unique surface morphologies, hence, they may prove to be good sorbents (Dresselhaus et al. 2001). CNTs were found to be superior sorbents for inorganic pollutants such as fluoride and several divalent metal ions. Li et al. reported that CNTs with more defects and poor quality possess higher surface area and exhibit better lead sorption capacity compared to aligned CNTs. Activation of CNTs plays an important role in enhancing the maximum sorption capacity. Activation causes modification in the surface morphology and surface functional groups and causes removal of amorphous carbon (Rupareliaa et al., 2008).

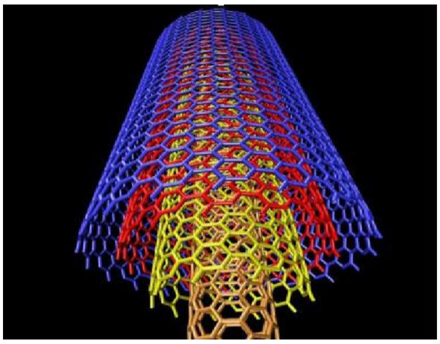

Figure 1. MWCNTs

METHODS

Characteristics of CNTs synthesised by chemical vapor deposition (CVD) process depend upon the type of catalyst and carrier gas (Dupuis, 2005; Andrews et al., 1999; Perez-Cabero et al., 2004; Kim, et al., 1991; Reilly and Whitten, 2006). Ryoo et al. proposed a novel silica template mediated approach for synthesis of nanoporous carbon using CVD. The resulting high surface area materials with uniform pores were suitable for a wide variety of applications: as adsorbents, catalyst supports, and materials for advanced electronics applications. Han et al. (2000) used the NPC synthesized using silica template for dye adsorption. The adsorption capacity of nanoporous carbon was found to be 10 times higher than that of commercial activated carbon for removal of direct blue-78 dye. Apart from the template-mediated method, another nanoporous carbon synthesis approach involves functionalization and introduction of nanopores in activated carbon by chemical oxidation and heat treatment. Such functionalized activated nanoporous carbon has been used for adsorption of Ca^{2+}, Cd^{2+}, Pb^{2+}, and Hg^{2+}, however, surface morphological analysis has not been reported. The maximum amount adsorbed decreased in the order $Hg^{2+} > Pb^{2+} > Cd^{2+} > Ca^{2+}$ (Xiao and Thomas, 2005). Rupareliaa et al., (2008) were synthesized two CNMs differing in surface morphology, using turpentine oil in a chemical vapour deposition (CVD) setup by varying the process parameters. Activation and catalyst removal were achieved by post-treatment with HNO_3 and KOH. Characterization of the CNMs produced revealed that both comprised of graphitic amorphous carbon, however, while the nanocarbon (NC) produced using cobalt catalyst in N_2 atmosphere comprised of varying grain sizes indicative of soot, the nanoporous carbon (NPC) produced using silica catalyst in H_2 atmosphere had a distinctive uniformly porous surface morphology.

RESULTS AND DISCUSION

Both Langmuir and Freundlich adsorption models have been used for representing sorption of heavy metals on CNTs. Maximum sorption capacity for heavy metals determined based on Langmuir model varies based on the type of metal. The maximum sorption capacity for cadmium, lead, nickel and zinc is reported to be in the range of 10–11 mg/g (Wang et al. 2003), 49–97 mg/g (Li et al., 2002; Li et al., 2003; Li et al., 2006), 9– 47 mg/g (Lu and Liu, 2006; Chen and Wang, 2006) and 11–43 mg/g (Lu and Chiu, 2008) respectively. Hence, with CNTs as sorbent, metal ion uptake followed the order Pb^{2+} > Ni^{2+} > Zn^{2+} > Cd^{2+}. The Langmuir and Freundlich model parameters are listed in Table 1. The parameter values for the Langmuir and Freundlich isotherm models were obtained by linear regression based on the experimental data of Rupareliaa et al.

Table 1: Isotherm model parameters for heavy metal sorption on AC and NPC (Rupareliaa et al.,2008).

Metal	Sorbent	Langmuir isotherm			Freundlich isotherm		
		Q_a^o (μeq/g)	b (L/ μeq)	R^2	K_F (μeq/g)*(L/μeq)^n	n	R^2
Cd	AC	217.4	0.0031	0.4103	16.84	0.3179	0.5906
	NPC	1428.6	0.0092	0.4397	475.5	0.1389	0.5897
Pb	AC	909.1	0.0025	0.7707	120.3	0.233	0.6027
	NPC	2000	0.01	0.6216	1044	0.0844	0.3617
Ni	AC	909.1	0.0004	0.5787	2.586	0.6652	0.6616
	NPC	1428.6	0.0075	0.5422	567.02	0.1124	0.4689
Zn	AC	625	0.0043	0.7362	69.5	0.2792	0.8087
	NPC	2000	0.0035	0.7088	220.85	0.2707	0.8277

A comparison of the Langmuir model parameter Qa^o representing the sorption capacity reveals that sorption on NPC is significantly more than on AC for sorption of all metals. Moreover, the sorption enegetics represented by the Langmuir parameter *b* is also more favourable as indicated by the significantly higher *b* values for NPC (except for zinc sorption studies). The larger *b* values in NPC indicate that utilization of the sorption capacity of NPC is likely to be higher in any treatment scenario since 50% monolayer coverage would be achieved at lower *Ce* (=1/b) values. The unique structure and uniform surface morphology of NPC may have facilitated heavy metal sorption. NPC demonstrates high sorption capacity for all the metals studied (Rupareliaa et al., 2008).

CONCLUSIONS AND IMPLICATIONS

Surface morphology plays an important role in sorption. The nanocarbon (NC) prepared using cobalt catalyst in a nitrogen atmosphere comprised grains with varying particle sizes which indicated the presence of soot and related particles. The porous NPC with distinctive surface morphology exhibited superior sorption of heavy metals compared to NC and AC, a commercially-available activated carbon. The sorption capacity and energetics for heavy metal sorption on NPC were more favourable compared to AC. This implies that at a low aqueous concentration of heavy metals, the sorption capacity of NPC will be efficiently utilized for the removal of heavy metals. NPC exhibited a high sorption capacity for all the heavy metals — lead, cadmium, nickel and zinc. Nanoporous carbon has a good potential for use in water treatment applications.

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URBAN RIVER WATER INFLUENCE ON SEASONAL POLLUTANTS FREE ENERGY CHANGES

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ABSTRACT

The thermodynamic diagnostics is carried out of hydrogen free energy seasonal changes in river Begej in urban zone of town Zrenjanin, on the basis of the monitoring data. The molar energy levels change are determined of hydrogen ions, of chemisorbed oxygen (as well as chemiosrbed oxygen entropy change according to Langmuir adsorption isotherm) and of its couple chemical reaction with iron and amonium ion.

Key words: *River quality monitoring, Thermodynamic functions, Free energy changes in urban zone.*

INTRODUCTION

According to the literature (S. Sieniutycz, 2010), oxygen and hydrogen reaction enthalpy with solute in river water between input and output from urban zone control the thermochemical and /or solid oxide fuel cell potential differnce.

On the basis of the monitoring data the molar enthalpy and free energy differences achieved after relaxation period of oxygen are calculated (Petar Ševaljević, 2012), on the basis of the slope of linear functional dependence of oxygen saturation degree and concentration logarithm on reciprocal value of absolute temperature, acc. to Wan' t Hoff law. The obtained results of oxygen molar energy change indicated according to thermodynamic functions data (Bard A., Parsons R., Jordan J, 1983) to oxygen specific chemisorption energy state seasonal changes, on input of O_2^- and on output from the urban zone, of HO_2^-.

The main objective of present paper is the study of molar free energy changes also of hydrogen ions, iron and ammonium ions, ΔG^θ , as well as of chemisorbed oxygen entropy change, ΔS^θ on the basis of monitoring data for monthly concentrations and water and air temperatures. The entropy changes of chemisorbed oxygen are determined according to Langmuir adsorption isotherm (Mirjana Ševaljević et al, 2013).

The calculated chemisorbed oxygen entropy seasonal changes and free energies seasonal changes of hydrogen and oxygen couple with irone and amonium ion and total free energy in urban zone enable the processes to be identified using databse (Bard A., Parsons R., Jordan J, 1983).

According to Gibbs relation, $\Delta G^\theta = \Delta H^\theta - T\Delta S^\theta$ could be determined:
- the temperatures achieved with fastest velocity for chemisorbed oxygen adiabatic state (where $\Delta H^\theta = 0$, $T = -\Delta G^\theta / \Delta S^\theta$) in the shortest time period
- reaction enthalpy of the successive slowest relaxation processes, $\Delta H^\theta = T\Delta S^\theta$ controlling the pollutants seasonal steady states, $\Delta G^\theta = 0$,
- exothermic reactions enthalpy, $\Delta H^\theta < 0$ of spontaneous processes, $\Delta G^\theta < 0$ in season at lower water temperatures causing water freezing $\Delta S_{aq} < 0$,

- exothermic relaxation processes reaction enthalpy , $\Delta H^{\theta} < 0$, and at enough high temperature $T > \Delta H^{\theta} / \Delta S^{\theta}$ also of couple spontaneous endothermic relaxation processes enthalpy , $\Delta H^{\theta} > 0$ enabling $\Delta G^{\theta} < 0$ during positive entropy change due to water evaporation $\Delta S_{aq} > 0$.

EXPERIMENTAL RESULTS

The monitoring data are obtained at the Institute of the Public health in Zrenjanin at 2010. -2011 in the each month in the river Begej in the urban zone of Zrenjanin, in two point:
-of entrance at the asphalt base (input),
-and ofoutput at the bridge in Ecka

The modified Winkler method analogous to EN 25813 is used after oxygen oxidation manganese (II) to manganese (III) and in acidic solution form red complex with Titriplex for the photometric determination with WTW photometer and oxygen cell test, WTW 14694 .

The Tables 1 - 4 and Figures 1 and 2 present the calculated seasonal changes of examined components: chemisorbed oxygen entropy changes and the total free energy changes of couple chemical reaction of hydrogen and oxygen with irone and amonium ion between input and output,i.e. in urban zone.

Table 1: Monitoring data of the average monthly water temperatures of the river Begej, $t_{w.av(\rho=2\%)}$ and inorganic ions content, pH and γ with dominant influence on oxygen chemisorption energy states on input and output from the town Zrenjanin

Input The dates	$t_{w.av(\rho=2\%)}$ ^{o}C	pH_{in}	$\gamma\ O_{2in}$ mg/l	$\gamma NH_4^+{}_{in}$ mg/l	γFe_{in} mg/l	pH_{out}	$\gamma\ O_{2out}$ mg/l	$\gamma NH_4^+{}_{out}$ mg/l	γFe_{out} mg/l
13.1.2010	5,45	7,82	12,4	0,7	0,64	7,85	12,7	0,65	0,72
3.2.2010	1,15	7,96	11,1	1,29	0,2	7,87	9,1	2,03	0,34
3.3.2010	7,9	7,88	11,8	0,75	0,64	7,85	11,7	0,62	0,8
29.4.2010	17	7,48	9,2	0,85	0,35	7,39	5,3	1,48	0,15
14.5.2010	18,6	7,451	9,9	0,94	0,2	7,33	6,5	1,39	0,2
6.6.2010	24	7,49	5,7	1,04	0,21	7,43	5,7	1,3	0,21
1.7.2010	23,9	7,47	4,2	0,66	0,05	7,55	6,4	1,93	0,07
13.8.2010	25,4	7,12	5,8	0,71	0,26	7,12	5,6	0,71	0,26
15.9.2010	19,8	7,16	6,8	0,7	0,05	7,03	3,7	1,69	0,07
15.10.2009	13,5	7,74	8,7	0,61	0,06	7,76	7,3	0,93	0,12
4.11.2009	8,1	7,94	9,2	0,76	0,13	7,84	8,1	1,34	0,14
2.12.2009	8,3	7,84	10,1	0,67	0,15	7,77	7,9	1,25	0,14

Table 2: Oxygen equilibrium monolayer seasonal constants determined according to Langmuir adsorption isotherm, K_{Lg} and corresponding entropy changes, $\Delta_{Lg}S^{\theta}(O_2)$

Input	$K_{Lg(O_2)\ in}$	$\Delta_{Lg}S^{\theta}(O_2)_{in}$ J/molK	$K_{Lg(O2)out}$	$\Delta_{Lg}S^{\theta}(O_2)_{out}$ J/molK	$\Delta_{Lg}S(O_2)_{in\text{-}out}$ J/molK
I-III	-2519	65,1	-3770	68,4	-3,3
IV-V	-4771	70,4	-9643,9	76,7	-6,3
VI-VIII	-11309	77,6	-11076	77,4	0,2
IX-XII	-4587	70,1	2456	64,9	5,2

Table 3: The examined solutes molar free energy changes, ΔG^{ϑ} in river Begej on input and output from urban zone

Input Months	$\Delta_{in}\,G^{\theta}(Fe)$ kJ/mol	$\Delta_{in}G^{\theta}$ (H^{+}) kJ/mol	$\Delta in_{r}G^{\theta}(NH_4^{+})$ kJ/mol	$\Delta_{in}G^{\theta}(O_2)$ kJ/mol	$\Delta_{out}\,G(Fe)$ kJ/mol	$\Delta_{out}\,G^{\theta}$ (H^{+}/H_2) kJ/mol	$\Delta_{out}G^{\theta}(O_2)$ kJ/mol	Δ_{out} $G^{\theta}(NH_4^{+})$ kJ/mol
I- III	117,934	22,452	113,13	6,9	84,212	-15,2	27,016	51,646
IV- VI	- 399,22	- 135,4	11,86	- 89,196	- 81,99	318,88	-18,864	- 101,68
VII- I X	165,399	874,5	9,576	-9,468	36,318	143,05	-51,02	-263,86
IX- XII	- 53,89	- 100,07	- 42,013	-26,536	- 32,949	-90,353	-51,02	- 66,738

Table 4: The pollutants total free energy changes in chemical couple processes, $\Delta_{in\text{-}o}G^{\theta}$ determined as the difference between input and output of urban zone and the possible reversible cells of hydrogen and chemisorbed oxygen, in the equivalent titration point of iron and amonium ion,,$\Sigma\,\Delta_{in\text{-}ou}\,G^{\theta}{}_{H^{+},\,O2,\,Fe2+,\,NH3}$

Input Months	$\Delta_{in\text{-}o}G^{\theta}(Fe)$ kJ/mol	$\Delta_{in\text{-}o}G^{\theta}$ (H^{+}) kJ/mol	$\Delta_{in\text{-}o}$ $G^{\theta}(NH_4^{+})$ kJ/mol	$\Delta_{in\text{-}o}G^{\theta}(O_2)$ kJ/mol	$\Sigma\,\Delta_{in\text{-}ou}\,G^{\theta}{}_{H^{+},\,O_2,\,Fe^{2+},\,NH_3}$ kJ/mol	Hydrogen and chemisorbed oxygen possible cells
I- III	33,72	37,65	61,48	-20,12	+112,74=114-RT/2	$\Delta G^{\theta}(N_2O_5)_c\text{-}RT_{eaq}/2$
IV- VI	-317,23	-454,28	113,54	-70,33	-728,3=-705,4-(23,4)	$\Delta G^{\theta}(Fe(CO)_5)_l\text{-}\Delta G^{\theta}(NH_2OH)_{aq}$
VII- I X	129,08	731,45	273,44	41,55	1175,5=1177,7 -RT_{eaq}	$\Delta G^{\theta}\,(O_2^{+})_g\text{-}RT_{eaq}$
IX- XII	-20,94	-9,72	24,73	24,48	18,55=16,3 – RT_0	$\Delta_{diss}G^{\theta}\ (O_2)_g$ - RT_0

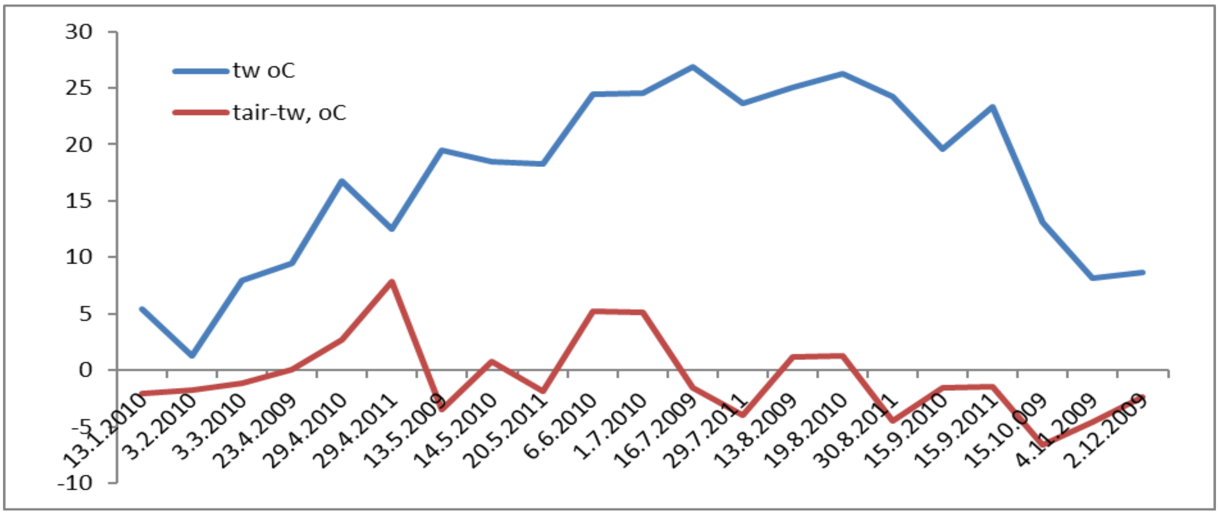

Figure 1. Diagram of the seasonal river water temperature and the difference between air temperature and water temperatures measured on entrance in the town

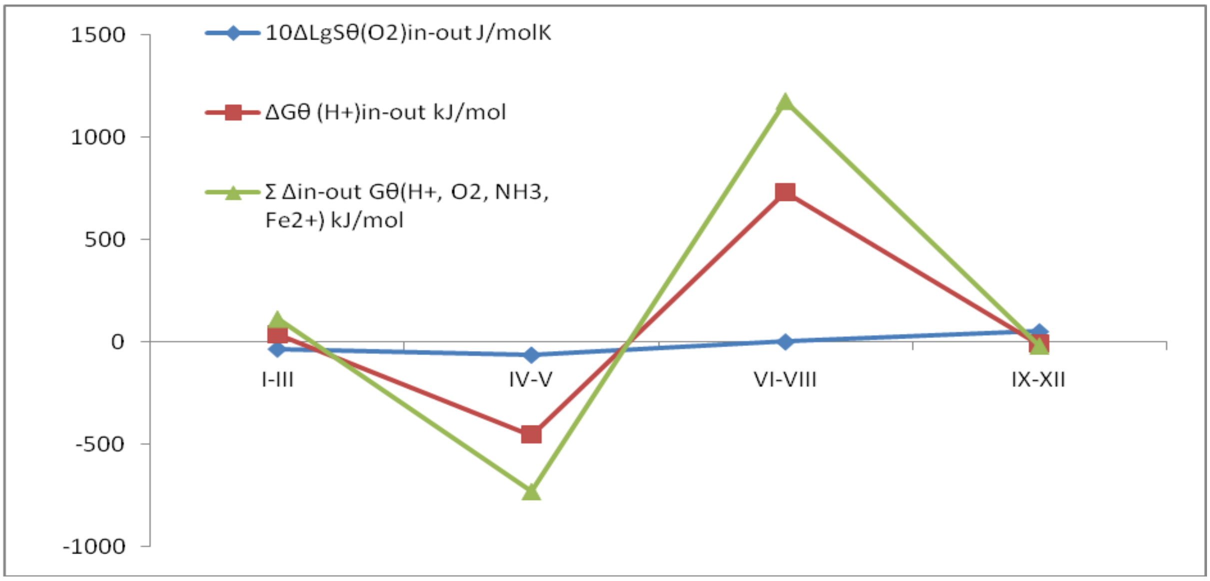

Fig.ure 2. Diagram of the seasonal hydrogen and oxygen thermodynamic functions changes in Begej river water in urban zone of Zrenjanin

CONCLUSION

The conclusion remarcs are as follows:

(a) At negative oxygen entropy change, - 3 J/molK in winter, endothermic titrations free energy couple exothermic spontaneous oxidation processes:

- $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3=112,74kJ/mol
- $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3= $\Delta\ G^{\theta}\ (N_2O_5)_c\text{-}RT_{eaq}/2\ = -\ \Delta_{couple}\ G^{\theta}(NO_3^{-},\ HNO_3)$
- reversible processes where ΔG=0 in contact surface with chemisorbed water crystallization nucleuses latent heat ($\Delta S^{\theta}{}_{ads\ active\ centers}$= 6008 /278 = 21,6 J/molK) control its entropy change equal to the sum of intermolecular hydrogen dispersion energy bonds 11,3 J/K and induced H_2O or NH_3 dipoles energy bond 10 J/K

(b) At negative oxygen entropy change -6 J/molK, in spring spontaneous exothermic are possible:

1. $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3 = - 728,3 kJ/mol
2. $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3 = $\Delta G^{\theta}(Fe(CO)_5)_l\text{-}\Delta G^{\theta}\ (NH_2OH)_{aq}$
3. where crystallization nucleuses latent heat: $\Delta S^{\theta}{}_{ads\ active\ centers}$= 6008 /291= 20,6 J/molK in reversible processes correspond to the sum of induced dipoles-active centers energy bonds , H_2O and NH_3

(c) The positive oxygen entropy change 0,2 J/molK in summer water and higher air temperatures enable couple dissociation processes :

- $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3 = 1175,5kJ/mol
- $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3 = $\Delta G^{\theta}\ (O_2^{+})_g\text{-}RT_{eaq}$ = A
  $A=3E_{bonds}\ (H_{\text{-}H}) - E_{bonds}(O\text{-}O)=3\cdot 436\text{-}138=1170$ kJ/mol
- at the stationary temperature controlling the couple of water crystallization nucleuses latent heat: $\Delta S^{\theta}{}_{ads\ active\ centers}$= 6008/296,4 = 20,2 J/molK , in reversible processes correspond to the sum of induced dipoles-energy bond , H_2O and NH_3 .

(d) The positive entropy oxygen entropy change 5,2 J/molK in autumn enable oxygen dissolution

4. $\Sigma\ \Delta_{in\text{-}ou}\ G^{\theta}{}_{H}{}^{+,}\ O_{2,\ Fe}{}^{2+}{}_{,}$ NH3 = 18,55 kJ/mol= $\Delta_{dissol.}G^{\theta}(O_2) + RT_0 = \Delta G^{\theta}\ (H^{+}/H_2)\ \text{-}\Delta G^{\theta}\ (NH_3)_g$
5. reversible processes in contact surface of chemisorbed water crystallization nucleuses latent heat ($\Delta S^{\theta}{}_{ads\ active\ centers}$= 6008 /278 = 21,6 J/molK) equal to sum of

hydrogen molecules dispersion energy bonds 11,3 J/K and H_2O or NH_3 induced dipoles energy bond 10 J/K .

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HEAVY METAL REMOVAL FROM WATER/WASTEWATER BY NANOMATERIALS WITH POROUS AND POLYMER SUPPORTS

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ABSTRACT

Nanometaloxides (NMO_S) provide efficient and specific adsorption of heavy metals. However, they are usually present as fine or ultrafine particles, which often lead to problems such as the loss of activity due to agglomeration, difficult separation and excessive pressure drop when applied in flow-through systems. An effective approach to overcome these technical problems, is to fabricate hybrid adsorbents by impregnating or coating NMO_S particles into / onto porous and polymer supports of larger size. The most commonly used supports include natural hosts such as bentonite, montmorillonite, metallic oxides materials such as Al_2O_3, etc. This paper presents an overview of the porous and polymeric supported nanometaloxide newer generation such as polyacrylonitrile nanofibers (PAN), hydrous manganese dioxide (HMO-001) onto a porous polystyrene cation exchanger resin D (001), poly (acrylic acid) stabilized with nanoparticles of amorphous calcium carbonate (ACC) and poly (aniline (AN)-co-5-sulfo-2-anisidine (SA)).

Key words: *heavy metal, adsorption, supported nanomaterials.*

INTRODUCTION

Nanometaloxides (NMO_S) provide efficient and specific adsorption of heavy metals. However, they are usually present as fine or ultrafine particles, which often lead to problems such as the loss of activity due to agglomeration, difficult separation and excessive pressure drop when applied in flow-through systems. An effective approach to overcome these technical problems, is to fabricate hybrid adsorbents by impregnating or coating NMO_S particles into / onto porous and polymer supports of larger size. The most commonly used supports include natural hosts such as bentonite, montmorillonite, metallic oxides materials such as Al_2O_3, etc. This paper presents an overview of the porous and polymeric supported nanomaterials newer generation such as polyacrylonitrile nanofibers (PAN), hydrous manganese dioxide (HMO-001) onto a porous polystyrene cation exchanger resin D (001), poly (acrylic acid) stabilized with nanoparticles of amorphous calcium carbonate (ACC) and poly (aniline (AN)-co-5-sulfo-2-anisidine (SA)).

THEORY

Environmental problems have recently gained a great deal of attention. Increasing worldwide contamination of freshwater systems has become one of the key environmental problems facing humanity. Among all water contaminants, heavy metals are toxic even in relatively low concentrations, as they can be stored, accumulated, and transferred by organisms. Strict drinking water standards have been made all over the world (Cai et al. 2010). Various treatment technologies have been used for water contaminated by heavy metals, including chemical precipitation, solvent extraction, reverse osmosis, ion exchange, evaporation, adsorption, filtration, flotation, and so on (Mohan and Singh, 2002). Economy and efficiency are key factors to be considered in water treatment. Compared with traditional materials, nanomaterials have shown much higher efficiency and faster rates on water treatment. Much research work has been focused on the development of nanomaterials for water decontamination, such as iron-based nanoadsorbents (Zhong et al. 2006, 2007), MnO_2 hollow structures, carboxymethyl cellulose grafted on multiwalled carbon nanotubes, magnesium silicate hollow nanostructures, and mesoporous F-TiO hollow microspheres. All of these materials could adsorb toxic contaminants in a short time span and with a high sorption capacity. However, the cost and inconvenience in product preparation has limited their commercial application. Therefore, a high efficiency and low-cost material is still needed for commercial applications (Cai et al 2010).

From an economic perspective, calcium carbonate is one of the cheapest materials in nature. Calcium carbonate has already been studied for heavy metal ions removal (Stipp et al, 1992). Amorphous calcium carbonate (ACC) has gained a great deal of attention. ACC contains various amounts of water, which makes it lower density than other forms of calcium carbonate. The solubility product of ACC is reported to be 4.0×10^{-7} at 25 °C, which is higher than other forms of calcium carbonate and most heavy metal carbonates like cadmium, lead, zinc, and so on. Therefore, ACC could be a suitable choice for ion exchange with metal ions, especially for precipitation transformation. For years, the preparation and characterization of ACC developed slowly, due to its unstable nature (Weiner et al. 2005). Recently, several additives have been found to stabilize ACC in a shorter time frame, such as magnesium ion, poly (acrylic acid) (PAA), phytic acid, poly (sodium 4-styrene sulfonate) and polypeptide. Polyacrylonitrile (PAN) microfibers, because of their availability as commodity textile materials, have been modified extensively to contain a chelating group for metal ion removal (Cai et al. 2010). Compared to other host materials, porous polymeric hosts are a particularly attractive option partly because of their controllable pore size and surface chemistry as well as their excellent mechanical strength for long-term use.

METHODS

PAN can be easily prepared into nanoscopic fibrous materials by a facile fiber spinning process, namely electrospinning (Kampalanonwat and Supaphol, 2010). Poly (acrylic acid) (PAA) stabilized ACC was prepared by a modified Wegner’s method (Faatz et al. 2004). A new hybrid adsorbent HMO-001, was fabricated in laboratory by impregnating nanosized hydrous manganese dioxide (HMO) onto a porous polystyrene cation exchanger resin (D-001) (Zhao et al. 2011). Poly (aniline (AN)-co-5-sulfo-2-anisidine (SA)) nanoparticles by chemical oxidative copolymerization AN and SA monomer (Li et al., 2010).

RESULTS AND DISCUSION

Manufactured polymer supports

Support polyacrylonitrile (PAN) nanofibers

Support polyacrylonitrile (PAN) nanofiber were prepared by "electrospinning" method and they were further modified to contain amidino diethylenediamine chelating groups on their surface via heterogeneous reaction with diethylenetriamine (DETA). The obtained aminated PAN (APAN) nanofiber mats were analyzed for their chelating property with four types of metal ions, Cu (II), Ag (I), Fe (II) and Pb (II) ions. The amounts of metal ions adsorbed on the support APAN nanofiber mats were influenced by the initial pH and initial concentration of metal ions. Increasing the contact time also resulted in a monotonous increase in the adsorbed amount of metal ions, and the balance is finally achieved for 10h for Cu (II) ions and around 5h for Ag (I), Fe (II) and Pb (II) ions. The maximal adsorption capacities of metal ions on the APAN nanofiber support, as calculated from the Langmuir's model, were 150.6, 155.5, 116.5 and 60.6 mg g^{-1}, respectively. Finally, exhausted APAN nanofiber supports can easily be regenerated (to 90%) with 10 M hydrochloric acid in aqueous solution (Kampalanonwat and Supaphol**,** 2010).

HMO-001

Compared to other host materials, porous polymeric hosts are a particularly attractive option partly because of their controllable pore size and surface chemistry as well as their excellent mechanical strength for long-term use. A recent review is now available concerning polymer-based nanocomposite for environmental application (Zhao et al. 2011). The charged functional groups bound to the polymeric matrix are believed to enhance permeation of inorganic pollutants of counter charges, which can be interpreted by Donnan membrane principle (Cumbal and Sengupta, 2005; Pan et al., 2010; Su et al., 2009.). A new hybrid adsorbent HMO-001, which was fabricated in laboratory by impregnating nanosized hydrous manganese dioxide (HMO) onto a porous polystyrene cation exchanger resin (D-001) (see Figure 1), provided a nice example (Su et al., 2009). Lead adsorption onto HMO-001 was tested and the maximum capacity of HMO-001 toward lead ion was about 395 mg/g. As compared to a macroporous cation exchanger D-001, HMO-001 exhibited highly selective lead retention from waters in the presence of competing Ca^{2+}, Mg^{2+}, and Na^{+} at high concen-tration levels. Fixed-bed column adsorption of a simulated water indicated that lead retention on HMO-001 resulted in a conspicuous decrease of this toxic metal from 1 mg/L to below 0.01 mg/L (the drinking water standard recommended by WHO). The exhausted adsorbent particles were amenable to regeneration by the binary NaAc–HAc solution for repeated use without noticeable capacity loss (Pakarinen et al., 2010).

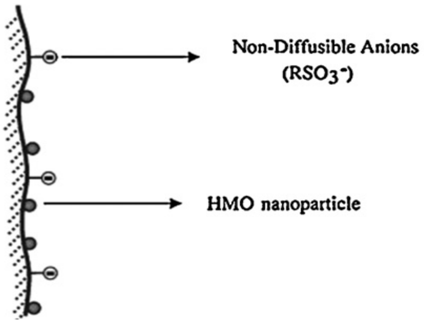

Figure 1. Schematic illustration of HMO-001

Poly (acrylic acid) stabilized with nanoparticles of amorphous calcium carbonate (ACC)

Cai Guo-Bin at al. (2010) has reported an efficient method for the synthesis of poly (acrylic acid) stabilized amorphous calcium carbonate nanoparticles (ACC) and its application for the removal of toxic heavy metal ions from aqueous solutions. Maximum capacity for the removal of Cd^{2+}, Pb^{2+}, Cr^{3+}, Fe^{3+}, and Ni^{2+} ions were found to be 514.62, 1028.21, 258.85, 320.5, 537.2 mg g^{-1}, respectively. Distinguishing characteristics of ACC nanoparticles in water include not only high removal capacity, but also decontamination ion trace. From an economic perspective, the calcium carbonate is one of the cheapest material in nature. Calcium carbonate has been studied for the removal of heavy metal ions (Stipp at al., 1992 ; Al-Degs at al., 2006; Shirvani at al. 2006). Natural calcite has very low adsorption of heavy metals. Other forms of calcium carbonate should be considered. Amorphous calcium carbonate is highly effective in the treatment of water with heavy metal ions (Cao at al., 2006).

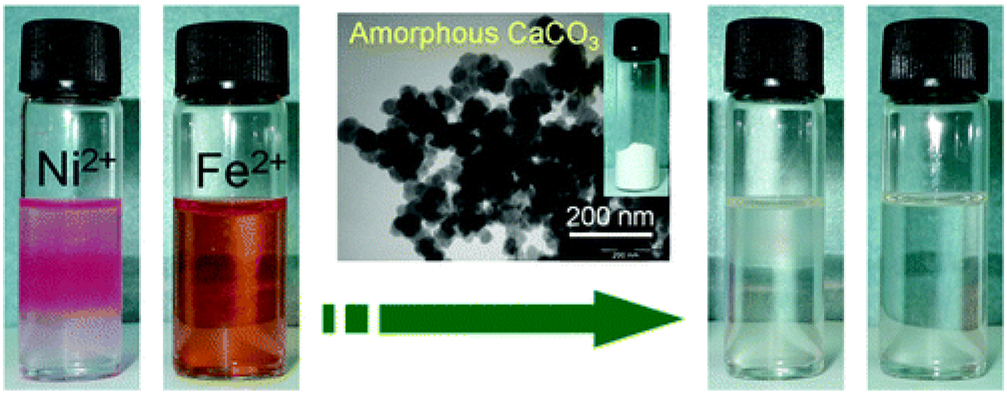

Figure 2. Removing Ni^{2+} i Fe^{2+} with amorphous $CaCO_3$

Poly (aniline (AN)-co-5-sulfo-2-anisidine (SA))

Xin-Gui Li et al. (2009) have synthesized poly (aniline (AN)-co-5-sulfo-2-anisidine (SA)) nanoparticles by chemical oxidative copolymerization AN and SA monomer and showed that they are extremely strong adsorbent for mercury ions in aqueous solution. While AN monomer tends to polymerizes, SA monomer tends to copolymerizes with AN monomer due to the large spatial barriers and the electron-attractive effect of sulfo groups, despite conjugation metoxy groups with benzene ring. Effect of initial concentration of Hg (II) on sorption time, temperature and sorption sorbent dose on sorption of mercury AN / SA (50/50) copolymer nanoparticles of an average diameter of about 120 nm were studied. The results show that the maximum Hg-ion sorption capacity of nanosorbent particles can reach even 2063 mg Hg per gram of sorbent, the highest Hg-ion adsorption. The sorption data fit the Langmuir isotherm, and the process kinetics obeys pseudo-second order. IR and UV / Vis spectral data of the Hg-loaded copolymer particles suggest that some Hg (II) was directly reduced copolymer to Hg (I) and even Hg (0). The proposed mechanism odsorpcije between particles and Hg ions in aqueous solution would be, physical / ion exchange / chelation / redox sorption ratio was about 2/3/45/50. Poly (aniline (AN)-co-5-sulfo-2-anisidine(SA)) nanograins with rough and porous structure demonstrate ultrastrong adsorption and highly efficient recovery of silver ions. The effects of five key factors AN/SA ratio, Ag^{I} concentration, sorption time, ultrasonic treatment, and coexisting ions on Ag^{I} adsorbability were optimized, and AN/SA (50/50) copolymer nanograins were found to exhibit much stronger Ag^{I} adsorption than polyaniline and all other reported sorbents. The maximal Ag^{I} sorption capacity of up to 2034mg g^{-1} (18.86mmol g^{-1}) is the highest thus far and also much higher than the maximal Hg-ion sorption capacity (10.28mmol g^{-1}). Especially at $\leq$ 2mM Ag^{I}, the nanosorbents exhibit 99.98 % adsorptivity, and thus achieve almost complete Ag^{I} sorption. The sorption fits the Langmuir isotherm well and follows pseudo-second-order kinetics. Studies by IR, UV/Vis, X-ray diffraction, polarizing microscopy, centrifugation, thermogravimetry, and conductivity techniques showed that Ag^{I} sorption occurs by a redox mechanism mainly involving reduction of Ag^{I} to separable silver nanocrystals (Li at al., 2010).

CONCLUSIONS AND IMPLICATIONS

The obtained results suggested that the APAN nanofiber mats possess a tremendous potential for use as a heterogeneous adsorbent for metal ions in wastewater effluents. APAN nanofiber mats showed high adsorption toward all four types of the metal ions. On the other hand, the adsorption capacity was found to increase with an increase in the contact time and the equilibria were reach at about 10 h for Cu (II) ions and about 5 h for the rest. The adsorption of these metal ions was fitted well with the Langmuir equation (Kampalanonwat and Supaphol**,** 2010). PAA stabilized ACC nanoparticles with negative charge and high surface area synthesized in large quantities can be applied for the removal of a series of toxic heavy metal ions, Pb^{2+},Cd^{2+}, Cr^{3+} and other metal ions, such as Fe^{3+} and Ni^{2+} ions from water. It is found that such ACC nanoparticles show powerful capability for fast removal of toxic heavy metal ions and are promising candidates for water treatment. However, some disadvantages still exist, such as non renewability and further treatment necessity for the sludge after ACC treatment. It is expected that the combination of the as prepared ACC with another decontaminator could achieve further enhancement and synergistic effects in water treatment, which requires further investigation in the future (Cao et al., 2010).

Competitive sorption of Ag (I) with coexisting Hg, Pb, Cu, Fe, Al, K, and Na ions was systematically investigated. In particular, the copolymer nanoparticles bearing many functional groups on their rough and porous surface can be directly used to recover and separate precious silver nanocrystals from practical Ag(I) wastewaters containing Fe, Al, K, and Na ions. The nanograins have great application potential in the noble metals industry, resource reuse, wastewater treatment, and functional hybrid nanocomposites. Copolymer nanoparticles can be one of the most powerful cost-effective sorbents for mercury ions with a wide range of potential applications for the efficient removal and even recovery of mercury ions from aqueous solution (Li at al., 2010).

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THE STUDY OF SEASONAL DEPENDENCE OF NOM CONTENT IN GROUND WATER ON IRON AND MANGANESE

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ABSTRACT

The functional linear dependences are found on the basis of the monitoring data, between natural organic matter, NOM and iron and manganese content. Iron and manganese – carbonyl complexes release peroxides measured by absorption of UV rays, 254 nm effective in NOM charge oxidation, chemisorbed on clay colloidal particles. The correlation are found, with strong correlation coefficients, between increased manganese content as well as UV-rays absorbance with the decreased NOM and turbidity in autumn months. On the basis of seasonal dependence of NOM content in ground water on iron and manganese contents with strong correlation coefficient R2=0.73 to 0.999, the concentrations corresponding to NOM removal can be calculated.

Key words: *Ground water, Natural organic matter content, NOM, Fe and Mn content, Linear functional dependences, Seasonal influence.*

INTRODUCTION

Natural organic matter is present in all surface, ground and soil waters. An increase in the amount of NOM has been observed over the past 10–20 years in raw water supplies in several areas, which has a significant effect on drinking water treatment. The presence of natural organic matter, NOM indicate to: (i) negative effect on water quality by causing colour, taste and odor problems, (ii) increased coagulant and disinfectant doses (which in turn results in increased sludge volumes and production of harmful disinfection by-products), (iii) promoted biological growth in distribution system, and (iv) increased levels of complexed heavy metals and adsorbed organic pollutants. NOM can be removed from drinking water by several treatment options, of which the most common and economically feasible processes are considered to be coagulation and flocculation followed by sedimentation/flotation and sand filtration. However, currently available treatment technologies do not adequately address the pollution problems, which could enable optimized coagulation, as well as new process alternatives for the better NOM removal (Le 2001, Jiang, 2007, Lim, 2009, Luo).

One of principal methods for improving the coagulation and filtration processes is preoxidation by chlorination and ozonation i. e. destroying of organic coating on the surface of colloidal particles. Manganese dioxide produced in permanganate preoxidation enhanced coagulation and filtration efficiency, by absorbing humic acid, to enhance efficiency by filtration. If permanganate is not overdosed the dissolved manganese can be controlled down to acceptable levels. A few recent studies have indicated significant treatment improvement through application of potassium permanganate, caused reduction of mutagenic activity (THM, acrylamide, chloro-phenole, etc) economic method to enhance the coagulation and reduce the settled turbidity on occasions with limited funds of capital investment. Using jar tests the settled turbidity from 60 to 40 or 4 to3 NTU at permanganate dose up to 2 mg /l in time period of 20 h and at the higher dose did not increased reduction in turbidity. Ferrate (FeVIO42−, Fe(VI)) is a versatile green chemistry compound to sustain the water supply. The by-products of its use are nontoxic iron oxides and oxygen. The efficiency of ferrate in removing dissolved organic matter is higher than that of traditional coagulants such as ferric chloride and alum. Ferrate preoxidation enhanced the coagulation of humic acids and algae. Acceptable values of Fe and

Mn control aeration method combined with retention and filtration. The higher NOM content favor surface adsorption of naturally organics charge clay particles and stabilize inorganic colloids by naturally occurring material and flocculants dosages, much increased in the case of high organic content. In this paper are observed seasonal changes of Fe and Mn contents, corresponding to NOM zero content on the basis of its functional dependences. The reaction mechanism is predicted on the basis of intermetalic binding energy of the possible binuclear carbonile of Mn2(CO)10 and Fe2(CO)10 influence on hydrogen, NO and CO chemisorbtions in metals electric double layer Then NOM could be indicator of chemisorbed hydrogen and oxygen quasi-stationary states on water active adsorption and condensation centers at equal hydrogen-metals migration and oxygen - NOM chemisorbed couple diffusion transport velocity.

MONITORING RESULTS AND CORRELATIONS

The result of laboratory analysis (Natural organic matter (on te basis of permanganate number, PN, mg/l), turbidity in NTU i.e. nefelometric turbidity units , hydrogen peroxide on the basis of absorbance of UV ray, A_{254} and Fe and Mn by AAS method are obtained in the Laboratory of thePublic health laboratory as well as in the Laboratory of the Waterworks . The seasonal values present Fig.1.

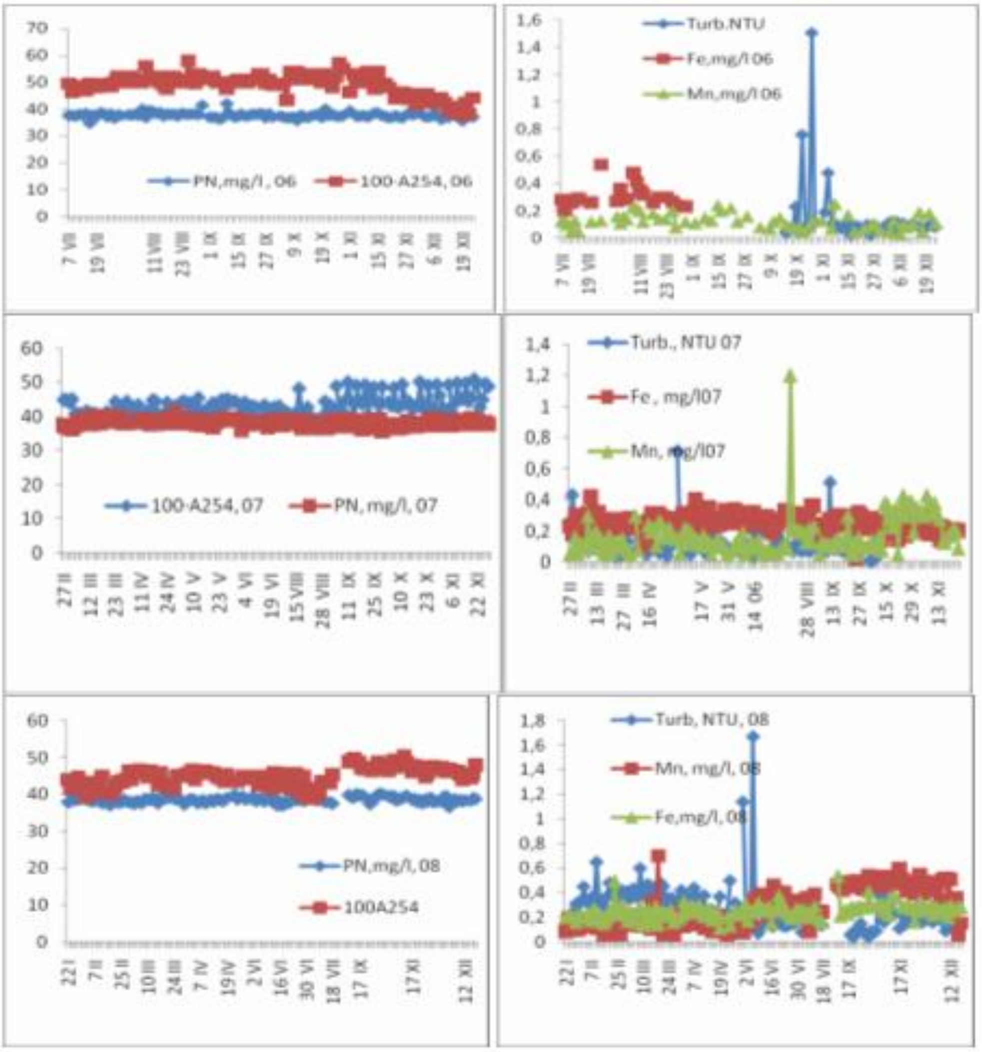

Figure 1. The monitoring results of permanganate number, PN as measure of NOM content, absorbance of ultraviolet ray A_{254}, as well as Mn , Fe and turbidity content in 2008.

The correlations are observed, (see Fig.1) which indicate on the stationary POM during increased H_2O_2 absorbance (corresponding to H_2O_2 decomposition rate of aquifer materials (Momir Vasiljević et al 2012)), and decreased turbidity at alternating seasonal changes of Mn and Fe steady:

-in 2006., between the increased absorbance A_{254} in July and increased Fe as well in October and maximums of turbidity at Mn steady state,

-in 2007., between increased A_{254}, from September to December and increased turbidity in September as well as increased Mn in October and November at Fe steady state,

-in 2008. between increased A_{254}, and Mn at decreased Turbidity content from July to December at Fe steady state.

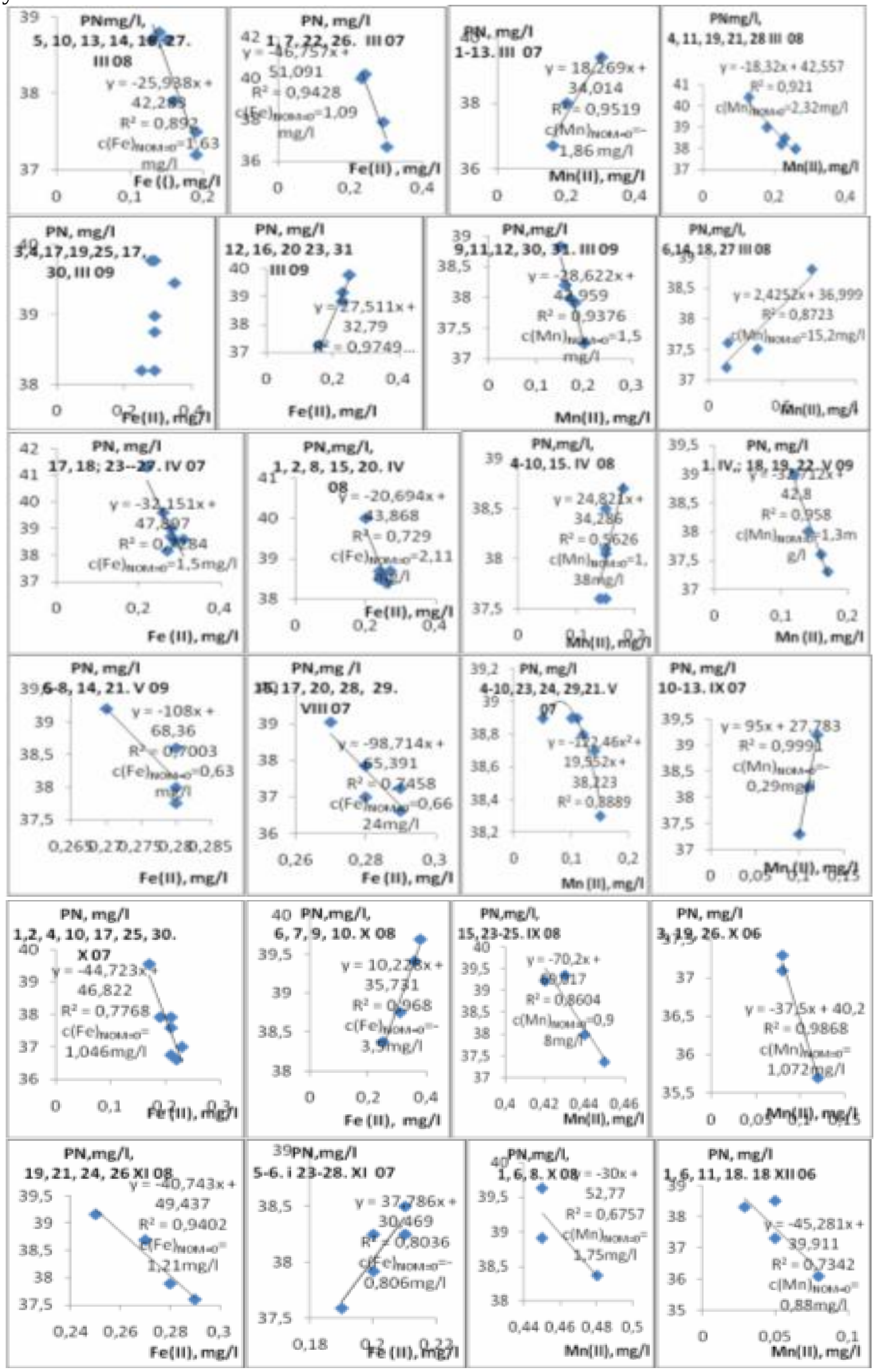

Figure 2. The choose obtained functional dependences with maximal slopes, of NOM contents on Mn and Fe content

The correlations (see Fig.2) can be explained on the basis of favored surface electrons titration of chemisorbed cation or anions exchangeable NOM in colloidal particles on reduced Fe or Mn double electric layer. The less energy binding of gaseous chemisorbed components control thermodynamic history of isochoric or relaxation isobaric hydrogen depolarization couple processes.

CONCLUSION

The concluded remarks according to obtained functional dependences are as follows:

- The decreasing of Mn and Fe contents up to 0,3 mg/l corresponded to solubility product of $FeCO_3$ and $Fe(OH)_2$ at increased NOM content up to 36-40 mg/l.
- Iron and manganese compounds with greater solubility products correspond to zero NOM content in ground water at c(Fe)=1.63 mg/l and c(Mg)=2.3 mg/l in winter , c(Fe)=1.63 , c(Mn)=2.3mg/l in spring, c(Fe)=0.63 and c(Mn)=0.3mg/l in summer and c(Fe) = 3.5 and c(Mn) = 2.3mg/l in autumn.

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THE CONCEPTS OF WATER QUALITY

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ABSTRACT

The term water quality is used to describe the chemical, physical and biological characteristics of water. It is a measure of the condition of water with respect to the requirements of one or more biotic species and or to any human need or purpose (i.e., drinking, swimming or fishing). The fundamental concepts of water quality are discussed including Definitions, Historical developments, Categories (human consumption, industrial and domestic use, environmental water quality), Water quality standards, Sampling and measurement (Sample collection, Chemical analysis, Drinking water indicators) and the Concepts of water reuse. The paper emphasizes the integration of alternative water supply and reuse practices from wastewater to reclaimed water to repurified water.

Key words: *The water quality, the water reuse.*

INTRODUCTION

The properties of water molecule are of large importance in many areas. Water plays an essential role in nature, because the water appears in various systems, from biological molecules to materials. Small size and high polarity govern water capabilities for the complex behavior. Pure liquid water has a very complex nature and this is still in the process of being clarified using spectroscopic techniques and computational methods (Bukowski et al., 2007; Huang et al., 2011; Agmon et al., 2012; Roberts et al., 2009).

Water quality is the physical, chemical and biological characteristics of water (Diersing, 2009). Physical characteristics of water (such as color, taste, temperature, odour and etc) are determined by senses of touch, sight, smell and taste. It is well known that macroscopic properties of water are substantially influenced by the presence of ions and molecules (Paschek et al., 2011; Collins et al., 2007), hence, the chemical characteristics of natural water are a reflection of the soils and rocks with which the water has been in contact. Recently studies on the influence of ions and molecules on the structure of water, using new types of spectroscopy and computer simulations (Paschek et al., 2011; Collins et al., 2007, Tielrooij et al., 2010; O'Brien et al., 2010; Mancinell et al., 2007; Holzmann et al., 2007), suggest that the structural change in the water is more than just the first hydration shell. In addition, chemical and microbial transformations also affect the chemical characteristics of water. The microorganisms in natural water include protists, plants and animals and some of the physical and biological characteristics of organisms are important for water quality. Namely, the protists, plant and animal materials are composed of carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur and these elements are building blocks for carbohydrates, lipids, proteins, phospholipids and nucleic acid.
Water quality refers to a set of standards used to assess water quality relate to drinking water, health of ecosystems, safety of human contact. It is a measure of the condition of water relative to the requirements of any human need or purpose (Johnson, 1997).

In this paper, the concepts of water quality are discussed including Categories (human consumption, industrial and domestic use, environmental water quality), Water quality standards, Sampling and measurement (Sample collection, Chemical analysis, Drinking water indicators) and Concepts of water reuse. The paper emphasizes the integration of alternative water supply and reuse practices from wastewater to reclaimed water to repurified water.

THE CONCEPTS OF WATER QUALITY

Categories of water

The water quality standards and parameters are determined by the intended use. The water is treated for:

> -***Human consumption***: We use water for drinking, washing, cleaning, cooking, and growing our food as well as many, many other things (Figure 1). Water for human consumption may contain at least small amounts of some contaminants (such as microorganisms, inorganic contaminants, organic chemical contaminants from industrial processes and petroleum use; pesticides and herbicides; and radioactive contaminants), but the presence of these contaminants does not necessarily indicate that the water poses a health risk.

Figure 1. Total residential water use (H2O University)

> -***Industrial use***: industry is reliant on water for all levels of production. It can be used as a raw material, solvent, coolant, transport agent, and energy source. Total industrial water use in the world is about 18%, with high-income countries using 59%, and low-income countries using a minuscule 8% (Figure 2). These figures will rise with industrial production.

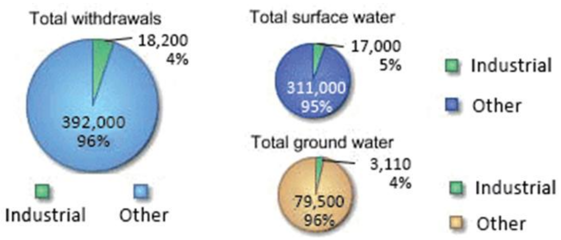

Figure 2. Total water withdrawals in 2005 (USGS)

> -***in the environment***: Environmental water quality, also called ambient water quality, relates to water bodies such as lakes, rivers, and oceans.

Standards

Water quality depends on the local geology and ecosystem, as well as human uses and degree of industrial uses. In other to protect public health, there are a lot of political and technical/scientific decisions about how the water will be used. As there are different categories of water, it is obvious that there are different water quality standards. Water quality standards for surface waters vary significantly due to different environmental conditions, ecosystems, and intended human uses.

Water quality regulated by the International Organization for Standardization (ISO, 13.060, 2011), ranging from water sampling, drinking water, industrial class water, sewage water. However, the examination of water for chemical, physical or biological properties, covers the standards of water supply systems (ISO, 91.140.60, 2011).

Sampling and measurement

There are several ways water quality at a basic level can be measured. The most accurate measurements of water quality are made on-site, because water exists in equilibrium with its surroundings. The quality of water here is determined by making measurements or by taking samples of water. Measurements commonly made on-site and in direct contact with the water source, and some of the most common measures of water quality are *Acidity (pH), Color, Ammonia, Bacteria, Dissolved Oxygen, Nutrients, Sediment, Temperature, Toxic Substances, Metals, Organics and Turbidity* (a measure of the suspended particles in the water).
The samples are typically sent out to a laboratory on the physical, chemical, and microbiological analyses. The biological test determines the toxicity of the water or the sediment to life forms or if there has been a fluctuation in the numbers and kinds of plants and animals. The biological tests are done in a laboratory, while some ones are carried out at the stream or lake.

THE CONCEPTS OF WATER REUSE

The fundamental concepts of water reuse are represent here and discussed including definitions, historical developments, the role of water recycling in the hydrologic cycle, categories of water reuse, water quality criteria and regulatory requirements, and technological innovations for the safe use of reclaimed water.

In other to facilitate communication among different groups, associated with water reuse, it is important to understand the terminology used in the arena of water reclamation and reuse.

- ***Wastewater reclamation*** is the treatment or processing of wastewater to obtain useful water.
- ***Water reuse*** is the use of treated wastewater for agricultural irrigation, industrial cooling or for other beneficial purposes.
- ***Reclaimed water or recycled water*** is former wastewater that is treated to remove solids and certain impurities and used for an intended water reuse application.

Wastewater reclamation, recycling and reuse represent the components of the hydrologic cycle (Figure 3), and many sub-cycles of the hydrologic cycle represent the continuous transport of water in the environment.

The irrigation, industrial use, surface water replenishment, and groundwater recharge are the major pathways of water reuse. The water transport depends on the watershed characteristics, climatic and geo-hydrologic factors, the degree of water utilization for various purposes, and the degree of direct or indirect water reuse.

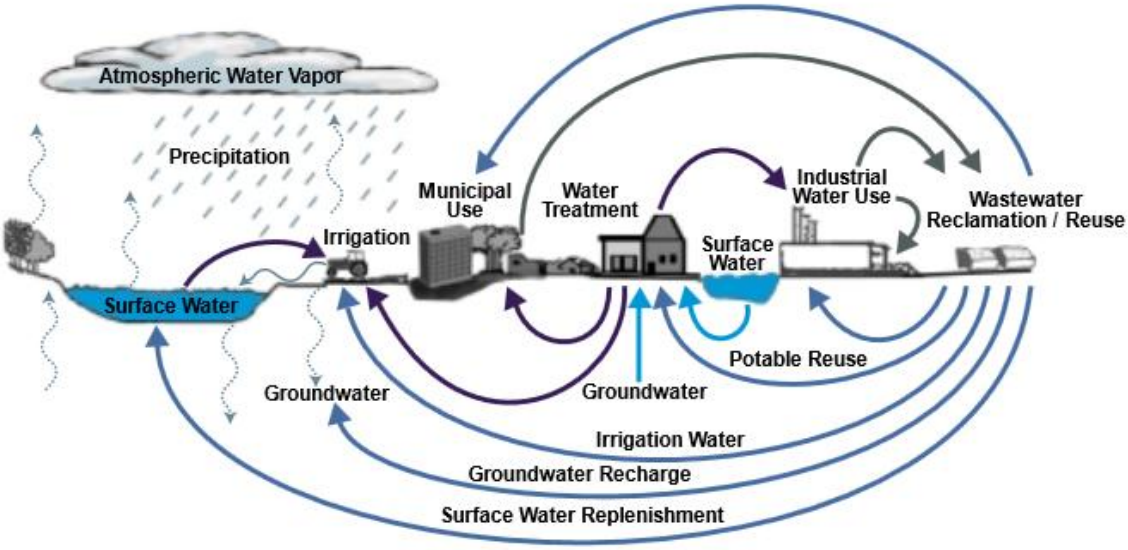

Figure 3. The role of water treatment, reclamation and reuse in the hydrologic cycle (Asano, 2002; Leverenz & Asano, 2011)

The main purpose of water reuse applications is to replace and expand water resources for specific applications (Asano, 2002; Leverenz & Asano, 2011), such as:

1. ***agricultural irrigation*** (the largest current use of reclaimed water),
2. ***landscape irrigation*** (the second largest user of reclaimed water; it includes the irrigation of parks, playgrounds, golf courses, freeway medians, landscaped areas around commercial, office, and industrial developments,; and landscaped areas around residences),
3. ***industrial reuse*** (the third major use of reclaimed water, mainly for cooling and process needs; the cooling water creates the largest industrial demand for water),
4. ***groundwater recharge*** (the fourth largest application for water reuse, either via spreading basins or direct injection to groundwater aquifers),
5. ***recreational uses*** (the fifth largest use of reclaimed water; involve non-potable uses),
6. ***non-potable urban uses*** (include fire protection, air conditioning, toilet flushing, construction water, and flushing of sanitary sewers),
7. ***indirect or direct potable reuse*** (the another water reuse opportunity).

Due to differences in specific water use requirements and geopolitical constraints, the amount of water used in each category locally and regionally varies (Figure 4).
The water quality changes by introduction of various constituents. Namely, the municipal and industrial water use tends to degrade water quality by introducing chemical or biological contaminants. To produce high quality drinking water that meets applicable standards for domestic (drinking) water supply, the water treatment technologies are applied (Figure 5) (Asano, 2002; Leverenz & Asano, 2011).

A key concern with water reuse applications is the potential risk of human exposure to pathogenic organisms. The World Health Organization (WHO) refers to the fact that high concentrations of pathogens can exist in wastewater and partially treated effluents. However, by controlling the extent of human exposure and ensuring the effective wastewater treatment of reclaimed water can minimize health impacts. The water reclamation criteria are developed by individual states, often in conjunction with regulations addressing land treatment and disposal of wastewater.

The question of safety of water reuse and acceptable health risks is still difficult to define. Despite a long history of water reuse in many parts of the world, in less developed countries, advanced levels of wastewater treatment are not possible or economically out of reach. In many countries, the agricultural and landscape irrigation using reclaimed water has been practiced for many decades. The management in irrigation may have the special role in many arid and semi-arid regions.

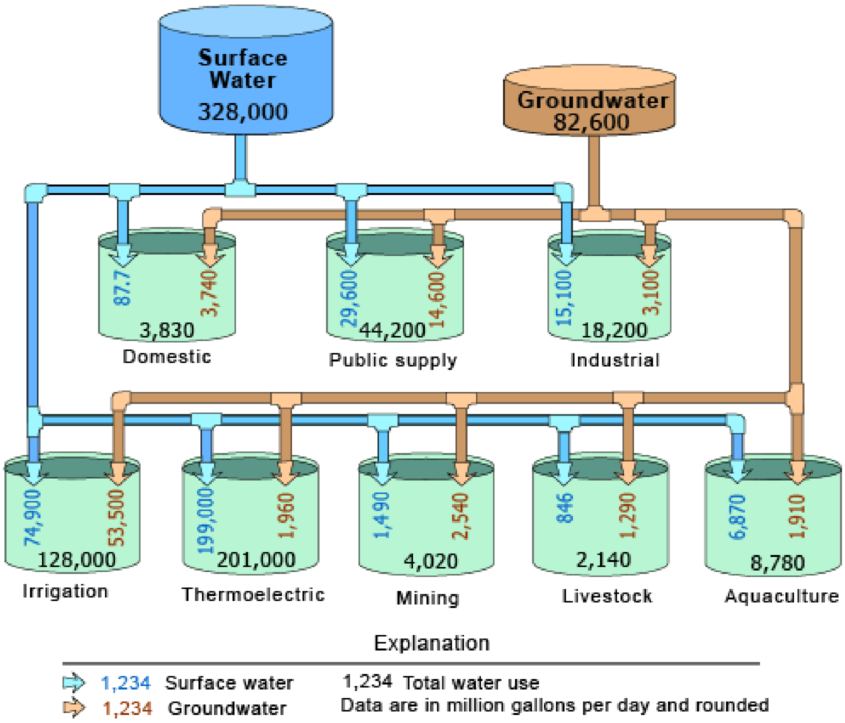

Figure 4. The sources and uses of water in USA, 2005 (USGS)

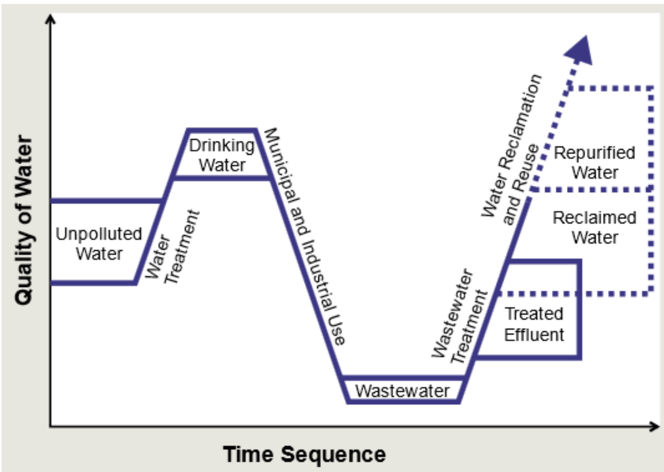

Figure 5. Water quality changes during municipal uses of water (Asano, 2002; Leverenz & Asano, 2011)

Reclaimed water is a locally controllable water resource, while potable reuse is still a distant possibility and may never be implemented except under extreme conditions. In USA, Australia, Israel, Germany, the Netherlands, and the United Kingdom, the groundwater recharge with advanced wastewater treatment technologies is available option backed for many decades.

Multiple uses of water via reclamation and reuse have become an essential element of future development in integrated water resources management.

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ASSESSMENT OF VOLUME OF COMMUNAL WASTEWATER IN AUTONOMOUS PROVINCE OF VOJVODINA

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ABSTRACT

The paper calculated the amount of communal waste water for every agglomeration in the Autonomous Province of Vojvodina. Investment costs calculated for the communal waste water treatment systems are estimated at 4.4 billion euros.

Key words: *waste water treatment system, amount of communal waste water, Autonomous Province of Vojvodina, Investment costs*

INTRODUCTION

The strategy for water supply and protection of waters in the Autonomous Province of Vojvodina has determined that the conditions for long-term sustainability of water sources to meet the needs of population in drinking water are good, provided, the management of water quality is in an organized and rational way (University of Novi Sad, Faculty of Science, Department of Chemistry 2009).

A good part of organized and rational management of water quality is the management of waste water, as the aquifer water quality largely depends on the wastewater discharged. To reduce or eliminate the negative impacts of wastewater on water recipients, and the environment in general, it is essential to perform its purification before discharging wastewater into water recipients.

In the Republic of Serbia, before Regulation on limit values for pollutants in water and deadlines for achieving them ("Off. Gazette of RS", no. 67/2011 and 48/2012), the required quality of wastewater was determined based on the required quality of recipient. Now the Regulation set emission limit values for certain groups or categories of pollutants, as well as deadlines for achieving them. However, a significant reduction of pollution from waste water as a result of this regulation, given the limits for achieving emission targets, the difficult economic situation and the high cost of building water purification systems, we can expect by the end of 2030, ie. 2045 when the legal entities, entrepreneurs and general population, or agglomerations with a load of more than 2000 population equivalent (PE) will be required to bring their emission of pollutants in line with this regulation. In the European Union, however, the required quality of wastewater is determined based on the required quality of treated water by the European Council Directive of 21st May 1999.

Developed countries in the mid and late thirties of the twentieth century started in solving the problem of wastewater – Republic of Serbia with this problem seriously begin to deal since seventies. At the end of 1939, 53 million people of total 70 million urban population in the United States had wastewater treatment (Imhoff 1950), in the Republic of Serbia seventies, of the total settlement only 18% had public water supply (1960 – 4%), and 2 % public sewage system (1960 – 1%) (Vujnovic 1995).

According to the last available data of the Statistical Office of the Republic of Serbia, the Republic of Serbia today has total 356,254,000 m^3 volume of wastewater, and purified total 52.599 million m^3 of wastewater (only 15.7%), while in Vojvodina of the total 79,035.000 m^3 15,368,000 m^3 (24.8%).

Table 1: Wastewaters in Serbia according to treatment methods, 2011 (Statistical Office of the Republic of Serbia 2012)

	Purified wastewater volume in thousand m^3				Discharged wastewater from municipalities by public sewers, in thousands m^3	Share purified wastewater discharges in total, %
	Total	Primary treatment	Secondary treatment	Tertiary treatment		
TOTAL	52 599	12 734	34 235	5 630	334 265	15,7
AP Vojvodina	15 368	1 951	7 923	5 494	61 971	24,8
Serbia - south	37 231	10 783	26 312	136	152 813	24,4
Western Serbia and Sumadia region	32 880	10 580	22 300	–	94 514	34,8
East and south Serbia	4 351	203	4 012	136	58 299	7,5

Table 2: Wastewaters of Republic of Serbia, 2009-2011. (Statistical Office of the Republic of Serbia 2012

	2009	2010	2011
TOTAL WASTEWATER, in thousand m^3	364 896	352 211	356 254
Community wastewater from public sewers	339 852	328 582	334 265
From households	228 953	236 011	246 506
From industry	63 958	54 905	52 090
From others	46 941	37 666	35 669
Wastewater treatment in thousand m^3			
Primary treatment	5 451	5 456	12 734
Secondary treatment	38 830	37 411	34 235
Tertiary treatment	6 770	5 144	5 630
Sewage collection networks			
Length of public sewers in km	13 856	14 144	14 371
Number of households connected to sewage collection system	1 319 380	1 359 385	1 389 373

WASTEWATER IN AUTONOMOUS PROVINCE OF VOJVODINA

In the case of AP Vojvodina, the total emissions of channeled wastewaters (municipal and industrial) is approximately 5,250,000 PE (population equivalent), of which about 40% come from the citizens themselves. These waters are sources of groundwater and surface water pollution (University of Novi Sad, Faculty of Science, Department of Chemistry, 2009).

Settlements, industry and agriculture are the main sources of water pollution in Vojvodina beside a part of the pollution from the neighboring countries.

Pollutants contained in wastewater are numerous, they are usually amino acids, fatty acids, soaps, surfactants (from detergents), etc., and from industrial effluents most often metals, oil and oil products, different solvents, phenolic compounds, organic acids, alcohols, aldehydes, etc.
Significant pollution of waters in Vojvodina comes from the food industry. Of total 447 industrial pollution, 293 polluters do not purify their water (71 pollutant discharge their wastewater purified with municipal wastewater and 83 pollutants has primary wastewater treatment). Only 10 % of the total volume of industrial wastewater has secondary treatment. (University of Novi Sad, Faculty of Science, Department of Chemistry, 2009).

There is total registered 511 polluters in AP Vojvodina. Its structure is as follows: industry (326 polluters), agriculture (livestock farms, 113 pollutants), towns (44 pollutants) and other (20 pollutants).

MUNICIPAL WASTEWATER

The city (municipal) wastewater containing inorganic and organic substances dissolved or in the form of suspension. In these waters are present different microorganisms, as well.

Municipal wastewater consists of household wastewater, wastewater from commercial and other buildings (hotels, shops, shopping centers, etc.). The amount of water consumed per capita per day, and thus the amount of resulting wastewater depends on the standards and culture in different countries and it ranges from 150 to 500 liters per capita / day (Djukovic and Stojanovic 2009).

The composition and the degree of contamination of municipal wastewater is estimated by the amount of matter in suspension, the amount of dissolved solids and the biological oxygen demand. It is estimated that, in normal circumstances, a resident rejects the average amount of pollutants whose composition is fixed. The composition of wastewater per fraction (the source of the household) is given in the following table:

Table 3: Characteristics of wastewater from households (Djukovic / Stojanovic 2009)

Parameter	**Mass of waste (g/apartment/day)**	**Concentration (mg/l)**
Total solids	115-170	680-1000
Volatile solids	65-85	380-500
Suspended solids	35-50	200-290
Volatile suspended solids	25-40	150-240
BPK_5	35-50	200-290
HPK	115-125	680-730
Total nitrogen	6-17	35-100
Ammonium	1-3	6-18
Nitrites and nitrates	< 1	< 1
Total phosphorus	1-4	6-24
Total coliform bacteria	-	10^{10}-10^{12}
Fecal coliform bacteria	-	10^{8}-10^{10}

Very important for planning wastewater treatment system is to have a reliable estimate of the amount of wastewater. In former Yugoslavia, planners are usually reckoned with future specific average amount of wastewater of 360 liter per capita per day (only people with no industry). In a case of separated sewage system, this amount is reduced (usually 15%) of the amount of water used for watering vegetation, watering and washing of streets, fire and other similar purposes (Ljubisavljević, Djukic, Babic, 2004).

The daily amount of wastewater of the separated sewage system we can calculate on example of the village of 1000 population equivalent. For this assessment we will need to determine the daily average wastewater in the days of maximum and minimum water consumption, as well as the minimum and maximum hourly flow of wastewater in this village. For case of simplicity we will omit the contribution of industrial wastewater pollution, and considers only separated sewage system one which not includes storm drain.

METHODS

It is considered that, depends of conditions of water supply, living standards, and involvement in sewerage, a resident rejects the average amount of polluting substances whose composition is fixed and constant (base equivalent is resident). Of course the average amount varies by country and region in which the resident lives.

France, with the exception of special cases, set the following daily amounts (per capita):

Table 4: France set daily amount of wastewater by size of settlement (per capita) (Degremont 1976)

For settlements of less than 10,000 inhabitants	150 l
For settlements from 10,000 to 50,000 inhabitants	200 l
For settlements with more than 50,000 inhabitants	250-500 l

In the following calculations we use daily average volume of wastewater (per capita) (Q_{sr}^{d}) determined by the type of settlement in France, and future specific average amount of wastewater of 360 liter per capita per day used in former Yugoslavia for daily maximum for settlements with more than 50,000 inhabitants.

Maximum amount of waste water per capita per hour during the day of settlements with more than 50,000 inhabitants we will calculate if with future specific average amount of wastewater of 360 liter per capita per day reduced by 15%, taking into account the daily fluctuations (see Figure 1), and then multiply with the estimated maximum amount per hour in a 24-hour run-off – which by Imhoff is estimated at 1/14 of the total daily wastewater runoff.

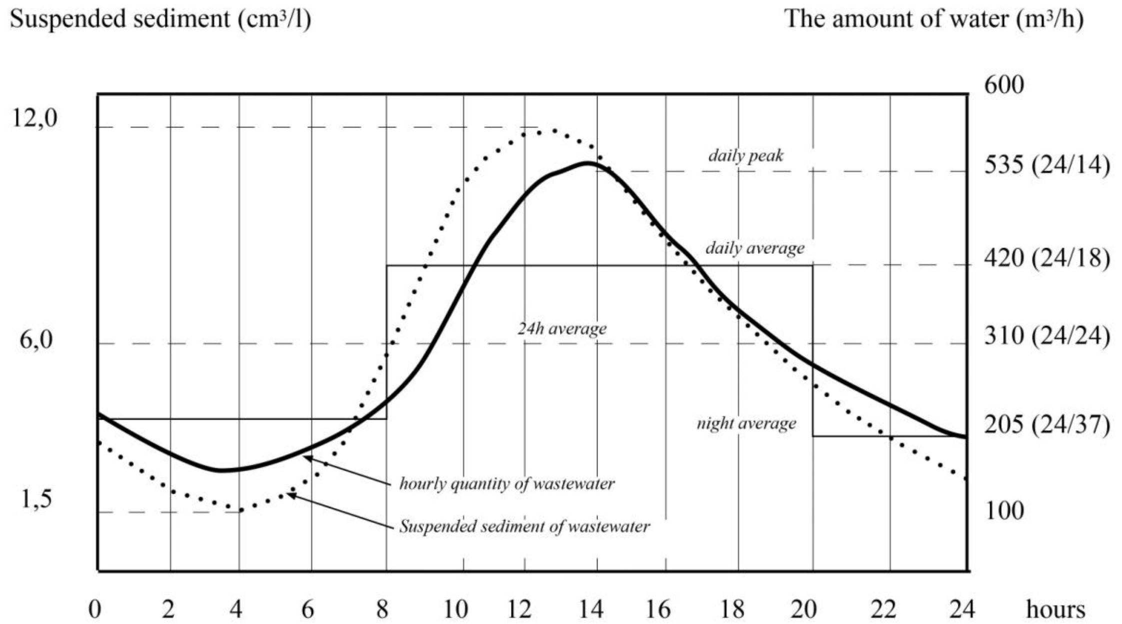

Figure 1. Oscillations of amount of wastewater and suspended sediments in settlement of 50,000 residents in 24 h (Imhoff 1950)

Maximum amount of wastewater per capita per hour during the day of settlements with less than 10,000 inhabitants:

$$Q^d_{max} = \frac{1}{14}(150 - 22,5)\frac{l}{day} = \frac{9.107}{24(60x60)}\frac{l}{s} = 0.0001054\frac{l}{s} = 0.009104\frac{m^3}{day} \quad (1)$$

Maximum amount of wastewater per capita per hour during the day of settlements from 10,000 to 50,000 inhabitants:

$$Q^d_{max} = \frac{1}{14}(200 - 30) = \frac{12,14}{24(60x60)}\frac{l}{s} = 0,0001405\frac{l}{s} = 0.012143\frac{m^3}{day} \quad (2)$$

Maximum amount of wastewater per capita per hour during the day of settlements with more than 50,000 inhabitants:

$$Q^d_{max} = \frac{1}{14}(360 - 54) = \frac{21.85}{24(60x60)}\frac{l}{s} = 0,0002529\frac{l}{s} = 0.02186\frac{m^3}{day} \quad (3)$$

While the maximum amount of wastewater from the village 1000 people per hour during the day is:

$$Q^d_{max\ 1000} \times 1000 = 0,0001054\frac{l}{s} \times 1000 = 0,1054\frac{l}{s} = 9,107\frac{m^3}{day} \quad (4)$$

The minimum amount of wastewater per capita per hour during the day we will calculate with established French daily wastewater flow (per capita) by size of the village, 150, 200 and 360 liter per capita per day, and multiplied it with the estimated minimum volume per hour in a 24-hour run-off (night average) – which by Imhoff estimated at 1/37 of the total daily wastewater runoff.

Minimal amount of wastewater per capita per hour during the day of settlements with less than 10,000 inhabitants:

$$Q^d_{min} = \frac{1}{37}(127,5) = \frac{3,44}{24(60 \times 60)}\frac{l}{s} = 0,00003981\frac{l}{s} = 0,00344\frac{m^3}{\text{dan}} \quad (5)$$

Minimal amount of wastewater per capita per hour during the day of settlements from 10,000 to 50,000 inhabitants:

$$Q^d_{min} = \frac{1}{37}(170) = \frac{4,59}{24(60 \times 60)}\frac{l}{s} = 0,00005313\frac{l}{s} = 0.00459\frac{m^3}{\text{dan}} \quad (6)$$

Minimal amount of wastewater per capita per hour during the day of settlements with more than 50,000 inhabitants:

$$Q^d_{min} = \frac{1}{37}(306) = \frac{8,27}{24(60 \times 60)}\frac{l}{s} = 0,00009572\frac{l}{s} = 0.00827\frac{m^3}{\text{dan}} \quad (7)$$

While the minimal amount of wastewater from the village 1000 people per hour during the day is:

$$Q^d_{min} = \frac{1}{37}(127,5) \times 1000 = \frac{3,44 \times 1000}{24(60 \times 60)}\frac{l}{s} = 0,03981\frac{l}{s} = 3,44\frac{m^3}{dan} \quad (8)$$

Average daily wastewater flow in the days of the maximum (Q^d_{max}), or minimal (Q^d_{min}) water consumption is determined by multiplying the average daily wastewater flow coefficients with daily imbalances:

$$Q^d_{max} = k_{dmax}\, Q^d_{sr} \quad (9)$$

$$Q_{min}^{d} = k_{dmin}\ Q_{sr}^{d} \tag{10}$$

k_{dmax} is the maximum, while k_{dmin} is minimum coefficient inequality of daily water consumption. The value of these coefficients depend on the climate of the studied area, standards and habits of the population. In Serbia, the value of these coefficients are $k_{dmax} \leq 1{,}5$ and $k_{dmin} \geq 0{,}5$.

The average daily volume of wastewater in the days with a maximum water consumption per capita for all three types of settlements are following:

$$Q_{max}^{d} = k_{dmax}\ Q_{sr}^{d} = 1{,}5\ \times 150 = \frac{225}{24(60 \times 60)}\ \frac{l}{s} = 0{,}002604\ \frac{l}{s} = \ 0.225\frac{m^3}{\text{dan}} \tag{11}$$

$$Q_{max}^{d} = k_{dmax}\ Q_{sr}^{d} = 1{,}5\ \times 200 = \frac{300}{24(60 \times 60)}\ \frac{l}{s} = 0{,}003472\ \frac{l}{s} = \ 0.3\frac{m^3}{\text{dan}} \tag{12}$$

$$Q_{max}^{d} = k_{dmax}\ Q_{sr}^{d} = 1{,}5\ \times 360 = \frac{540}{24(60 \times 60)}\ \frac{l}{s} = 0{,}00625\ \frac{l}{s} = \ 0.54\frac{m^3}{\text{dan}} \tag{13}$$

While the average daily volume of wastewater in days with minimal water consumption per capita in settlements of less than 10,000 inhabitants:

$$Q_{min}^{d} = k_{dmin}\ Q_{sr}^{d} = 0{,}5\ \times 150 = \frac{75}{24(60 \times 60)}\ \frac{l}{s} = 0{,}0008681\ \frac{l}{s} = \ 0{,}075\frac{m^3}{\text{dan}} \tag{14}$$

For settlements from 10,000 to 50,000 inhabitants:

$$Q_{min}^{d} = \ 0{,}5\ \times 200 = 100\ \frac{l}{st.dan} = \ \frac{100}{24(60 \times 60)}\ \frac{l}{s} = 0{,}001157\ \frac{l}{s} = \ 0{,}1\frac{m^3}{\text{dan}} \tag{15}$$

For settlements with more than 50,000 inhabitants:

$$Q_{min}^{d} = \ 0{,}5\ \times 360 = 180\ \frac{l}{st.dan} = \ \frac{180}{24(60 \times 60)}\ \frac{l}{s} = 0{,}002083\ \frac{l}{s} = \ 0{,}18\frac{m^3}{\text{dan}} \tag{16}$$

Daily exposure to wastewater pollution per capita per day expressed in BOD_5 (the biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period) in France usually assess the level according to the following table:

Table 5: In France, the determined value of BOD_5 for different types of sewage system (Degremont 1976)

For separated sewage system	54 g
For semi separated sewage system	60 g
Combined sewer	74 g

Now we will calculate the daily biological load for the separation sewage system of settlement of 1,000 people:

$$54g\ \times 1000\ ES = 54000\ \frac{g}{dan} = \ \frac{54000}{24}\ \frac{g}{h} = 2250\ \frac{g}{h} \tag{17}$$

FINDINGS AND DISCUSSION

Pollution of surface waters in Serbia and in Vojvodina is a problem that must be systematically addressed as soon as possible. Measurements during the last 30 years to about 160 measuring points (profiles) show that the quality of surface waters in the Republic of Serbia is at the level required class only 15 profiles (below 10% of the total). Water flows are temporarily or permanently outside the class prescribed by the Regulation of Waterways. Number of profiles in which the bacteriological contamination beyond the norm is very high (137 measurement points), ie. about 85% of all observed, as a result of discharges of untreated wastewater.

Based on calculation done for each settlement in Vojvodina and calculated total volume of wastewater in Vojvodina done in this paper, annual volume of wastewater is significantly higher than those analyzed in the Statistical Office of the Republic of Serbia. In this paper, it is calculated that the total annual amount of wastewater in Vojvodina approximately 371 million cubic meters while the data of Statistical Office of the Republic of Serbia shows that this is 79 million cubic meters. And, given that municipal wastewaters are only 40% of the total generated waste water (which includes industrial as well), total wastewater can be evaluate to 928 million cubic meters, which is nearly 12 times more than amount of wastewater evaluated by Statistical Office of the Republic of Serbia. Bearing in mind that the amount of wastewaters in Vojvodina which are treated is approximately 15.5 million cubic meters, we can conclude that in Vojvodina treated only 2% of the wastewater. That is catastrophic data with respect to state of all water recipients in Vojvodina.

Other results of this study on the quantities of wastewater discharge and nutrient load of AP Vojvodina are presented in the following table:

Table 6: Volume of municipal wastewater in AP Vojvodina, the results of the study

Popula-tion	Popula-tion equivalent	The average daily volume of wastewater (m^3/day)	The average daily volume of wastewater in the days with a maximum water consumption (m^3/day)	The average daily volume of wastewater in days with minimal water consumption (m^3/day)	The maxi-mum amount of wastewater per capita per hour (l/s)	The minimum amount of waste water per capita per hour (l/s)	Daily exposure to wastewater pollution expressed as BOD_5 (g/hour)
2031522	4107503	1016565	1449413	482946	1683	636	1296063

Of the total 468 settlements in Vojvodina, the largest number (154) belongs to a group of settlements in which the volume of municipal wastewaters are less than 2000 population equivalent, in a group of settlements from two thousand to five thousand population equivalent are 148 settlements. The volume of wastewater in 87 settlements are equivalent to the pollution of 5 thousand to 10 thousand population equivalent, in 66 settlements are equivalent to the pollution from 10 thousand to 50 thousand population equivalent, and, in 13 cities pollution is equivalent of over 50 thousand population equivalent.

Table 7: The structure of the settlements of Vojvodina with wastewater population equivalent

Total settlements	Less the 2 thousand PE	From 2 to 5 thousand PE	From 5 to 10 thousand PE	From 10 to 50 thousand PE	Over 50 thousand PE
468	154	148	87	66	13

From total 22 facilities built for the treatment of municipal wastewaters in Vojvodina, regardless of their lack of tenure, in office are only: Bač, Bečej, Horgoš, Kanjiža, Novi Banovci, Novo Miloševo, Ruma, Sombor, Subotica, Stara Moravica i Vršac (total 11). In these plants, which are in use, the technology are mechanical-biological treatment ie. secondary treatment in which the biological treatment process are conducted by the activated sludge. Not a single plant in operation have tertiary treatment (Dalmacija 2008).

CONCLUSIONS AND IMPLICATIONS

Due to the worsening quality of water recipiens in Vojvodina, as well as their very high bacteriological contamination, it is essential that all new plants contains at least tertiary treatment which removes nitrogen and phosphorus. To stop further causing of biological surface water pollution and their eutrophication.

Compact prefabricated solutions that include the removal of phosphorus and nitrogen (SBR plant), with respect to their ease use, are recommended for settlements from 2,000 to 5,000 population equivalent. The paper is estimated needs of 148 such plants whose construction required total 13,980,000 euros.

For settlements whose wastewater exceeds amount of wastewater equivalent to more than 5000 population equivalent are recommended traditional plants which includes preliminary, primary, secondary and tertiary treatment of wastewater. Total 155 such plants in Vojvodina need to be constructed, and the construction costs are estimated at approximately EUR 4 billion.

The cost of building new facilities and upgrading existing plants from secondary treatment to tercial treatment plants was calculated based on estimates of the Canadian Association for the Water and Wastewater. For the building new tertiary plant, costs are estimated to € 1,455 per capita equivalent, for the improvement of primary to tertiary facilities to € 873 and for the improvement of plant from secondary on tertiary treatment to € 290 per capita.

Table 8: The investment cost of different types of wastewater treatment plants in Vojvodina

	Population	Population equivalent	The average daily volume of wastewater (m^3/day)	Investment costs (€)
New facilities (Over 5000 PE)	155	2,849,000	711,840	4,145,295,000
SBR plant (From 2000 to 5000 PE)	148	478,000	71,700	13,980,000
Upgrading existing plants from secondary treatment to tercial treatment plants (Total 11 plants)	11	623,000	209,400	180,670,000
TOTAL	**314**	**3,950,000**	**992,940**	**4,339,945,000**

Industrial wastewater of AP Vojvodina are necessary to be subjects of further studies.

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GAS CHROMATOGRAPHY SCREENING OF ORGANIC POLLUTANTS AND CHARACTERISATION OF NATURAL ORGANIC MATTERS PRESENT IN DANUBE WATER

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ABSTRACT

Characterisation of natural organic matter in Danube River and gas chromatography with mass detector screening of organic pollutants was done. Samples were taken during March and May, 2012. downstream from GC-2 discharge of municipal wastewater in Novi Sad, Serbia. Influence of ozonation on structure of natural organic matters and presence of organic pollutant was interrogated as well. Based on results, it is concluded that structure of natural organic matters is changing with change of time in various seasons. Ozonation changes structure of natural organic matters by increasing polarity of present compounds. Some of found organic pollutions are completely removed by ozonation and some of them are not. It is noticed that some of compounds exist only in ozonated water, what can mean that they arise as a reaction product of ozonation.

Key words: *ozonation, natural organic matters, Danube River.*

INTRODUCTION

Natural organic matter (NOM) is a term used to describe the complex matrix of organic material present in natural waters. NOM originates from the elutriation of soil and from biological, chemical and photochemical reactions in water occurring in the presence of algae, animal and vegetable by-products [1]. NOM are complex heterogeneous mixture of compounds. They are found in all water bodies in different quantities and they are credited for brown-yellow colour of most waters. Even waters that have clear look contain certain amount of NOM [2].

Natural organic matter in water can have different effects on human health and/or ecosystems. They can be toxic depending on their attributes and also NOM can react with other compounds or metals which can lead to change of their impact on environment [3]. Some organic compounds can be decomposed under the influence of microorganisms which creates more or less toxic substances. During microbial degradation of organic matter in water comes to increased oxygen usage, which can change complete chemistry of ecosystem, and even bring the fish pestilence [4].

Organic pollutants, xenobiotics comes into water and the environment only by anthropogenic means. Xenobiotics are compounds that are naturally not found in environment and have a negative influence on human health and/or ecosystems [5]. These compounds frequently enter the environment i.e. by releasing the unpuruified or insufficiently purified industrial or comunal waste water, from the traffic, agricultural fields, atmosphere, etc [6].

This paper present assessment of properties and composition of natural organic compounds found in water of Danube using fractionating column with inlay and characterization of organic compounds by using gas chromatography and mass spectrometry (GC/MS). Also, the change in structure of NOM is monitored after ozonation.

EXPERIMENTAL PART

Sources of Danube water are taken downstream of GC-2 discharge of waste water (H45°15'438" E 19º51'233"). Samples are taken during March and May 2012 by following procedure defined in “Standard Methods for the Examination of Water and Wastewater” for collecting the water samples [7]. Properties and composition of NOM in Danube water have been determined by fractionation using XAD-4 and XAD-8 resins. Content determination of organic matter is done by following contents of dissolved organic carbon in raw water of each fraction. GC/MS technique is used to determine the organic pollutants in Danube water.

Fractionation of organic matter in water represents technique of separation of dissolved organic matter into groups based on their structural, physical and/or chemical properties. Separation is done by running the water sample through series of different resins which have tendency to absorb specific compound group. Elution with dissolvent is done with less volume then the volume of sample, after which we get concentrated fraction. By using this technique, fractions can be characterised as hydrophobic, rarely present in water, fulvic and humic acids, and hydrophilic which is constituted by carbohydrates of low molecular mass, proteins and aminoacids, while hydrophobic matter mostly have aromatic structure.

Additionally, the research included ozone influence on change in water composition, change of organic matter in water, change of structure and creation of reaction by-products. Water was treated with ozone which dose was 1.5 mg O_3/l of dissolved organic carbon (DOC). Figure 1 shows the schema of experiment.

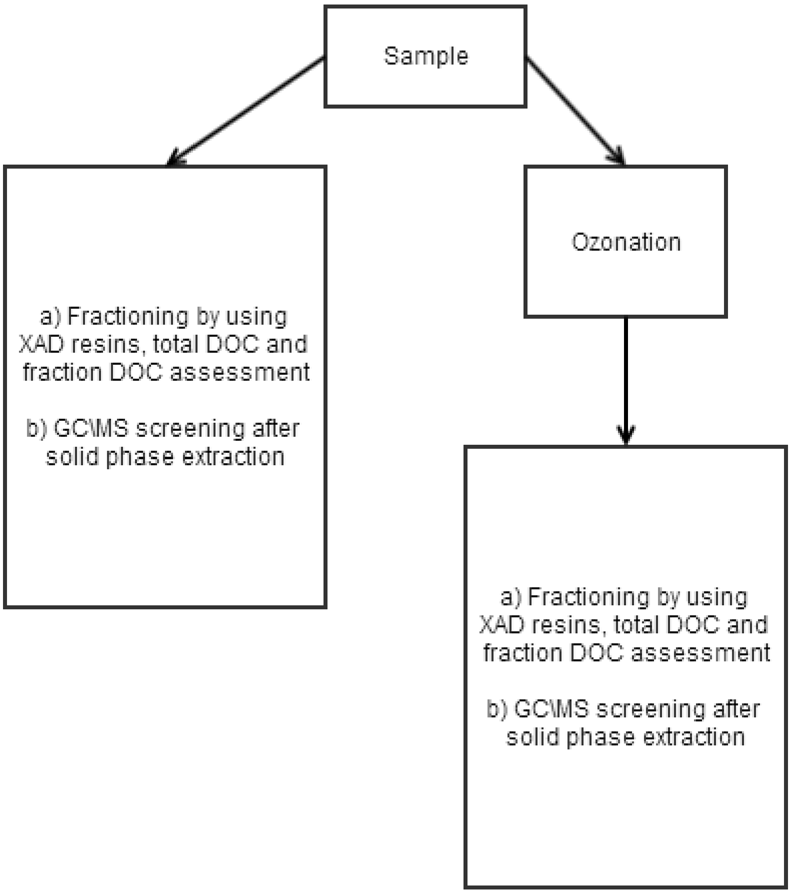

Figure 1. Experiment schema

ASSESMENT AND CHARACTERIZATION OF NATURAL ORGANIC MATTER

Characterization of organic matter in Danube water is used for determination of its properties and contents. Assessment of properties and contents NOM found in surface level of Danube water downstream of GC-2 waste water discharge, has been determined by fractionation on columns with XAD resins.

RESIN PREPARATION

XAD-8 and XAD-4 resins were used. Before usage, resins XAD-8 and XAD-4 have been prepared using Soxhlet extraction with hexane, acetonitrile and dichloromethane. In each of fraction we determined the value of dissolved organic carbon.

SAMPLE PREPARATION

Figure 2 shows schema of fractioning with XAD resins. FAF represents fulvic acids, HAF humic acids, HPI-A hidrophilic acids, HPI-NA hydrophilic nonacid fraction [8].

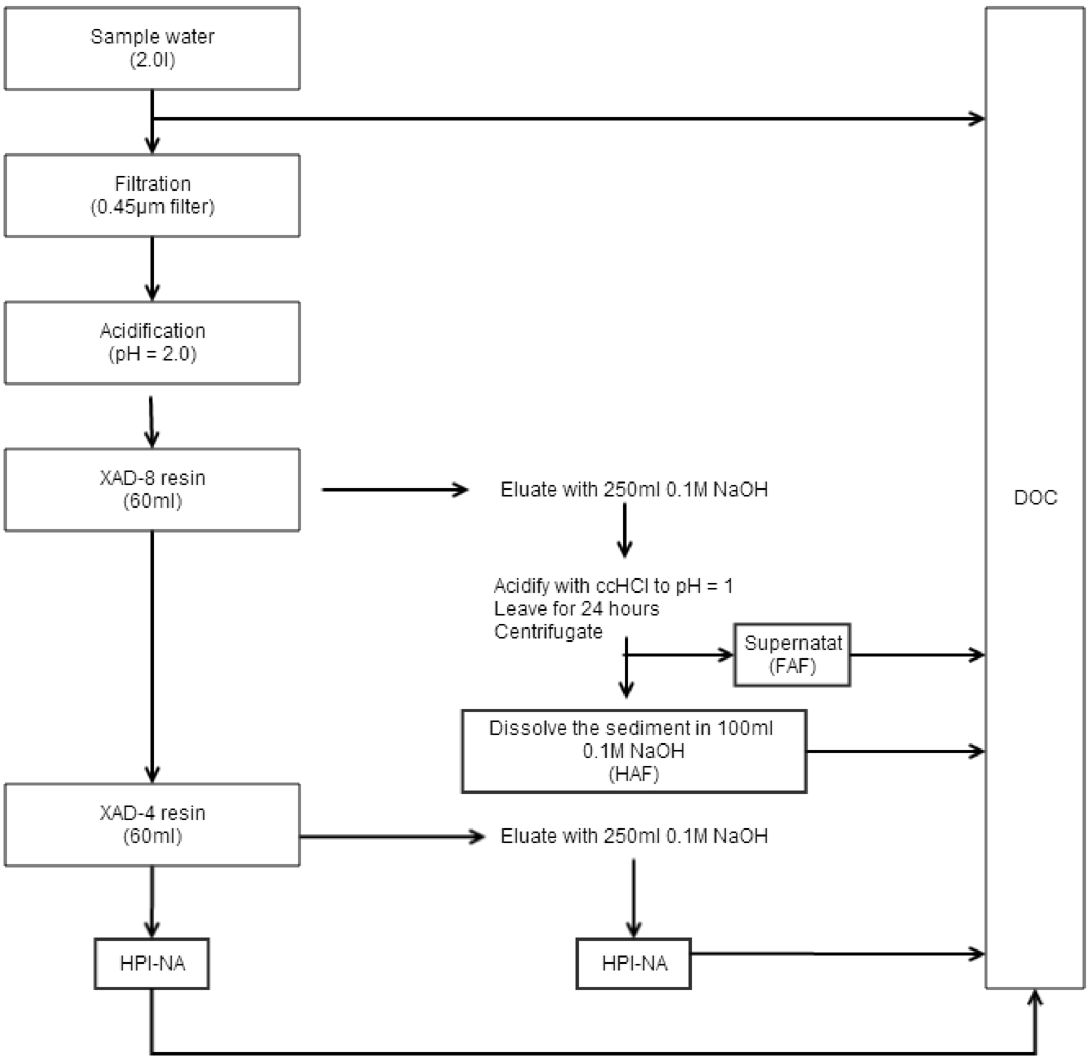

Figure 2. Schema of fractioning procedure

GC SCREENING OF ORGANIC POLUTANTS

Figure 3 shows schematic treatment of water sample by using extraction on solid phase. Analysis was done by gas chromatography with mass detection. Identification of compounds is done by using the software for deconvolution. Each chromatogram is also checked by hand and measured against blind test fraction to remove the possibility of getting false positive results [9].

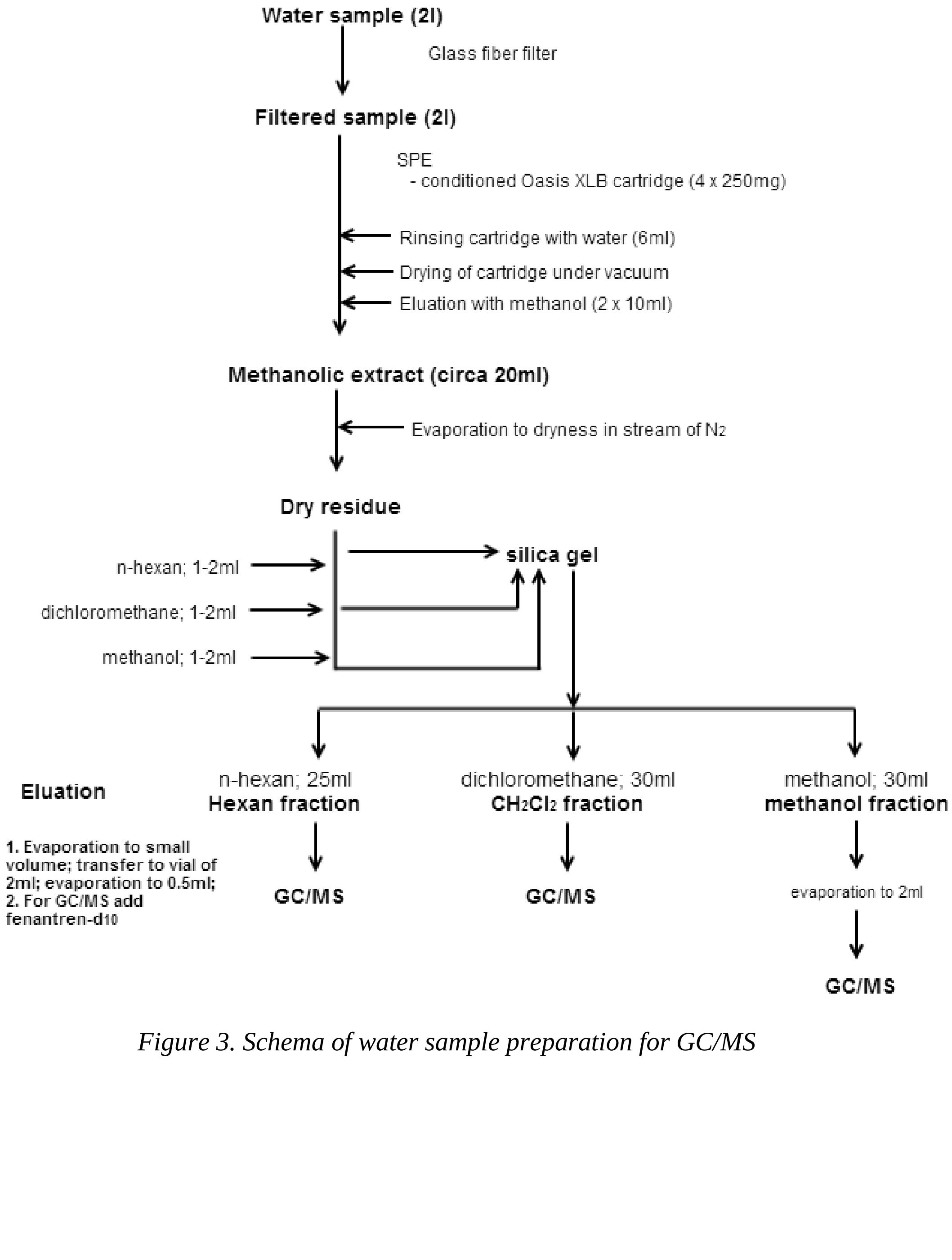

Figure 3. Schema of water sample preparation for GC/MS

RESULTS AND DISCUSSION

Table 1 shows the DOC results by fractions for March and May.

Table 1: DOC results by fractions for March and May

	Raw water		Ozonated water	
	Mart	Maj	Mart	Maj
FAF (mgC/l)	0.51	0.83	0.83	0.83
HPI-A (mgC/l)	1.76	2.12	2.12	2.12
HPI-NA (mgC/l)	0.71	0.72	0.72	0.72
Ukupno (mgC/l)	2.99	3.66	3.05	2.17

In samples taken in March 2012. DOC is 2.99mg/l. Among total dissolved organic matter hydrophilic fraction dominates with 83%, while hydrophobic fraction has only 17%. After ozonation (1.5mg O_3/mg DOC) total amount of dissolved organic matter rises by 19%. Also, hydrophilic organic matter in water is risen. No definite predictions of the increase in DOC upon ozonation can be given since the characteristics of the water play a major role [10]. Increase of total dissolved organic carbon is not common but can be interpreted as effect of additional destruction of more stable humic matter which leads to easier decomposition during analysis of DOC.

In samples taken at May 2012. DOC is 3.66 ± 0.20mg/l. Results show that contents of organic matter in Danube is mostly hydrophilic. Hydrophilic fraction takes 78% of total amount of dissolved organic carbon. Hydrophobic fraction is 22% of total calculated DOC. Ozonation has removed 41% DOC from raw water. In relation to structural change of natural organic matter, polarity and hydrophilic rises and little rise in HPI-A fraction in relation to raw water.

In Table 2 are shown results of GC/MS screening.

Table 2: Results of GC/MS screening

Compund name	March						May					
	Raw water			Ozonated water			Raw water			Ozonated water		
	I	II	III	I	II	III	I	II	III	I	II	III
Aliphatic hydrocarbons and derivatives												
pentadecane					+						+	
1-tridecene		+	+			+		+		+		
Hexadecane		+			+						+	
Icosane					+		+				+	
Pentadecane							+					
4-methyl-decane	+					+	+					
Cyclohexane			+			+	+					+
Alcohols												
1-octadecanol								+		+		
1-butanol		+										
Substituted benzene and benzene derivatives												
triphenyl phosphate											+	
1-methyl-2-(1-methylethyl)-benzene			+			+						
Dibenzofuran				+								

1,1’ethylidenebis-benzene							+			+		
Organic acids and esters												
benzoic acid, methyl ester								+			+	
1,4-Benzenedicarboxylic acid, dimethyl ester			+			+			+			
dodecane acid, dimethyl ester						+			+			+
1,2- benzene di hydroxy carboxylic acid, bis(2-methylpropyl)-ester		+	+		+	+		+		+	+	+
hexadecanoic acid, methyl ester		+			+						+	
Decanoic acid, methyl ester	+		+			+			+			+
9-oktadekanonska kiselina (Z)-, methyl ester			+			+						+
octadecanoic acid, methyl ester		+	+		+	+		+			+	+
hexanedioic acid, bis(2-ethylhexyl) ester		+			+							
Phenol and his derivates												
m-tert-butyl-phenol			+					+		+	+	+
2,4-bis(1,1-dimethylethyl)-phenol						+						+
p-tert-butyl-phenol									+	+		
Phthalate												
Diethyl phthalate	+					+			+			+
Bis(2-ethylhexyl) phthalate	+	+	+	+	+	+		+	+	+	+	+
Aldehydes and ketones												
2,6-bis(1,1-dimethylethyl)-2,5-cikloheksan-1,4-dione												+
4-methyl-3-penten-2-one			+			+						
Propanal								+				
Glutaraldehyde					+							
Nitric compounds												
Trimethylamine			+									
Izocijanato- methane				+								
2-methylaziridine				+								
Piperidine	+											
Terpenes												
Camphene												+
6,6-dimethyl-2-methylene-bicyclo[3.1.1]heptan												+
Ethers												
2,2,4-trimethyl-oksetan			+									
polyaromatic hydrocarbons (PAH)												
Anthracene				+								+
Phenanthrene							+					

The majority of the identified compounds belongs to groups of long-chain hydrocarbons (C11 - C30), alcohols, ketones, phenols, benzene derivatives and organic acids and their esters. Most of them are alkanes from 3 to 20 carbon atoms. Only 1-tridecen is found of all alkenes. Nonpolar compounds in nature are bound to suspended particles, are removed by filtration before extraction. Therefore, they are much less prominent in the samples than other groups of compounds. Well known polyaromatic hydrocarbons, anthracene and phenanthrene were also found. Terpens were also identified in the water sample taken in May.

Fraction of mildly polar compounds is the most diverse. Aldehydes, ketones and nitric compounds are the most prevalent in the sample taken in March, while the phenols are the most prevalent in the sample taken in May. The most prominent representatives of the mildly polar fraction are the xenobiotic components of dibutyl-phthalate and diethyl-phthalate. All compounds which belong to the alcohol group which were found in the raw water were also found in ozonated water, which means that ozonation cannot remove them entirely while on the other hand ozonation did not lead to significant changes in terms of the identification of a certain group of compounds using the applied technique.

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INTEGRATED MONITORING SYSTEM OF LARGE ADMINISTRATIVE-ECONOMIC REGION IN TECHNOGENESIS

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ABSTRACT

The concentration of industrial, energy, agriculture and municipal engineering enterprises, road transport in the large administrative and economic regions, coupled with high population density has led to problems of environmental, sanitary and hygienic, social issues. Growing conflict between environmental pollution and its ecological capacity has determined the need to develop a system for evaluating impacts and to find ways to optimize the industrial impact on the environment. In order to address the problem of environmental pollution and its impact on public health the integrated monitoring system of large administrative-economic region are proposed in this work. The monitoring system is based on a common methodological approach to evaluating the effects of anthropogenic impact. The studies were performed subject to the regional characteristics of territories. Management decisions to prevent disasters and mitigate their effects are the ultimate goal of the developed integrated monitoring system.

Key words: *city (region), polluters, complex monitoring, decision making.*

INTRODUCTION

The recent period of development of society is characterized by more and more accruing contradictions between the person and the surrounding medium (SM). Level of anthropogenous loadings in a number of regions comes nearer to critical marks (Abramov et all., 2005; Brushlizkij, 2001). In Belarus annually there is more than one thousand emergency situations (ES) of natural and technogenic character as a result of which the number of victims is estimated in thousand people, and the material damage makes hundreds millions rubles. The steady tendency of body height of scales of technogenic catastrophes remains and weight of their consequences that causes to consider them as serious threat of safety of the person, society and SM, and also stability of development of economy of the state (Akimov et all., 2001). Concentration of the enterprises of the industry, power engineering, rural and municipal services, automobile transport in the large administrative regions (LAR) in combination with high population density led to emergence of problems of ecological, sanitary and hygienic and social character. Contradictions accruing in this regard between pollution of SM and its ecological capacity define need of development of the system of an assessment of consequences and searching of paths of optimization of technogenic impact on SM. Problems of pollution of SM, its influence on health of the population have to be solved taking into account regional features of territories on a basis of uniform methodological approach to an assessment of consequences of technogenic influence. Adoption of administrative decisions on the prevention of an emergency and to mitigation of their consequences is impossible without complex system of supervision, an assessment and the forecast of consequences of influence of polluters and dangers of natural character, a condition of SM and population health.

Systems of monitoring existing now are tightly departmental, received information in a complex is not analyzed and not fully used for the prevention and emergency elimination. Generally monitoring is conducted for separate subsystems or influence factors. Calculation of risks and management of safety in the territory of LAR requires the complex analysis of data of monitoring and the condition forecast by all types of dangers of natural and technogenic character (Marchuk et all., 1982). Development of regional system of the monitoring including overseeing by polluters, condition of SM and health of the population is a basis of regulation of a situation in LAR. The complex assessment of a radiokhemoekologichesky situation in LAR is the complex problem and has to be considered as uniform system "pollution sources - surrounding medium - person" (PSSMP). Polluters as a result of made emissions (dumpings) cause negative consequences in natural and agrarian ecosystems that immediately influences health of the person and a condition of its activity, and extent of influence of different types of pollutants substantially depends on ecological factors of natural and agrarian ecosystems. Therefore complexity of the solution of this task is caused by a mnogofaktornost and interdependence of flowing past processes.

THEORY

Informational basis of an assessment of technogenic influence is the regional complex monitoring (CM) which solves problems of identification of zones of possible natural and technogenic dangers, territories with the raised background radiation and the abnormal content of xenobiotics, and also keeping tracks of by sources of radioactive and chemical pollution, a population state of health. The solution of the modern problems of civil safety is impossible without an assessment of risk of technogenic accidents and impact of polluting factors on the population and SM (Adrianov, 2003; Sanjuk, 2004). According to monitoring the assessment and the forecast of a condition of system of PSSMP with elaboration of actions for mitigation of the consequences of technogenic influence and natural dangers on SM and the population are carried out (Gusev et all., 2000). The highest level of this system – adoption of administrative decisions on safety of accommodation of the population in conditions technogenesis (*figure 1*).

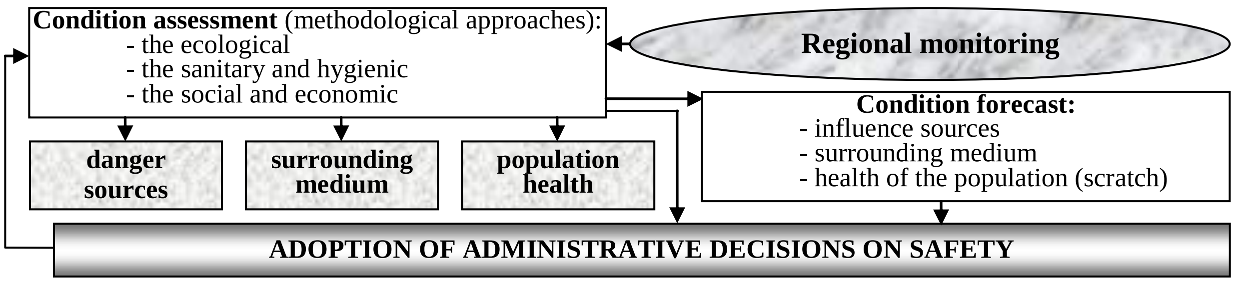

Figure 1. The conceptual scheme of an assessment of influence of technogenic factors on surrounding medium and the population

METHODS

The methodological principles of a complex assessment and the forecast of a condition of sources of danger, environment and health of the population are based on a combination of the ecological, sanitary and hygienic and social and economic approaches which use has equivalent value and is realized at various stages of an assessment. So, principal components of SM (natural and agrarian ecosystems) have a number of the characteristics caused by natural processes that defines need of their assessment from ecological positions. On the other hand, natural and agrarian ecosystems are an initial link of the food line-ups conducting to the person that determines need of rationing them by the sanitary and hygienic principle. At the same time, sources of natural and technogenic danger make impact on ecosystems, the population, the social environment and economy that causes need of application of social and economic approach at an assessment of consequences.

FINDINGS AND DISCUSSION

For the analysis of interrelations in PSSMP system as a methodological basis systems approach is used. In relation to a problem of a complex assessment of natural and anthropogenous influences it can be formulated as the approach based on use of set of the scientific directions, united by common methodology of the analysis of all factors, paths and task methods of solution in specific conditions. Thus set of sources of the influence being in the territory of LAR, following systems approach, it is necessary to consider as the composite system of common anthropogenous impact on the person and environment. At the same time, each source can be considered as system, but the system being on more low hierarchical level. Ultimate goal of systems analysis a risk assessment for the person and SM of technogenic and natural factors of influence and adoption of administrative decisions on the basis of the analysis of interrelations "a dwelling person source Wednesday". Systems analysis of a separate source of technogenic danger, in our opinion, also has to be based on application of procedures of a choice. As the alternate options in this case it is possible to accept various conditions of dangerous object and SM characterized by values of a particular parameter, or ratios of parameters. As such parameter it is expedient to consider the level of safety expressed, for example, through size of risk. The option of a condition of object, SM and population health can be result of systems analysis of a separate source of technogenic danger optimum, taking into account all factors taken into account.

All complex of these interactions demands the organization of system of regional CM which gives necessary information for an assessment of situations. Main objective of creation of system of CM is informational support of preparation and adoption of administrative decisions on the prevention and elimination of ES and to mitigation of their consequences on the basis of join of intellectual, informational and technological capabilities of the various departments dealing with issues of monitoring in a technosphere and environmental environment. Primal problems of CM treat:

- accounting of sources of anthropogenous influence and potentially dangerous objects of economy;
- keeping track of by the address radioactive and abnormally chemically dangerous substances, monitoring behind a radioactive and chemical waste;
- identification of the main sources and paths of radioactive and chemical pollution of SM;
- establishment of priority radionuclides and chemicals;
- filing of the current level of radioactive and chemical pollution of ecosystems and anthropogenous landscapes, supervision and identification of tendencies in its changes;
- the forecast of technogenic danger in territorial and object links of economy;
- complex assessment of a condition of SM and forecast of possible negative consequences of radioactive and chemical pollution;
- studying of common regularities of behavior of radioactive substances and chemical pollyu-tant in ecosystems, synthesis of information and creation of databanks;
- development of recommendations about the prevention and elimination of the negative tendencies bound to radioactive and chemical pollution, emergence of ES of natural and technogenic character;
- providing bodies of executive power with objective information on the current condition of potentially dangerous objects of economy and SM, levels of its pollution radioactive and chemicals for a decision making, directed protection of the population and territories, the prevention and elimination of ES of natural and technogenic character.

According to existing classification by carrying out scales monitoring of LAR falls into to regional level. However, existence of a large number of potentially dangerous objects, including radiation and chemically dangerous, defines need of carrying out local monitoring round them. Because potentially dangerous objects of LAR (for example, in regional and in the regional centers), as a rule, a little, there is a need of carrying out monitoring at local level. Thus, three levels of monitoring are allocated for territories of LAR: regional, territorial (local) and local. Monitoring exercise at all levels demands creation of the relevant hierarchical structure and a control system of monitoring (figure 2). For a cartographical binding the geoinformational program complex which unites databases on all natural and anthropogenically changed environments, to sources of technogenic influence and a population state of health can be used, and also contains necessary data for calculations for imitating models (Sanjuk, 2004). GIS-technology use with a binding of data and visualization of simulated processes allows to carry out scheduling of actions for protection of the population in case of ES, to develop the strategic directions on natural, technogenic and ecological safety of the population of LAR (Mirontchik et all., 2006).

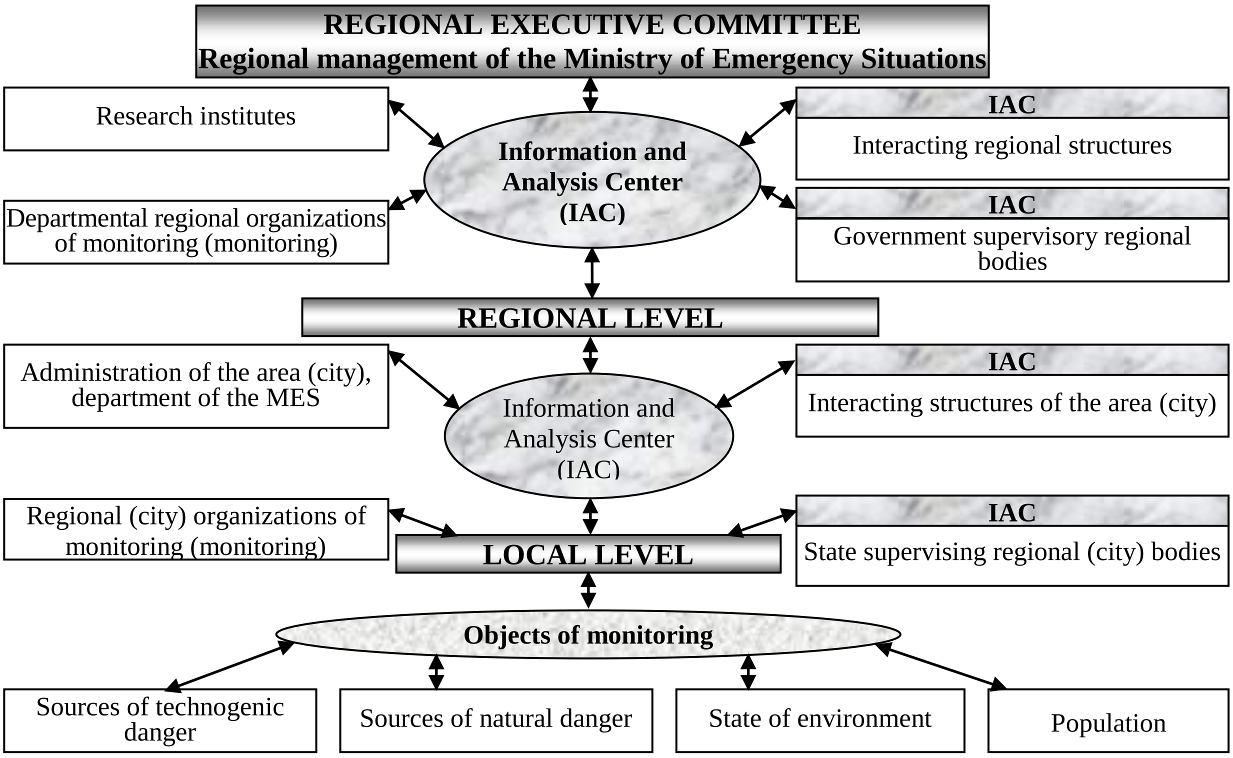

Figure 2. Scheme of management of large administrative regions monitoring

At regional level cooperative technogenic loading on the basis of quantity and features of placement of potentially dangerous objects, cooperative emissions and dumpings radioactive and chemicals is estimated at the air pool and the surface water, common pollution of environments, selitebny agglomerations and agricultural grounds. The assessment of technogenic risk for LAR as a whole, certain settlements and objects of economy, and also risk of accommodation of the population in territories polluted by radioactive substances and chemical pollyutant is carried out.

At local level the condition of SM, objects of economy and population health on controlled parameters is in more detail estimated in: emissions and dumpings (parameters of streams and the content of pollutants in them); free air (meteodata, speed and the wind direction on the horizons, temperature, humidity, pressure, settlings, illuminating intensity, etc., pollutants: dioxides, oxides, sulfates, phenols, suspended matters with element structure); the surface and ground waters hydrological parameters of concentration of pollutants (in the surface water, besides, numerical and qualitative structure of hydrobionts); soil cover agrochemical indexes, pollution by heavy metals, pesticides and toxic chemicals, radioactive substances; objects of flora and fauna number, specific structure, content of pollutants and change in result of anthropogenous influences; on potentially dangerous objects type of dangerous substance and its quantity, way of storage and technology of use; quantity working and the population getting to a zone of defeat; ways of protection and measure of the prevention of ES; in the social and hygienic relation types of diseases on gender and age groups, birth rate, mortality, risk for health from various factors of technogenic loading and the natural phenomena.

At local level monitoring in a zone of placement of separate chemically and radiation-hazardous objects is carried out. Supervision, as behind an influence source, and SM is carried out; existence of gaseous emissions radioactive and chemicals in the atmosphere; loss of aerosols of free air by a sedimentation method in a sanitary protection zone and a supervision zone; the contents radioactive and chemicals in water of open reservoirs; change γ-phon; pollution of the surface layer of the soil; the contents radioactive and chemicals in vegetation, in tail and service waters of object and others. As a technical basis of collecting, storage, processing and issue of information the system of the distributed databanks founded on the modern computer technology is created. Functioning of this system is provided with the unified software, allowing to carry out: the analysis of reliability and completeness of received information; assessment and forecast of possible ES; the analysis of effectiveness of counter-measures for the purpose of the prevention of negative tendencies and decrease in technogenic loadings; elimination of ES.

The forecast of natural and technogenic influences for SM and the person is carried out on the basis of collected during maintaining CM of information on a condition of SM, sources and factors of anthropogenous influence, and also on the basis of scientific regulations on regularities of course of processes in this subject domain. In parallel with collection of information mathematical models of processes of anthropogenous influence taking into account data of the retrospective analysis and empirical regularities of formation of factors of anthropogenous influence are created. After carrying out necessary calculations and visualization of results the assessment of adequacy of model to actual processes and reliability of received expected information is made. In the situations bound to technogenic influence, depending on many factors of the stochastic nature and being characterized indeterminacy, it is expedient to apply a method of a maximum of the credibility, based on probability approach. The forecast of a condition of technogenic sources of danger, SM and health of the population is formed by means of use of a complex of mathematical models:

- possible ES in the industry, on transport, agriculture, etc.;
- distributions of pollutants in free air and water objects depending on the quantitative and qualitative characteristics of emissions and dumpings of pollutants;
- meteosituation and other factors;
- meteosituations at the regional, local and local levels, allowing to define and predict temperature, humidity, settlings, characteristics of airflows on the horizons;
- the biocenoses, allowing to estimate reaction of biological systems to change of a condition of SM;
- the medico-ecological models opening impact on health of the population of the region of anthropogenous and natural factors, risk assessment (technogenic, physical, chemical, including carcinogenic; the natural: high waters, forest and peat fires, extraordinary weather conditions);
- the ekologo-economic models, allowing to estimate economic damage from natural and technogenic emergency situations and costs of environment restitution.

According to the developed concept and organizational structure the following main stages of creation of regional CM of LAR are allocated:

1. Development of regulatory legal base.
2. Creation and organization of work of system.
3. Development of systems of support of adoption of administrative decisions on optimization of preventive measures and actions in ES of natural and technogenic character.

Proceeding from the analysis of sources of technogenic influence, the last are divided into two groups potentially dangerous (danger constitute at emergence of the emergency and ES) and the continuous regulated influence (emissions and dumpings of pollutants in SM and physical impact in the form of noise, vibration, electromagnetic and ionizing radiation). In turn, potentially dangerous objects are classified by types of influence (radiation, biological and chemically dangerous, vzryvo-both fire-dangerous and hydrodynamic (figure 3), and objects of the regulated influence by types of the functional activity (the industry, a power engineering, transport, rural and municipal services, military units and other closed territories (figure 4).

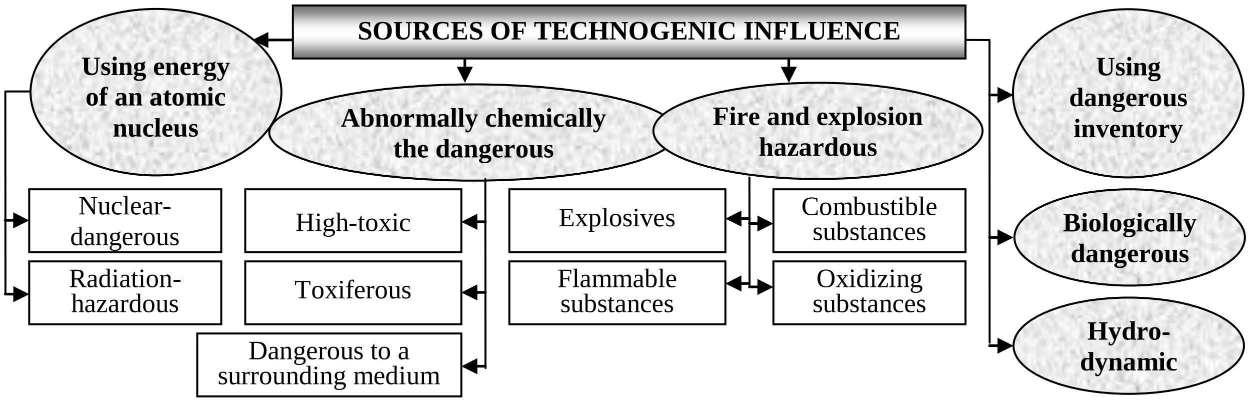

Figure 3. Potentially dangerous sources of technogenic influence

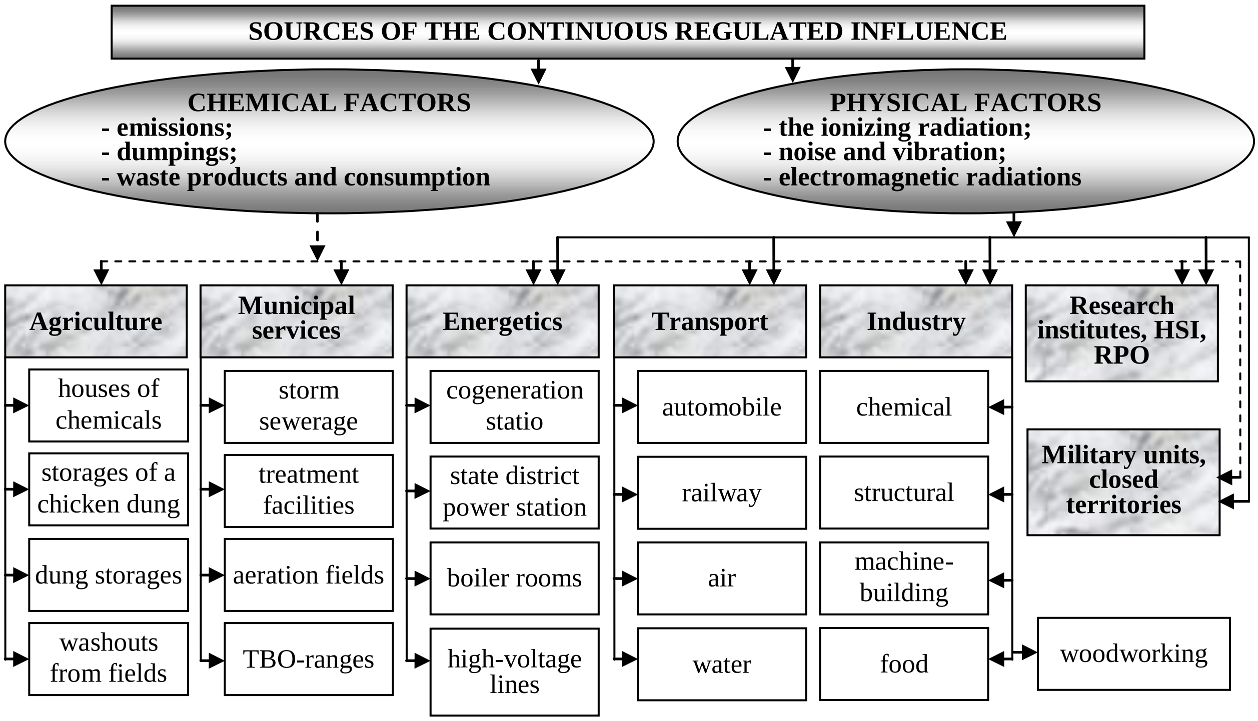

Figure 4. Sources of the continuous regulated influence

The level of safety corresponding to a condition of society, to its scientific and technical and economic opportunities, has the stochastic nature and is defined by a number of the casual phenomena which are characterized by risk of technogenic accidents, accidents and dangerous natural events and risk of deterioration of health of the person and negative changes in SM and risk of emergence of ES of ecological character.

The assessment of risk includes four main stages:

1. Danger identification with creation of databases and knowledge bases about a condition of SM and sources of anthropogenous influence, physiographic, social and economic, demographic and other data.
2. Assessment of influence of sources of danger, establishment of the leader receipt paths in an organism, identification of that part of population which is subject to influence, an assessment of doses and definition of levels of influencing concentration.
3. Definition of the quantitative risk levels and their comparison with acceptable values.
4. The risk characteristic with use of systems analysis, identification of adverse effects in a state of health, numerical values of risk.

Management of safety and risk makes an important field of activity of government bodies of management of regional and local levels, and also an operating controls of the objects constituting technogenic danger to the person and SM. It is based on the following principles (figure 5):

- correctness of practical activities (any activity if the advantage of it for society does not exceed damage from the related risk, cannot be justified) and provides areas of excessive, negligible and acceptable risk (for adoption of administrative decisions interest represents only area of acceptable risk);
- protection optimization (at such approach the risk for the population from various technologies and kinds of activity is expressed in reduction of expected life expectancy, and benefit in its extension);
- the principle of an integral assessment of danger (all cumulative range has to be included in management of risk existing in the society of dangers and common risk from them for any person and society as a whole should not exceed excessive level);
- stability of ecosystems (rigorous restrictions of influence on natural ecosystems).

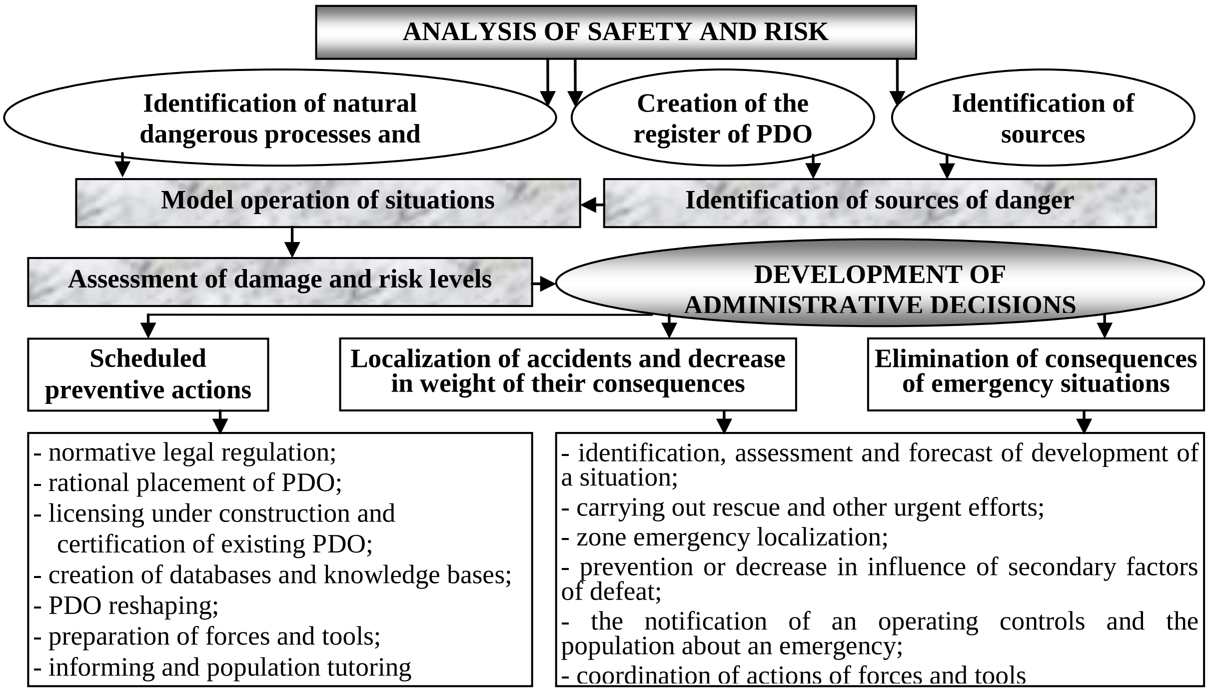

Figure 5. Block diagram of management of safety and risk

In such statement the solution of a problem of risk management demands carrying out a huge complex of actions of political, economic, scientific and methodical, social, ecological, informational and other character as in relation to society as a whole, to its certain regions, objects and risk sources, and to concrete groups of the population. It is expedient to build management of safety and risk on the basis of system of the prevention and ES, with a support on an intelligence system of CM and the monitoring organized in the territory of LAR. The maintenance of the functional tasks and orientation of actions on management of safety and risk significantly depend on hierarchy level in structure of system of the prevention and actions in the ES which have occurred in the territory of LAR.

In management of safety and risk an important role is played by economic mechanisms (economic responsibility; share and budgetary financing; application of penalties). At the organization of informational and intellectual support of preparation and adoption of administrative decisions usually important part is assigned to an assessment of effectiveness of analyzed options of actions, i.e. actions on economic level control of safety and risk. The assessment of effectiveness of economic mechanisms can be carried out in size of residual profit after introduction of the corresponding economic control levers by safety level. Approach to such assessment can be carried out at introduction of the mechanism of quotas or restrictions of economic character on the size (level) of the factors defining the negative impact of object on degree of safety (radioactive, chemical environmental, emergence of physical fields of influence).

For social and economic development of the region of a problem of safety are socially significant factor, and the term "civil safety" (CS) as well as possible reflects safety system in territorial level. the CS includes (figure 6):

- identification of sources of danger (natural, technogenic, ecological);
- carrying out urgent (rescue efforts and ensuring activity of the population in ES) and preventive measures (development and exercise of the practical actions directed on decrease of risk of emergence of ES and mitigation of their consequences;
- enactment of the economic mechanisms stimulating engaging of investments for realization of actions for the prevention and elimination of ES and the solution of problems of safety, protection of the population and SM).

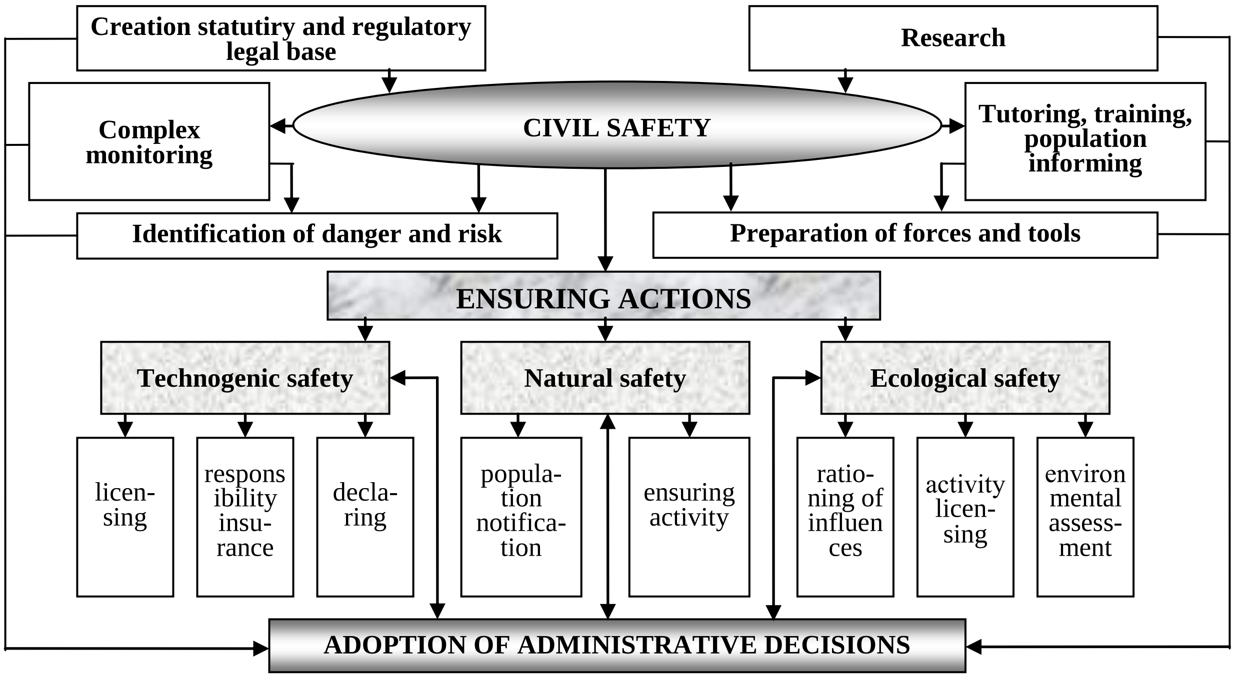

Figure 6. Concept of civil safety of the large administrative region

CONCLUSIONS

In the modern conditions the extreme importance is got by optimization of existing approaches to an assessment and providing CS. Use of methodology of an assessment of risk in management of CS will allow to carry out prediction of probability of development of adverse effects of anthropogenous influence at better level and is well-timed to accept proved the decision on their prevention or mitigation of the consequences of impact on the person and the environment of his dwelling. Results of carrying out CM form initial base for creation of system of safety of accommodation of the population in conditions technogenesis. Key link of this methodology health of the person and his protection from the inevitable risk bound to influence of toxic substances, being in water, air or the soil. Thus the comprehensive approach at a risk assessment, irrespective of its source becomes a key factor. Application of results of researches possibly in practice of work of bodies of legislative and executive power of LAR (for example, the Mogilev area) when scheduling actions for the prevention and elimination of ES of natural and technogenic character, and also by preparation of normative legal and administrative documents.

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SLOVENIAN STEEL PRODUCERS AND ENVIRONMENT

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ABSTRACT

Global steelmakers or steel producers increased emphasis on protecting the environment and deploy into the production and support the activities of the so-called concept of sustainable development, which is reflected in particular in the implementation of environmental management systems. Slovenian Steel Group (SIJ) is one of the largest business groups in Slovenia in terms of both income and the number of employees. At the same time it is one of the key elements of Slovenian economic development. The biggest steel producer (steelwork) in this group is ACRONI. Slovenian Steel Group's, and especially ACRONI's, environmental awareness constantly grows. This can be proven by their concern with international standard ISO 14001, which gives the requirements for environmental management systems, confirms its global relevance for organizations wishing to operate in an environmentally sustainable manner, and OHSAS 18001, an international occupational health and safety management system specification. They introduce environmentally friendly technological processes that have the least impact on the environment. They also constantly monitor emissions of waste gasses and waste waters. Equal attention is devoted to the management of energy sources. Within the frame of the proposed work the life cycle assessment (LCA) method is discussed, and its usefulness for the Slovenian steel producers analyzed.

Key words: *steel production, environment, environmental management, LCA.*

INTRODUCTION

Steel touches every aspect of our lives. No other material has the same unique combination of strength, formability and versatility.

Steel is a perfect and everlasting material, unlimited in its practicality and possibility for upgrading. It is the only material which can be recycled to one hundred per cent (Figure 1). Due to its versatile applicability it is a reliable partner in various fields, such as construction, mechanical engineering, automotive industry, ship-building, production of pipes, home appliances and so on. The variety of advantages of steel products range from technical, such as material strength and high production technology, economical as steel ensures quick and easy construction, fast assembly and fast installation, to advantages as regards safety as it enables low weight and anti-seismic construction. Due to its aesthetic advantages it is also often used for thin and light construction, and is cherished for its simplicity. The possibility of recycling steel to 100% also presents a significant environmental advantage.

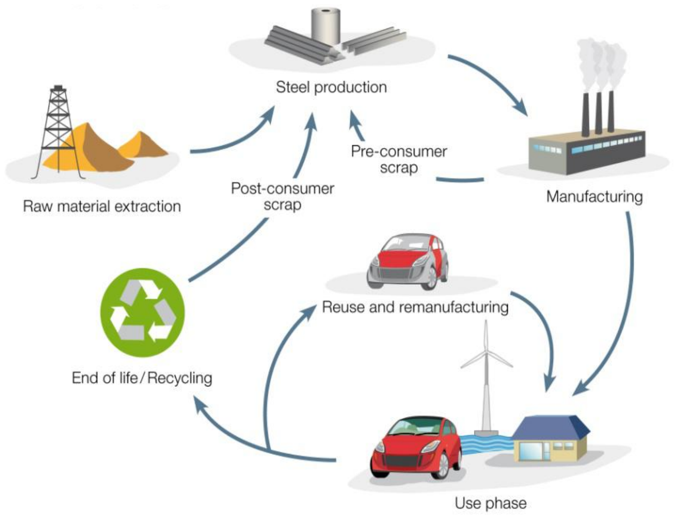

Figure 1. The life cycle of steel (WorldSteel Organisation, 2013)

WORLD STEEL PRODUCTION

The amount of energy required to produce a 1 tonne of steel has been reduced by 50% in the last 30 years. All steel created as long as 150 years ago can be recycled today and used in new products and applications. By sector, global steel recovery rates for recycling are estimated at 85% for construction, 85% for automotive, 90% for machinery and 50% for electrical and domestic appliances. Leading to a global weighted average of over 70%. Nowadays, 97% of steel by products can be reused.

In the 1970s and 1980s, modern steel plants needed an average of 144 kg of raw materials to produce 100 kg of steel. With investments in research, technology improvements and good planning, the steel industry today uses only 115 kg of inputs to make 100 kg of steel – a 21% reduction (WorldSteel Organisation, 2013).

Table 1: World steel production for the period 1970-2012

Year	World steel production (Mt)
1970	595
1975	644
1980	717
1985	719
1990	770
1995	752
2000	849
2005	1144
2010	1414
2011	1527
2012	1510

Steel is a key driver of the world's economy (see Table 1). World crude steel production: From 28.3 megatonnes (Mt) in 1900 to 851 Mt in 2001 to 1,527 Mt in 2011. The World production of steel in year 2012 was 1510 Mt, in EU27 was production of steel in year 2012 169.4 Mt (production stagnated), and in China 708.8 Mt. For example: average Slovenian steel production in last 10 years is approximately 640.000 tonns per year (WorldSteel Organisation, 2013).

World steel industry directly employs 2 million people worldwide, with a further 2 million contractors and 4 million in supporting industries. As key product supplier to industries such as automotive, construction, transport, power and machine goods, steel industry has employment multiplier of 25:1. Steel industry is at the source of employment for more than 50 million people. World average steel use per capita has steadily increased from 150 kg in 2001 to 220 kg in 2010 (WorldSteel Organisation, 2013).

Today global steel producers give increased emphasis on protecting the environment and deploy into production and supporting the activities of the so-called concept of sustainable development, which is reflected particularly in the implementation of environmental management systems.
Under green economy steel industry has to be sustainable on 3 levels:

- financially sustainable,
- socially sustainable, and
- environmentally sustainable.

The most used and established method for detecting the effects of the product on the environment is a method of life cycle assessment (LCA), which analyzes the effects of the product on the environment in all its life stages (design, materials selection, manufacture, use, and ultimately its removal), and is an important tool when we deciding on choosing and optimizing the technology and raw materials (Hodolič et al., 2012).

SLOVENIAN STEEL PRODUCTION

The biggest owner of the Slovenian Steel Group (SIJ) and at the same time of the Slovenian steel industry is Russian company KOKS (which is majority owned by the Zubitskiy family). On September 1st.2013, the parent company SIJ had the ownership presented in Table 2 (ACRONI d.o.o., 2013).

Table 2: Shareholders

Shareholders	Number of shares	% of ownership
OAO KOKS	718.351	71.2239
Republic of Slovenia	248.655	25.0001
D.P.R. d.d.	21.468	2.1530
Others	16.142	1.6230

The SIJ (Slovenian Steel Group) is one of the largest business groups in Slovenia according to both income and the number of employees, and such is one of the key elements of Slovenian economic development. The biggest steel producer (steelwork) in this group is ACRONI.

Vision and Strategy: SIJ will continue orientation towards constant improvement of the technology, production processes and logistics, and they will also intensively build our their sales network to maintain and increase our market share in the EU and worldwide.

The production range of Slovenian Steel Group (and ACRONI), comprises products of a flat and long steel program and forgings made of high quality steel in an electric arc furnace and vacuum metallurgy processes with a high processing rate. The steels grades produced can be devided into 5 basic groups:

- structural steel,
- tool and high-speed steel,
- stainless steel,
- electrical sheets, and
- other special steel.

STEELWORK ACRONI

ACRONI is a niche producer of flat-rolled stainless and special steels which are produced as quarto heavy plates and hot and cold rolled coils (Figure 3). Annual production of ACRONI in year 2012 was approximatelly 450.000 tonnes (approx. 70% of whole Slovenian steel production). ACRONI exports more than 80% of its products, and it is the biggest supplier of stainless steel quarto plates in Europe.
ACRONI's goals:

- to exercise customer demands,
- constant development of new products and technologies,
- putting research achievements into practice, and
- innovations as a part of business strategy.

Figure 2. ACRONI production: from steel scrap to final products

ACRONI services (ACRONI d.o.o., 2013):
1. Chemistry: Sector of Chemistry operates within the ACRONI and is responsible for(to) the quality of the field of chemical analysis. It includes a workshop laboratory preparation of samples, the chemical laboratory and a laboratory for the monitoring of steel production in the steel plant. In the field of environmental protection to monitor the operation of industrial waste water treatment plants, waste-water monitoring is performed and produced estimates of the waste to the needs of businesses, as well as for external customers.
2. Technical control: The laboratory is competent to carry out the mechanical and technological tests in accordance with the applicable standards SIST, EN, DIN and ISO. Mechanical tests, in most cases supplemented by chemical and metallographical investigation, which knowledge of the properties of metallic materials rounded off.
3. Research and development: The tradition of steel producing in ACRONI presents support for our activities but its also a great obligation for the future development. The inherited knowledge and experiences we have enriched with new knowledge and efforts are promise that they will continue their successful work.

ACRONI and environment

For centuries, ACRONI has been manufacturing high-quality steels that have been successfully selling on the most demanding markets. Gradually reduced environmental impacts and protection of environment has become one of the priorities of company’s strategy. ACRONI's environmental awareness constantly grows, what can be proven with international standards ISO 14001 (Figure 3), which gives the requirements for environmental management systems, confirms its global relevance for organizations wishing to operate in an environmentally sustainable manner, and OHSAS 18001, an international occupational health and safety management system specification. They introduce environmentally friendly technological processes that have the least impact on the environment. Equal attention is devoted to the management of energy sources. In ACRONI they constantly monitor emissions of wastes, gasses and waste waters (Vidic, 2013).

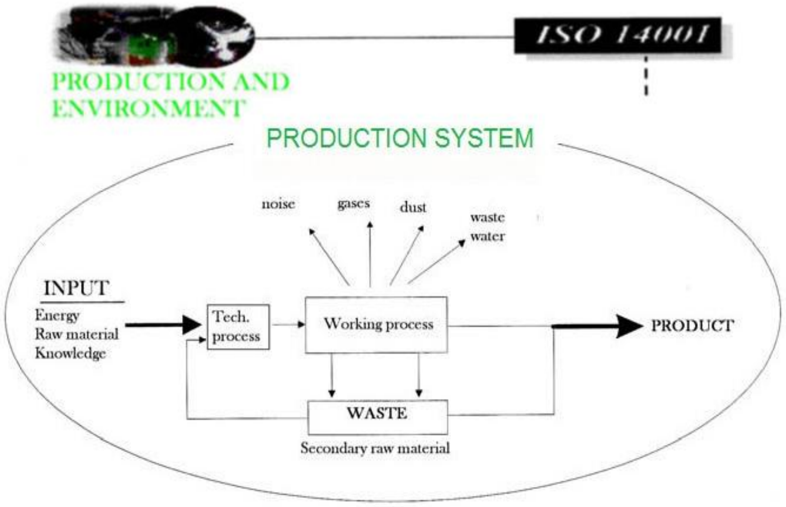

Figure 3. Production system according to the international standards ISO 14001 (Kosec et al., 2008)

LIFE CYCLE ANALYSIS

What is a product’s life cycle? Simply stated, the life cycle of a product embraces all of the activities that go into making, transporting, using and disposing of that product. The typical life cycle consists of a series of stages running from extraction of raw materials, through design and formulation, processing, manufacturing, packaging, distribution, use, reuse, recycling and, ultimately, waste disposal.

What is LCA? Life cycle assessment (LCA) involves the evaluation of some aspects - often the environmental aspects - of a product system through all stages of its life cycle. Sometimes also called “life cycle analysis”, “life cycle approach”, “cradle to grave analysis” or “Ecobalance”, it represents a rapidly emerging family of tools and techniques designed to help in environmental management and,l onger term, in sustainable development (Milanković et al., 2012).

Environmental-energetic analyisis of the process which is the base for Life cycle assessment (LCA) is the same for the bank and steelwork (Figure 4).

Figure 4. Environmental-energetic analysis of the process

In the year 2011 the steel producer ACRONI was invited to cooperate in the project of life cycle assessment (LCA) for the two groups of steel grades 304 and 316.

For the project has been used the standard software for LCA analysis GaBi (Agarski et al., 2012). The aim of the project was to show that steel producing industry knows how important is the synergy between steel producer and society.

Rational handling and manipulation with materials and resources considering two main principles: reduction of consumption of natural and unrenewable resources, and reduction of pressure on environment, when materials and products become unapplied and transformed into a waste.

Advantage of a steel producers (steelworks) is in the fact that its products are 100 % recyclable at the end of their life cycle.

CONCLUSIONS

A short review of the World and Slovenian steel production, and the state in the biggest steel producer (steelwork) in Slovenia is presented.

In the frame of our study is discussed life cycle assessment (LCA) method in the praxis the most used and established method for detecting the effects of the product on the environment. We analyzed potential application of LCA for the Slovenian steel producers, especially the case of ACRONI, the biggest steel producer in Slovenia. Heavy plates of two typical steel grades from ACRONI production program were analysed during the pilot project.

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ENVIRONMENTAL MANAGEMENT SYSTEMS IN URBAN AREAS – PROCESS OF ISO 14000 STANDARDS SERIES IMPLEMENTATION

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ABSTRACT

The environment around us is becoming more threatened day by day. What nature has been creating for millions of years has been destroyed for various reasons by men's negligent action and thus the harmony has been disrupted. Adverse effects on the environment are reflected not only in the depletion of natural resources and the necessities of life but also in harmful emissions into air, water and soil, and degradation of environment in which neither ecologically nor economically can life and economic activity be continued. Urban areas as potential and actual polluters must be aware of that impact, and on the basis of this knowledge take the necessary action to make their impact as small as possible. Urban areas must give the deserved importance to this segment of the activities through the implementation of legislation, defining the vision and mission of environmental protection, inspection, monitoring requirements of the public and scientific and professional institutions, cooperation with companies and encouraging the implementation of an environmental management system in their institutions and in general in institutions and companies operating in the urban environment. Through adoption of the international standard ISO 14001 and the establishment of an environmental management system, all requirements for the fulfillment of these tasks in terms of environmental protection are being met. Ecological problems today have taken on dramatic proportions because they directly affect the health of people and threaten the survival of life on Earth. Besides the energy problems, environmental problems today are the key issue of all relevant organizations and modern countries. This article explains one of the possible approaches for the implementation of ISO 14000 standard series in existing functioning systems in urban areas.

Key words: *environmental management, ISO 14000, urban areas, implementation*.

INTRODUCTION

Efficient and effective implementation of the requirements of ISO 14001 in the existing environmental management system can be conducted in several ways, depending on several factors, which have a crucial impact on the decision to use a specific procedure. Some of the relevant factors are:

- Functionality, efficiency and level of organization of the existing environmental management system
- Organizational structure - workflows and information flow; defined responsibilities of the authority in environmental protection, organizational schemes
- Size and characteristics of the organization in terms of impact on the environment
- The infrastructure of the organization, and the application of technological procedures in the processes, which primarily includes:
    - buildings, workspace and associated resources
    - process equipment
    - software and hardware support
    - supporting activities such as transport and communications
- Level of education, awareness and training of employees to embrace modern ways of doing business and environmental trends
- Functionality and efficiency of the main and auxiliary processes, which primarily relates to:
    - the characteristics and tasks of work operations

  - the conditions under which the operations are performed
  - resources, aids and devices by which the operations are performed
  - time, in terms of preliminary-final and main time
  - the information needed for realization of an operation and
  - interactions between processes.
- Dislocation of the organization, which can have its segments or affiliates in several cities, towns and even states, which in a specific way complicates the project of implementation of ISO 14001
- The timeline for the implementation of the project, as well as general awareness and willingness of people to accept decisions regarding ISO 14001 standard.

To establish environmental management system according to the requirements of the International Standard ISO 14001 means to improve the existing environmental system, that is, to establish a transitional system between the existing and the system which prefers business excellence.

PROJECT METHOD FOR STANDARD IMPLEMENTATION

For a project to be successfully implemented within the given space and time, it is necessary to meet all the requirements. The realization of the project **"Implementation of ISO 14001 in the existing environmental management system"** should be systematic and successive, meaning implemented systematically, by a sequence of phases and activities that must follow one another. This approach is known as the "project approach", which was verified by many organizations, achieving good results.

The proposed methodology of implementation of the requirements of ISO 14001 in the existing environmental management system is implemented through the following phases:
Phase 1- recognizing the problem and orientation in relation to the problem – task
Phase 2- defining the problem
Phase 3- recording the existing condition
Phase 4 - education
Phase 5 - preparing the documentation for an environmental management system
Phase 6 - implementation of procedures and instructions
Phase 7- internal audit and inspection of the system by the management
Phase 8 - elimination of detected non-conformities
Phase 9 - certification of the environmental management system
Phase 10 - improvement of the system.

The methodology is designed to disable a successful transition to one of the following stages if a prior stage is not realized. Throughout the project there are three distinctive parts, each with a special program of activities and purpose. These are:

1. **Preparatory part for the implementation of the project**–recognizing the problem, orientation to the problem, defining the problem, recording, that is, determining the existing condition of environmental management system
2. **Actual work on the project -** education, preparing of the documentation, implementation of the procedures and operating instructions
3. **Final part of the project**–supervision of the environmental management system (internal audits, inspection by the top level management), certification of the system by an independent certification company.

It is evident that an individual cannot successfully and in time realize such a complex project. The anticipated tasks are very extensive and diverse, so it is necessary and advisable to form teams or workgroups. The number of people in a group or team and their qualifications will depend on the type and size of the organization, and its activities. Given that most institutions and organizations do not have experience in the implementation of such large-scale projects, it is recommended to hire a consulting expert that can help with his knowledge and experience. For successful implementation of the project ISO 14001, all employees must be aware that **this project begins and ends with**

education. The ISO 14001 standard is based on principles of environmental protection. For these reasons, it is recommended that they are theoretically studied in detail and implemented in all phases of the realization of this project.

Recognizing the problem

In this case the problem is the application of ISO 14001 standard to the existing environmental management system. Recognizing the problem means to perceive that environmental management according to the principles of ISO 14001 contributes to profitable business and the general public interest. It should be noted that the time passed from the moment of making the decision to implement the environmental management system according to ISO 14001 until the time of certification is long and accompanied by a series of problems and disturbances that need to be addressed. Institutions and organizations that wish to implement the requirements of ISO 14001 in the existing environmental management system are recommended to study in detail the ISO 14000 series of standards and issues related to it. It is important to understand that basically there are two main types of ISO standards, namely: normative and information. Information standards provide guidance for the application of normative standards. They cannot be certified and are not subject to assessment. ISO 14001 standard can be considered the only normative standard of environmental management system. All other standards of the "family" of ISO 14000 are informative. Table 1, according to, shows a part of the "family" of ISO 14000 standards.

Table 1: Series of the "family" of ISO 14000 standards

Serial number	Symbol of the standard	Name of the standard
1.	ISO 14001	Environmental management systems : Requirements with guidance for use
2.	ISO 14004	Environmental management systems : General guidelines on principles, systems and support techniques
3.	ISO 14010	Guidelines for Environmental Auditing: General Principles
4.	ISO 14011	Audit Procedures and Auditing of Environmental Management Systems
5.	ISO 14012	Guidelines for environmental auditing : Qualification criteria for environmental auditors
6.	ISO 14020	Environmental Labeling: General Principles
7.	ISO 14021	Environmental Labels and Declarations: Self-Declaration Environmental Claims, Terms and Definition
8.	ISO 14022	Environmental Labels and Declarations: Self-Declaration Environmental Claims, Symbols
9.	ISO 14023	Environmental Labels and Declarations: Self-Declaration Environmental Claims, Testing and Verification
10.	ISO 14024	Environmental Labels and Declarations: Environmental Labeling Type I, Guiding Principles and Procedures
11.	ISO 14025	Environmental labels and declarations: Type III environmental declarations, Principles and procedures
12.	ISO 14031	Environmental management: Environmental Performance Evaluation, Guidelines
13.	ISO 14040	Environmental management: Life cycle assessment, Principles and framework
14.	ISO 14041	Environmental management: Life cycle assessment, Goal and scope definition and inventory analysis
15.	ISO 14042	Environmental management: Life cycle assessment, Life cycle impact assessment
16.	ISO 14043	Management environmental: Life cycle assessment, Life cycle interpretation
17.	ISO 14050	Environmental management: Vocabulary
18.	ISO 14061	Information to assist forestry organizations in the use of Environmental Management System standards ISO 14001 and ISO 14004
19.	ISO 14062	Environmental management: Integrating environmental aspects into product design and development
20.	ISO 14063	Environmental management: Environmental communication , Guidelines and examples
21.	ISO 19011	Guidelines for auditing management systems

Orientation for the application of ISO 14001 and its implementation

In general, orientation is coping with the problem. It follows after the recognition of the problem. After previous knowledge of ISO 14001, the management of the organization is taking steps to further gather information, seeking answers to the following questions:

- What is the cost of the application of the standard?
- How can we implement the standard?
- What are the specifics of our institution?
- Who will implement the standard?
- How long will it take to implement the standard?
- Which are the required resources?
- What was the impact on others by implementing the ISO 14001 standard?
- What are the foundations for implementation of the ISO 14001 standard?
- What is the environment and readiness for implementation of the standard?

Practice shows that the orientation about the project ISO 14001 is implemented most efficiently through the following activities:

- interviews with representatives of organizations and institutions that have already realized this kind of a project or a similar one (time of realization, costs, procedure, consulting, good and bad experiences, documentation, expectations, etc.)
- collecting of professional literature dealing with environmental issues,
- attendance at symposiums where environmental protection is discussed,
- organization and realization of professional and popular lectures in the organization
- collecting information about the professional institutions and individuals who are directly or indirectly involved in environmental protection (environmental protection agencies, centers for education and consulting, certification institutions, etc.)
- collecting information about associations that are related to environment with their work.

After successful completion of the professional and personal orientation, it is necessary to conduct the time orientation. That means to perceive the realistic timeframes for the implementation of this project in the conditions in which the organization is operating. It should be taken into account that the institutions must function normally and perform everyday tasks during the realization of this project. Time orientation should answer the following questions: When is the project expected to start? When is the project expected to end? Is it possible to shorten the time of the project and how is it possible? What are the intermediate phases of the project implementation?

Generally speaking, the following factors influence on the time period needed for solving the problem, that is, the successful implementation of ISO 14001:

- motivation of the management for implementation of the standard
- atmosphere in the environment (immediate and broader)
- employees' awareness
- existing environmental management system
- organizational structure
- available resources (primarily human and financial)
- the method selected for implementation, etc.

Defining the problem

After recognizing the problem and orientation regarding its implementation it is necessary to completely define the problem. Most often complete definition of the problem or task is associated with defining and adopting concrete decisions crucial for the start and complete success of the project.

Decisions are related to the top management of the institutions which is expected to be completely and truly committed to the establishment of an environmental management system.

For a complete definition of the problem, "Implementation of ISO 14001 standard in the current system" it is necessary to conduct activities such as, for example, making the decisions on initiating the project and the appointment of persons responsible for the project, defining goals and resources, etc..

Determining the current state of the environment

This phase refers to the introduction to the current state of the environmental management system in a particular institution and the environment. The institution that is starting the project ISO 14001 must be aware of the success of the existing system of environmental protection. Some systems are successful and distinguished, while some of them are less successful and difficult to be observed. It is important to notice that the system currently exists, because the institution is functioning. Because of this, it is necessary to record the current system and determine the condition. That is the preliminary review, and as such is not part of the environmental management system, but gives an insight into the impact that the institution has on the environment. In short, determining the state of the existing system of environmental protection must be done for the following reasons:

- Determine the initial state – origin, so solution obtained at the end of the project would not be worse than the current
- Inform in detail about environmental problems, management systems and different approaches to environmental protection
- Prepare employees to accept this project and work on creating a feedback
- Gain insight into the knowledge in the field of environmental protection.

Phase of determining the current state of the environment, i.e., the preliminary review, includes at least the following four areas:

1) Requirements in relation to legislation and other regulations
2) Assessment of significant environmental aspects
3) Examination of all existing procedures and processes related to environmental management
4) Evaluation of data obtained by research of the previous accidents and non-conformities.

When determining the current state, it is necessary to take into account the work of the institution in "ordinary" and "out of the ordinary" circumstances. Methodology of conducting the preliminary review depends on the size of the organization and complexity of its processes, and whether the preliminary review is conducted by the organization itself with its employees or with the help of an external expert consultant. When conducting the preliminary review, the following is of great benefit and assistance: specially designed questionnaires, checklists, interviews and other forms of information and data gathering, and direct measurements and monitoring.

The process of determining the state of the existing environmental management system is implemented through the following activities:

a) Selection of appropriate criteria and benchmarks
b) Data collection
c) Recording of the state
d) Determining the achievements of others
e) Determining the state

a) Selection of criteria and benchmarks

For assessment of the quality of solutions that will be achieved by implementing the requirements of ISO 14001 in the existing environmental management system, it is necessary to define and determine the appropriate criteria and benchmarks. In other words, this means that it is necessary to set appropriate criteria and benchmarks for the defined goals that will show the degree of realization in practice.

Selected criteria and benchmarks should enable:

- defining of procedures for data collection
- assessment of the validity and effectiveness of alternatives that will be appearing in almost all phases and at the end of the process of implementation of this project
- comparison of alternatives and selection of the optimal solution.

It is important to be careful when selecting criteria and benchmarks because the wrong choice can lead into the wrong direction and significantly complicate the process of implementation of the requirements of ISO 14001 in the current system of environmental management. Inadequate selection of criteria and benchmarks is often one of the reasons for unduly long, multi-year project implementation.

b) Data collection

The main objective of this activity is gathering information and data relevant for the implementation of the project. Practice has shown that during the implementation of this phase the information about the negative impacts and effects is of great importance. It should be noted that the excessive amount of information does not contribute to efficiency and effectiveness of the analysis, because it draws attention away from the essential knowledge and makes the whole procedure slower and more expensive. At this phase a large responsibility lies with the expert consultant, who must properly focus the team on gathering the relevant information.

In order for the state of the existing environmental management system to be correctly determined, it is necessary to collect data and information on: the implementation of legislation in the environment, documents relating to the environment, reclamations and complaints of stakeholders in the environment, reclamations to the suppliers that are associated with environmental protection, waste collection, recycling of waste, air emissions, etc.

Data and information are to be found in the following documents: laws and standards related to environmental protection, plans and work programs, schemes, books of regulations and instructions, analyses, etc. Data can be useful only if they are systematized in an appropriate manner that ensures and facilitates their analysis after the collection. Therefore, it is important to prepare the appropriate records and tables in which the data is easy to notice and recognize. Thus, priority is given to records in electronic form.

c) Recording of the state

Results of the analysis of data collected from the documents form a part of the basis for determining the state of the existing environmental management system. No organization, including its systems, operates as it is planned and regulated. In practice, there is the "other organization" with an environmental management system that exists. How to identify the actual system? The easiest way is by recording the state.

The most common methods for recording and analyzing of the state of the environmental protection system are:

- employee interview
- employee survey
- process monitoring (method of current observation)
- analysis of the data collected about the impact on the environment.

Depending on the size of the institution and the type of its activities, many other methods of collecting information and data can be conducted.

d) Determining the achievements of others

Upon recording the existing environmental management system, before the final determination of the existing state, it is desirable to determine the achievements of other (similar) institutions that realized the project of implementation of the requirements of ISO 14001 in the current system of environmental management.

When determining the achievements of others it is desirable to find an answer to the following questions:

- What approach did they use in implementation of this project?
- How did they solve the problem with documenting the system?
- Who was their expert consultant, what was his role and how do they evaluate his contribution?
- What were the biggest problems and how were they handled?
- What was the management’s attitude towards this project?
- What criteria were used for evaluating the project?
- How were the teams for implementation of the project formed?
- How do they measure and supervise the impact on the environment?
- How do they validate their processes in relation to environmental protection?
- How did they define and implement the policy and objectives of environmental protection?
- How do they define the programs in the environment and how do they monitor their realization?
- And other questions.

e) Report on the recorded state of environmental management system

By data collection and recording of the existing state of environmental management system, a large number of information is gathered. That information should be adequately systematized, so that they could be used for analysis. The existing state can be shown descriptively, graphically and in the form of a table. The following forms of display are very useful:

- table representation
- diagram (trend, correlation, etc.)
- flowchart
- network diagram
- workflow etc..

Education

The phase of education in this project begins after the completion of recording and determining the state of existing environmental management system. Education is conducted during all phases of the process of the implementation of the ISO 14001 standard. In this phase the emphasis is on the role of education of top management and employees directly involved in the implementation of the project, in order to understand the requirements of ISO 14001 certification.

Documentation preparation

After successful completion of the initial education for the implementation of ISO 14001, the next phase is the preparation of the documentation of environmental management system. Taking into account the requirements of the standard, the team in charge of the environment must define documentation, including appropriate records necessary for the establishment, implementation and sustainment of the environmental management system.

Documenting environmental management system is one of the most important activities in the process of implementation and structuring of the system. All areas and all business functions within the organization are included in preparation and sustainment of documentation. Documentation must not describe an ideal or desired situation, but the actually implemented environmental management system in the organization. Documentation should describe the standard and specific processes in the organization, in order to identify aspects of the environment and their impact on the environment, as well as actions for monitoring and improvement could be taken.

The content and scope of the documentation should meet the legal regulations (international, national, local), the requirements of standards and other normative acts and demands of other stakeholders. Documentation should be adjusted to the organizations, that is, its employees. It can be in any form or in any medium that suits the needs of the organization. One of the main responsibilities of the environmental management representative or person working on the documentation of environmental management system is highly rational approach to the preparation of the documentation in terms of scope.

Implementation of thedocumentation

Prepared documentation of the environmental management system is being reviewed and approved and then distributed into processes, i.e., put in use. Most often the environmental management representative is in charge of the distribution. Documentation is distributed to individuals, that is, the processes that need to coordinate their work with the content and requirements of the documentation. Each document has its own distribution list from which you can see the following: who and when received the document, in which department or process, and the signature of the recipient.

Some documents, such as the environment manual or general procedures (for instance, the procedure for document and records management) are distributed to all departments in the organization, which definitely makes sense, because the requirements relate to the organization as a whole and all of its parts. The procedure that, for example, describes a specific process or environmental aspects of the production is distributed to managers of the specific process (for example, procedure for the management of waste in the production process).

Each environmental management system document needs to be studied in terms of requirements and obligations that derive from it. This is followed by the education of the employees, conducted by the creators of the documents. All the details and lacks of clarity must be conformed and clarified. Work cannot be conducted according to the valid documentation until all employees understand their duties and responsibilities. Application of the documentation in practice is actually harmonizing the practice and the applicable requirements of ISO 14001 that are transferred to the processes through the documentation. One would think it is a simple activity that should not cause any problems with the employees. However, experience shows that the situation is quite different. Changing habits and the existing practice is the most difficult thing of all. This is especially noticed in areas where changes in the way of doing business are rare and everything is done by the old, well-established principles.

The documentation must be available to everyone who uses it regularly or occasionally. Managers are responsible for the continuous monitoring of the conformity between documentation and practice. They make the decisions regarding the changes of the practice or documentation. When documentation falls behind the practice, the procedure for its modification is initiated.

Internal audit and inspection by the (top) management

The ISO 14001 standard does not define the way in which the audit is carried out, but it emphasizes that the audit is to be performed as an organized and planned procedure in all areas of activity. The intervals in which the internal audits are conducted are different and are determined based on the results or the importance of specific business processes. Internal audit has one and only one purpose alone: *determining the compliance of the actual state of environmental management system in the organization with all standard requirements, laws and other regulatory acts with the ultimate objective of it being improved.*

Inspection by the management (the top management of the institution) is an obligatory review by which the top management confirms the efficiency and effectiveness of environmental management system. It is conducted after the completion of internal audits. The top management of the institution has to evaluate the environmental management system in planned intervals to ensure its continuous suitability, applicability and efficiency. The process of evaluation must include an assessment of improvement opportunities and the need for changes in environmental management system, including changes in environmental policy, the general and specific objectives.

Elimination of non-conformities

In this phase the project of implementation of the requirements of ISO 14001 standard enters the final stage, when actions for giving the "final touch" to environmental management system are taken. The duration of this phase depends on the quality of previously implemented phases, and the goal is to eliminate all existing or possible non-conformities in the environment before the certification phase.

To ensure timely action, top management should define the responsibilities and authorizations of employees to report non-conformities at all phases of the process. After the detection of the non-conformities that have already occurred or may occur, adequate preventive and corrective actions to eliminate them are conducted as soon as possible. The nature of the non-conformities and any actions taken must be noted in the records.

Certification (independent audit)

The final part of the implementation of the requirements of the ISO 14001 standard in the existing environmental management system includes the phase of certification of that system by an independent certification company. In other words, this means that the organization has successfully overcome all the previous phases of the project and wants to "crown" the results of its work with a document called a certificate. The certificate is actually a confirmation of the validity of an environmental management system, that is, a guarantee that the system is organized, applicable and maintained in accordance with the international standard ISO 14001, regulations and requirements of the stakeholders. Based on its own assessment, the organization selects a certification company that will best evaluate its system. Today there are quite many accredited certification companies. Which of them will the organization select depends on: references, reputation in the market, price, etc.

The certification process generally consists of the following steps:
- selection of an authorized certification institution
- submission of the application for certification
- delivery of the certification offer
- reaching an agreement on certification
- pre-certification audit (if needed)
- verification of the documentation
- certification
- periodic monitoring of the system
- re-certification.

Improving the environmental management system

The process of improvement is primarily a natural process, present in all aspects of human life.The current state represents the current achievement on a permanent road to improvement. The goal of every improvement is rationalization. This means that with the use of available material and human resources the best possible results are achieved, without damage to any interested party.

Improvement of any process and the entire system in institutions or organizations is inevitable. Even the best structured environmental management system must be subjected to the process of constant improvement. Deming’s famous statement is: „There is always a better way“.

The management has a significant role in the improvement processes. The management is expected to timely make decisions on improvement, constantly encourage the improvement processes at the lower levels of management, monitor the implementation of the process and the results achieved, and to initiate new improvement processes. Management should create a working environment which includes employees in actively finding opportunities to improve process and product performance in terms of reducing the harmful impact on the environment. That is why employees should have the competences, authorizations and responsibilities to take improvement actions. The decision on improvement is based on pieces of information that result from continuous process analysis.

Methods of improvement of environmental management system can be observed through the continual gradual and continual sharp improvements. The preferred and most common situation in organizations and institutions is the combination of gradual and sharp improvements. It leads to the defined goal considerably faster.

CONCLUSION

Local and national governments have to give greater importance to the problem of environmental protection than the one they are giving today. They must create a climate for environmental protection in their own institutions and organizations. With their own example of the introduction of standards in their work processes, local and national institutions must be the driving force for the systematic approach to environmental protection.
The presented methodology of applying the requirements of ISO 14001 is only one of many possible ones. It is based on the modern principles of management theory and has been verified in practice on real situationsin manufacturing, service and social organizations.

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KINETICS OF CRYSTALLIZATION OF ZEOLITES OBTAINED FROM WHITE OPALIZED TUFF - MACEDONIA

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ABSTRACT

Crystallization of the zeolites is the most important process in the course of the synthesis of the zeolites since, due to character of the process there are several factors which have influence on the process.The kinetics of the crystallization process is determined with the following of the percentage of crystallization of zeolite subject to the time.Determination of the percentage of the crystal phase of the trials with zeolite is performed from the beginning till the and of the crystallization.Dependence of the crystallization on the time for the obtained zeolites from the type A is graphically presented. In order to be expressed the kinetics of crystallization of the obtained there have found logarithim of the values of the curves which represent the dependence of the crystallization on the time,using the eguation. $Z = Kt^n$ *and it" logarithmic form* $\log Z = \log K + n \log t$ *The natural raw material – white opalite tuff oriinates from Strmos, R. Macedonia.*

Key words: *white opalite tuff, crystallization, kinetics.*

INTRODUCTION

Natural material – white opalized tuff is holder of SiO_2 and Al_2O_3 components, necessary for zeolite synthesis. Chemical content is the most important criteria for raw material choice, as it determines the contributions raw material in the synthesis of zeolites. By chemical content it can be fortifiled for which type zeolite. By chemical content it can be fortifiled for which type zeolites the raw material is suitable in accordance with the content of SiO_2 and Al_2O_3.

The natural raw material – white opalite tuff originates from Strmos, R. of Macedonia. According to the mineralogical – petrographical investigations, this raw material originally consisted of phenol – crystals of intermediate plagiooglasses : biotite, pyroxenes and amphiboles, with idiomorphic hipyidiomorphic forms between 200 and 800 um. According to this, tuff is opaline and andensitely argillated with relict poriferous structure. Oxide molecular relation SiO_2 / Al_2O_3 is important criteria, as it shows for wich type zeolite raw material is suitable and which other substances, and in which quantity should be added in order requested content be given of the reaction mixture. In this study kinetic of the crystallization of zeolite of A type by the white opalized tuff will be given.

EXPERIMENTAL PART AND RESULTS DISCUSSIONS

The main task and difficulty during zeolite synthesis is producing of homogenous crystals by content, structure and size. Successful solving of this task depends by effecting and strictly observing to the synthesis conditions. Zeolites synthesis is brought down to the synthesis conditions. Zeolites synthesis is brought down to crystallization of alkali allumosilicate hydrogel. Crystallization is lasting form several hours to several days. Gels which are used for synthesis of zeolite by type A, are prepared by the natural raw material, natrium alluminate, NaOH and water. They have crystallized in closed systems generally on temperature from room to 448 K. In some cases higher temperatures are used up to 573 K. Pressure generally is suitable to the pressure of solid water steam during temperature. Producing of the gel and crystallization of the system Na_2O – Al2O_3 – SiO_3 – H2O can be represented schematic against the following equation 1/,2/:

$$NaOH\ (aq) + NaAL\ (OH)_4\ (aq) + Na_2\,SIO_3\ (aq)$$

$$(Na)a\ (ALO_2)\ b(SiO_2)\ c\ NaOH\ H_2O\ (gel)$$

$$Nax\ [(AlO_2)\ x\ (SiO_2]m\ H_2O + solution$$

Crystals zeolite

Gel high reaction capability, corresponding concentration of alkali and high surface activity, conditioned by ungrate article dimensions of the soluble hard phases explains zeolite crystallization mechanism. Depending of due time of zeolite A, crystallization of white opalized tuff if followed by the percentage of crystal phase. Also, it is followed by X – ray diffraction and by this way it is examined how percentage of crystal phase of zeolite increases in duration with the time and even crystallization process being finished.

Dependence of the crystallization of time, at zeolite A synthesis of tuff, is graphically shown by Fig.1 and 2. We can see by kinetic curve that crystallization starts after 1.5 hours and ended after 6 hours.

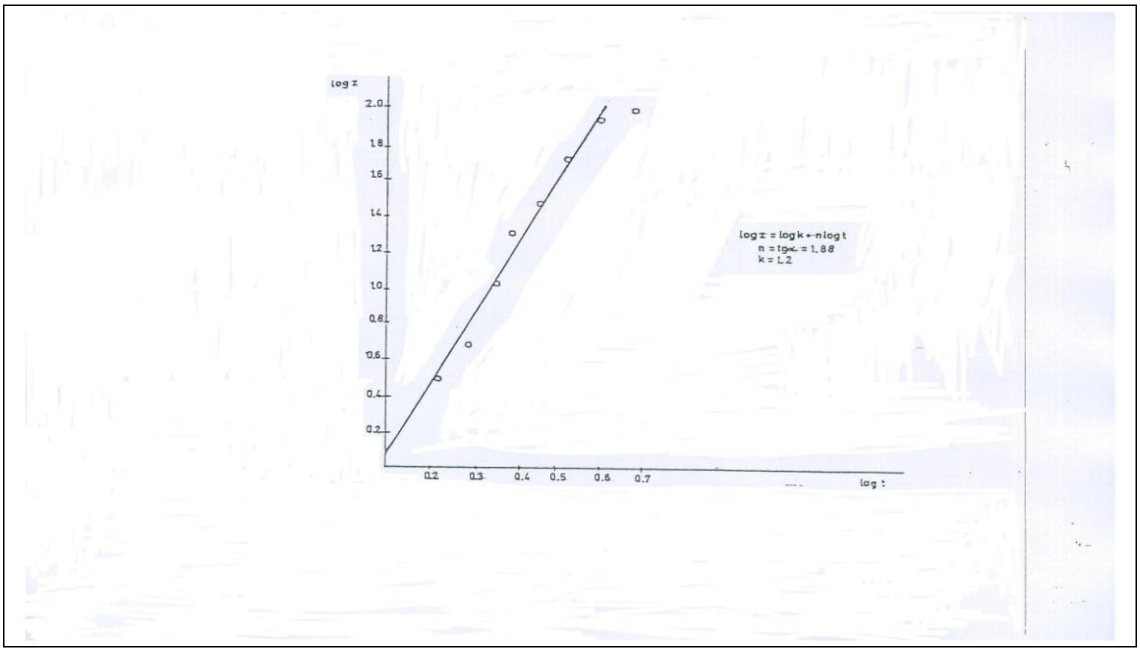

Figure.1. Crystallization of zeolite A, obtained from white opalized tuff

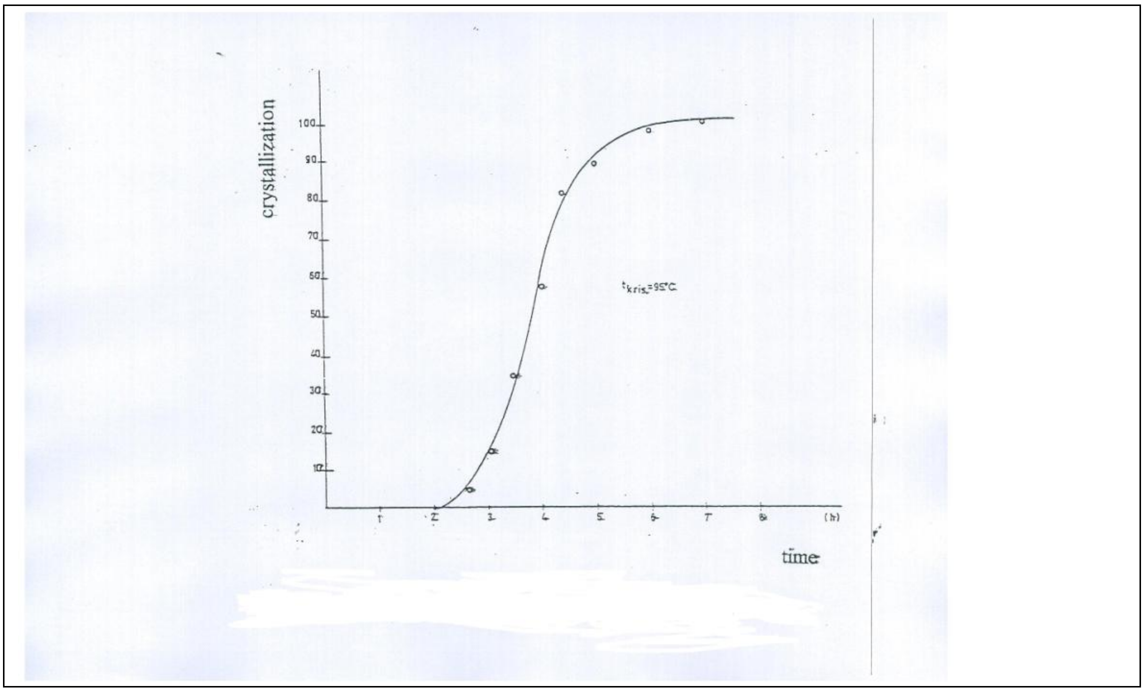

Figure 2. Kinetic of zeolite A crystallization of white opalized tuff

There is the most intensive crystallization of zeolite A from white opalized tuff, during the time of 3.5 – 5 hours, when crystallization conditions of zeolite are totally provided.

During good chosen mol relation of the oxides, good making of the synthesis, crystallization is 100 %.

One of the most important facts which conditioned to time of nucleation is the temperature, because of high temperature time of nucleation is short and crystallization is quickly made.
Reaction mixtures content has been given by formula as follows /3/ :

$$4\ Na_2O\ Al_2O_3\ 2SiO_2\ 210\ H_2O$$

Crystallization of the zeolites is the most important process in the course of the synthesis of the zeolites since, due to the character of the process there are several factors which have influence on the process.

The kinetics of the percentage of the crystallization of zeolite subject to the time. Determination of the percentage of the crystal phase of the crystallization. Dependence of the crystallization on the time for the obtained zeolites from the type A is graphically presented. In order to be expressed the kinetics of crystallization of the obtained there have been found logarithm of the values of the curves which represent the dependence of the crystallization on the time, using the equation:
$Z = Kt^n$
And its logarithmic form :

$$\text{Log } Z = \log K + n \log t$$

Where :
t – time is expressed in (h) ;
Z – crystallization (%) ;
K – and n – constants which are graphically determined.

CONCLUSION

It can be concluded by the effected synthesis of zeolite type A of the natural material and got results, that crystallization is 100 % if base raw material is good prepared and if synthesis is good effected.

These examinations will be useful in silicate material application in new technology – zeolite, which have white spectrum for industrial task application.

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REVIEW OF METHODS FOR OCCUPATIONAL AND ENVIRONMENTAL RISK ASSESSMENT

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ABSTRACT

Risk assessment and risk management are very important components for analysis and research of occupational and environmental safety. Successful solution of the problem of providing safe working and living conditions and of managing occupational and environmental risks and hazards is possible if one is familiar with the phenomena to be managed and the management methods. Since risk assessment is the basis of risk management, it is necessary to be familiar with the methods that can be used for this purpose. This paper presents the methods, tools, and techniques used for occupational and environmental risk assessment.

Key words: *methods, environmental risk, occupational risk, risk assessment, risk management*.

INTRODUCTION

During the final decades of the 20^{th} century technological development and modernization led to both positive and negative effects for occupational and environmental quality. There are numerous risks due to exhaustion of natural resources, failures of technical-technological systems, or human and organizational errors, which can threaten human safety and health, as well as the working and the living environment in various ways.

Creation of safe and good living and working conditions (reduction of injuries, professional diseases and disabilities, fire elimination and prevention, emergency management, environmental protection, etc.) is accomplished through application of diverse and complex preventive measures, which help prevent and eliminate occupational and environmental risks of different nature and character.

All activities of an organization involve risks that should be managed. The risk management process aids decision making by taking account of uncertainty and the possibility of future events or circumstances (intended or unintended) and their effects on agreed objectives.

Risk management includes the application of logical and systematic methods for (ISO 31010:2009):
- communicating and consulting throughout this process;
- establishing the context for identifying, analyzing, evaluating, treating risk associated with any activity, process, function or product;
- monitoring and reviewing risks;
- reporting and recording the results appropriately.

The most important methodological step for adequate risk management is risk assessment. Risk assessment provides an understanding of risks, their causes, consequences and their probabilities. This provides input to decisions about: whether an activity should be undertaken; how to maximize opportunities; whether risks need to be treated; choosing between options with different risks; prioritizing risk treatment options; the most appropriate selection of risk treatment strategies that will bring adverse risks to a tolerable level. Therefore, risk assessment is an analytical instrument for designating risk factors to human health or material and natural resources, as well as for determining priorities for risk-reducing measures.

METHODS FOR RISK ASSESSMENT

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation (see Figure 1).

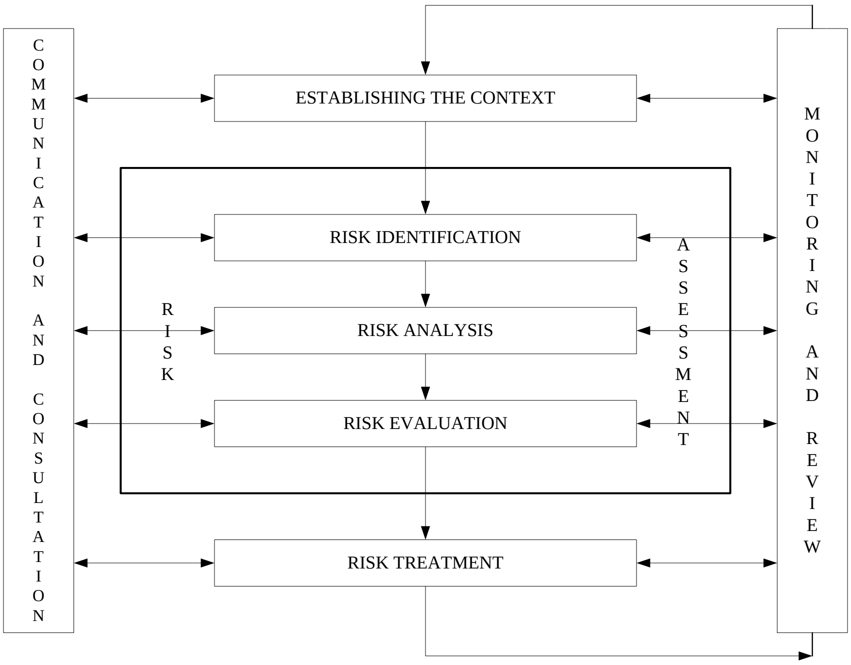

Figure 28: Contribution of risk assessment to the risk management process (ISO 31000:2009)

Risk assessment may require a multidisciplinary approach since risks may cover a wide range of causes and consequences. Risks can be assessed at an organizational level, at a departmental level, for projects, individual activities or specific risks. Different tools and techniques may be appropriate in different contexts.

According to the data they use, risk assessment methods can be qualitative, quantitative, and combined. They are divided into probability assessment and consequence assessment methods. The purpose of probability assessment methods is to identify and quantify areas where risk can potentially occur, whereas the purpose of consequence assessment methods is to assess negative consequences and their potential effects, as well as to describe possible safety measures for eliminating those effects (Stojiljkovic, 2007).

Qualitative methods use qualitative data so the result of the assessment is also a qualitative value. They also assess the implementation of and compliance with the criteria defined by standards, laws, regulations, and norms for the studied systems.

Quantitative methods use quantitative data. They imply knowledge of the probability of an undesired event, which is obtained according to relevant historical data, use of analytic techniques, or expert assessment. Likewise, they imply knowledge of the quantitative values of the expected consequences in case the event actually occurs. These values are then used to determine the quantitative measure of risk, which is usually their product.

Combined (semi-qualitative) methods are based on expert assessment. As it is often impossible to assess the probability (especially in the case of rare events) or the extent of the consequences (which differ in different conditions), these values are assessed and ranked by experts. Probability and consequence scales are the basis for assessment of risk measure, which is usually the product or sum of probability and potential consequence measures.

According to the aspect of application, risk assessment methods are classified into (see Table 1):

- Methods for risk assessment of technical systems (e.g. Hazard and Operability Analysis, Fault Tree Analysis…);
- Methods for human reliability assessment (e.g. Absolute Probability Judgement, Success Likelihood Index Method…);
- Methods for accident analysis (e.g. Safety Function Analysis, Change Analysis…) and
- Methods for management risk assessment (Audits, Management Oversight and Risk Tree…).
-

Table 1. Methods for Risk Assessment (modified to: Harms-Ringdahl, 2001; Stojiljkovic & Grozdanovic, 2005; Stojiljkovic, 2007; ISO 31010:2009; Stojiljkovic, 2011)

Ord.	*Methods*	*Methods for Risk Assessment of Technical System*	*Methods for Human Reliability Assessment*	*Methods for Accident Analysis*	*Methods for Management Risk Assessment*
1.	Energy Analysis – EA	**X**			
2.	Deviation Analysis – DA			**X**	
3.	Hazard and Operability Analysis – HAZOP	**X**			
4.	Safety Function Analysis – SFA			**X**	
5.	Failure Mode And Effects (and Criticality/Detection) Analysis – FMEA/FMECA/FMEDA	**X**			
6.	Human Error Assessment and Reduction Technique – HEART		**X**		
7.	Fault Tree Analysis – FTA	**X**			
8.	Event Tree Analysis - ETA	**X**			
9.	Absolute Probability Judgement – APJ		**X**		
10.	Change Analysis – CA			**X**	
11.	Success Likelihood Index Method – SLIM		**X**		
12.	Management Oversight and Risk Tree – MORT				**X**
13.	Job Safety Analysis – JSA			**X**	
14.	Technique for Human Error Rate Prediction – THERP		**X**		
15.	Audits – in general				**X**
16.	The complex method for assessment of overall hazard of an accident – CMA			**X**	
17.	Safety, Health and Environment Management System – SHE-MS				**X**
18.	Accident Evolution and Barrier Method – AEB			**X**	
19.	Paired Comparisons – PC		**X**		
20.	International Safety Rating System – ISRS				**X**

Table 1: (Continued)

Ord.	*Methods*	*Methods for Risk Assessment of Technical System*	*Methods for Human Reliability Assessment*	*Methods for Accident Analysis*	*Methods for Management Risk Assessment*
21.	Safety Barrier Diagram – SBD	**X**			
22.	Influence Diagrams Approach – IDA		**X**		
23.	Safety Culture Hazard and Operability Study – SCHAZOP				**X**
24.	Human Cognitive Reliability – HCR		**X**		
25.	Cause - Consequence Diagram – CCD	**X**			
26.	Systemic Human Error Reduction and Prediction Approach – SHERPA		**X**		
27.	Consequence/probability matrix	**X**			
28.	Tecnica Empirica Stima Errori Operatori – TESEO		**X**		
29.	Multilinear Events Sequencing – STEP			**X**	
30.	Cognitive Reliability and Error Analysis Method – CREAM		**X**		
31.	Consequence Analysis Models – CAM	**X**			

However, depending on the aspect of implementation, certain methods can be used within other risk assessment methods (e.g. Hazard and Operability Analysis can be used both for technical system failure identification and for human error identification). It should also be emphasized that risk assessment methods often include tools and procedures from the previous hazard analysis, such as Check-lists, What-if Analysis, etc. (Grozdanovic & Stojiljkovic, 2013).

For assess the environmental properties of products and processes and to summarize their possible environmental impact in each life-cycle stage, from the extraction of raw materials, through production, distribution, and use to their disposal, using the following methods: Life Cycle Analysis and Exergetic Life Cycle Analysis, which represent methods for environmental risk analysis.

According to the ISO 31010:2009 and considering the steps involved in risk assessment, the methods are classified into (ISO 31010:2009):

– Methods for risk identification (Brainstorming, Check-lists, Hazard and Operability Analysis, What-if Analysis, Delphi method, Human Reliability Analysis, Environmental Risk Assessment...);
– Methods for risk analysis – qualitative, quantitative, and combined probability assessment (Fault Tree Analysis, Failure Mode And Effects (and Criticality/Detection) Analysis, Cause - Consequence Analysis, Human Reliability Assessment, Consequence/Probability Matrix, Environmental Risk Assessment...);

- Methods for risk analysis – consequence analysis (Event Tree Analysis, Hazard and Operability Analysis, Failure Mode And Effects (and Criticality/Detection) Analysis, Cause - Consequence Analysis, Scenario Analysis, Consequence/Probability Matrix, Human Reliability Assessment, Environmental Risk Assessment...);
- Methods for risk analysis – level of risk (Failure Mode and Effects (and Criticality/Detection) Analysis, Human Reliability Assessment, Consequence/Probability Matrix, Multi-criteria Decision Analysis, Environmental Risk Assessment...);
- Methods for risk assessment (Failure Mode and Effects (and Criticality/Detection) Analysis, Monte Carlo simulation, Bayesian statistics and Bayes Nets, FN curves, Environmental Risk Assessment...).

Therefore, methodological approaches to occupational and environmental risk assessment need to be based on the use of: an analytic-synthetic research model, descriptive methods, hierarchical task analysis, acquisition technique, and combination of expert knowledge, i.e. on a synergistic use of the abovementioned risk assessment methods (Grozdanovic & Stojiljkovic, 2013).

CONCLUSION

Analysis of risk assessment methods leads to a conclusion that their applicability is highly uneven. The choice of a method to be used depends on: the capabilities of the method itself; the complexity of the process; organizational level and amount of experience related to the process; the degree of indeterminacy of the problem, i.e. the quality of available information; the resources necessary for the implementation of risk analysis and assessment; the depth of analysis; etc.

Based on our years of research in improving occupational and environmental safety and emergency management, we reached a conclusion that the use of individual methods cannot yield true risk assessment, because no method on its own can achieve the set goals. Consequently, achievement of practical solutions requires a synergistic effect of multiple mutually complementary methods. Therefore, only synergetic implementation of risk assessment methods can provide hazard identification in the studied systems, risk assessment of complex systems, and introduction of adequate measures to reduce risk to an acceptable level.

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OPTICAL AND LASER METHODS IN SUGAR CONTENTS MEASUREMENTS AND DIAGNOSTICS IN VARIOUS APPLICATION

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ABSTRACT

In this study are presented some modern measuring methods generally based on laser sources. Optical measurements from the metrological point of view are treated in the second part of this study. The third part presents measurement of sugar content in water solution performed on spectrophotometric device in laboratory. data which are obtained in laboratory. Beside new propositions for possible laser applications, the results and possibilities some of them have shown. Metrological point of view includes filter role, calibration procedures and interpretation of uncertainties. Characteristics of transmission data from one sugar solution are also presented.

***Key words**: absorbance, laser, glucose, spectrophotometer, calibration.*

INTRODUCTION

Laser applications for concentration measurement of the sugar based materials for various purposes from food industry, science applications up to biomedical diagnostics purposes are still topics. The devices overall dimensions decreased from meter size to the size of a pen. The laser applications for concentration and type of sugar determination are extensively studied due to diabetes mellitus and other widespread diseases where sugar in blood contents has to be often controlled. For various purposes different methods are developed using simple as well as complex devices based on linear and nonlinear effects. The relatively new laser types as are quantum well lasers and others for mentioned purposes are implemented. Beside turbidity measuring techniques as the simplest, polarisation dependent techniques, and ellipsometric approaches, many spectroscopical measurements of linear and nonlinear types could be applied (including polarisation state of light i.e. laser beams). In the same time there are some multipurpose instruments as well as these directly linked to sugar concentraton and its chemical formulations. Some of them are in every days use, and others are potentially usable [1-19].

MATERIALS AND METHODS

Laser applications methods

Overview of Non-Invasive Optical Glucose Monitoring technique [4] can be grouped as subcutaneous, dermal, epidermal and combined dermal and epidermal measurements. Tests sites are: finger tips, cuticle, finger web, forearm, ear lobe. Subcutaneous methods are linked to micro dialysis, wick extraction, implanted electrochemical and competitive fluorescence sensors. Epidermal monitoring applications: infrared spectroscopy (IR) and, combined with dermal monitoring, extraction fluid techniques (iontophoresis, skin suction, suction effusion methods, etc). Many optical techniques are developed with procedures that have to be respected in measurements and interpretation [1,2,3,4]. The selected techniques are listed in Table.1.

Common NON-invasive Optical Techniques

Some laser methods are known as optical methods where optical activity was measured controlling rotations angles which are dependent on the sugar concentration in water. The later on, the natural well known sources (sodium lamp, other spectroscopic sources, halogen lamps, hot wire bulbs, historically including Sun, too) or the others were substituted with laser sources.
This type of measurements will be used in the third part of this study where the series of turbidity - absorption measurement were performed.

Table 1: Comparison of sugar monitoring methods.

Technique	Definition	Remark
Infrared spectroscopy IR in the NIR range	Absorption or emission measuring data in 0.7-2.5μm range are compared to data for glucose or other sugar formations	Iraser with tuned wavelengths can be sources, beside *classical* sources in mentioned range
Raman Spectroscopy -various methods	Laser beams induce emission from transitions near the excited level (rotation and vibration molecular transition depend on the molecular structure)	Many laser source in continuously *cw* and pulse regime including *ps* and *ns* regions
Photo-acoustic spectroscopy	Laser beam excitation provoke acoustic response in fluids; laser can be with wavelenght tuning possibility	Many laser source in continuously *cw* and pulse regime including *ps* and *ns* regions
Scattering methods	The scattering of laser beams via elastic and inelastic processes indicate a change in the material. Glucose (or other sugar formation) molecules belong to the scattering centres of great size	Many laser source in continuously *cw* and pulse regime including *ps* and *ns* regions
Polarisation methods	Glucose presence is known to provoke the polarisation change. The angle of polarisation rotation is specific for different molecules present in water (or other solvent)	Many laser source in continuously *cw* and pulse regime including *ps* and *ns* regions
IR Spectroscopy in mid IR range	Absorption or emission measuring data in 2.5-25μm range are compared to data for glucose or other sugar formations	Irasers with the possibility of wavelength tuning are used as sources, beside *classical* sources

Many common optical methods use the sources of incoherent radiation. The relatively new measuring solution are produced substituting the classical sources with coherent sources i.e. quantum generators (uvaser, laser, iraser). These types of measurements use relatively small number of subsystems including source- measuring cell and detector (with adequate signal processing, visualisation, computer, recorder or screen, etc). The advantages of these types can be simplicity of measuring-optical system, and smaller uncertainty . Among new developed methods are:

1. Non-invasive fluid glucose measurement using optical techniques for glucose control in diabetes,
2. Non-invasive blood glucose level measurement based on laser beam reflection processes (spectral patterns images),
3. Optical glucose monitoring using new laser types as are vertical cavity surface emitting lasers VCSELs,
4. Optical coherence tomography for glucose monitoring in blood (methods for glucose quantification in flowing blood),
5. Methods based on giant optical activity of sulphate in thin soap films,
6. System for measuring sugar content in liquid using the laser pointer,
7. Various new methods for measuring blood sugar with laser beam, based on different physical processes; trending to be non-invasive,
8. Laser photo-acoustic different methods for monitoring glucose in human tissue,
9. Two wavelength carbon dioxide laser application to measurement in vitro blood glucose,
10. Fiber optics solutions in sensor, source (fiber laser) and measuring data transmission (using different non-fiber techniques). [5,6,7,8,9,10,11,12,13,14,15,16,18,19]

Metrological points of view to some optical measurements

The laboratory for photometry and radiometry [2,3] has a holmium-oxide solution in perchloric acid for wavelength calibration, and it has also optical neutral density filter standards for spectral transmittance. It is necessary for respectively absorbance calibration of spectrophotometers.
The authors’ intention in this study was to present various contributions to the total measuring uncertainty by spectrophotometer calibration. The contribution to the uncertainty of wavelength standards, i.e. spectrophotometer filters will be emphasized. Further metrological estimations of influencing parameters will refer to these two spectrophotometer filters-wavelength standards.
The spectral range of holmium oxide is between 200 nm and 650 nm. It’s apparent that these standards cover both the UV and VIS ranges of optical radiation. Therefore, they are very convenient for absorption spectrophotometers calibrating, in terms of wavelength. These standards’ spectral characteristics are presented in Fig. 1.

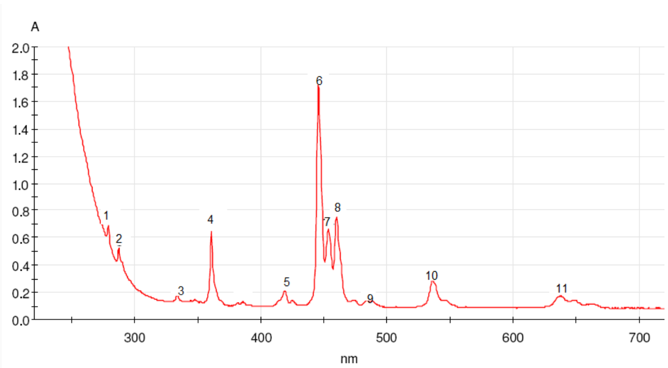


Figure 1. Spectral coefficient of absorption of the holmium-oxide glass filter with 1 nm bandwidth of absorption spectrophotometer, obtained in the Standardization and Validation Laboratory.

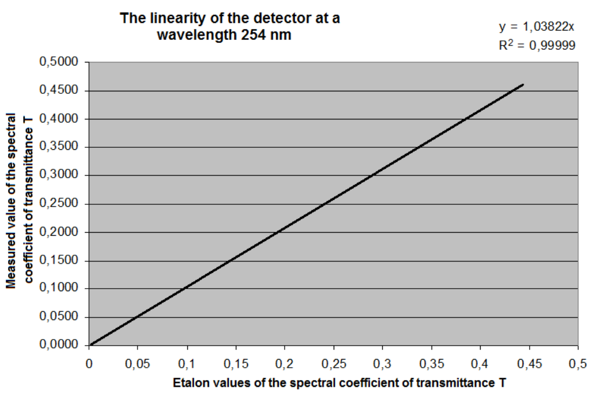
There are several parameters, which may (or may not) influence the accuracy during measurement of spectral characteristics of mentioned filters. In other words, the accuracy of the position of the maximum value of the spectral coefficient absorption, or the minimum value of the spectral coefficient of transmittance is of significant importance. Due to these circumstances, it’s very important to define the contribution of each parameter to the total uncertainty of calibrating absorption spectrometers, the most important being the standard filter. Common influencing parameters, which may appear while designating the spectral characteristics of spectrophotometer filters as wavelength standards are:

- temperature influence during measurement,
- influence of the solution purity,
- influence of the concentration of the solution,
- influence of the spectral bandwidth.

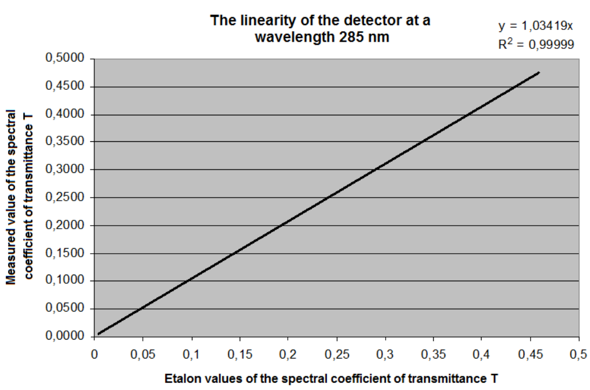
A method which determines the spectral coefficient of transmittance (absorption) has been designed in the Laboratory of Photometry and Radiometry for determining these influencing parameters.
Measuring values were obtained by the spectrophotometer Perkin-Elmer lambda 16 on couple different wavelength. They have shown the linearity of the detector e.g. spectrophotometer on these wavelengths. The detailed results of measurements interpretations are presented in Table 2 and Figs.2 (a-d).

Table 2:

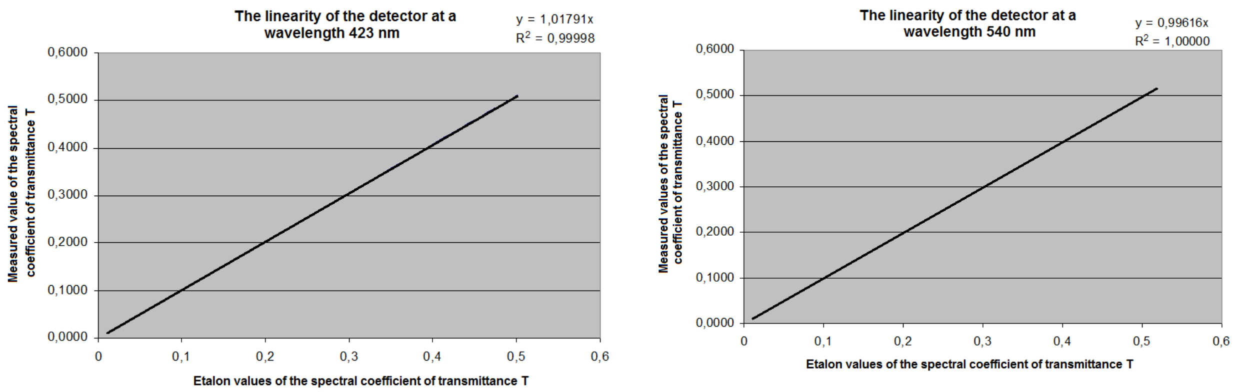
Standard values for wavelength of 254 nm	**Measuring values of absorbance for wavelength of 254 nm**	**Absolute deviation**	**Relative deviation [%]**	**Total uncertainty of measuring**
1.18469	1.1738	0.0109	0.92	0.0060
0.35303	0.3366	0.0164	4.65	0.0040
2.65365	2.6383	0.0154	0.58	0.0040
Standard values for wavelength of 285 nm	**Measuring values of absorbance for wavelength of 285 nm**	**Absolute deviation**	**Relative deviation [%]**	**Total uncertainty of measuring**
1.10347	1.0950	0.0084	0.76	0.0060
0.33843	0.3237	0.0148	4.37	0.0040
2.34679	2.3312	0.0156	0.67	0.0060
Standard values for wavelength of 423 nm	**Measuring values of absorbance for wavelength of 423 nm**	**Absolute deviation**	**Relative deviation %**	**Total uncertainty of measuring**
0.99264	0.9910	0.0017	0.17	0.0060
0.29987	0.2919	0.0080	2.65	0.0040
1.97428	1.9672	0.0071	0.36	0.0044
Standard values for wavelength of 540 nm	**Measuring values of absorbance for wavelength of 540 nm**	**Absolute deviation**	**Relative deviation [%]**	**Total uncertainty of measuring**
1.00305	1.0045	-0.0014	-0.14	0.0060
0.28493	0.2866	-0.0017	-0.59	0.0040
1.97881	1.9815	-0.0027	-0.14	0.0045



a)



b)



c) d)

Figure 2. a-d

Some results of spectrophotometer methods

In Table 3 and Fig. 3 are presented some data of light intensity versus sugar concentration in water solutions measured by another optical spectrophotometer system of laboratory design. Device was calibrated using tap water [17].

Table 3:

Percentage [%]	0	5	10	20	30	40	50	60
Abs [cm^{-1}]	0	0.041	0.082	0.167	0.250	0.304	0.414	0.495

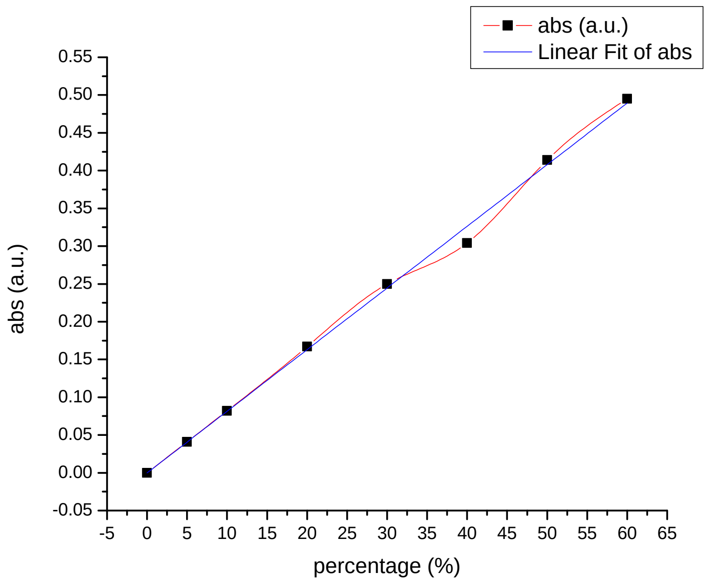


Figure 3. Measurements of the realtionship between sugar concentration in water solution and absorbance

CONCLUSION

The state of the art laser measurements of glucose in human body and the other non-laser existing techniques for sugar monitoring are studied in this paper. We presented also metrological point of view as well as some experimental results of sugar solutions measurements performed by photometric devices. The principal conclusion about laser implementations is that the application of laser technology is more convenient for sugar monitoring in living beings (human or animal body). Some laser techniques are with *no pain*. Sterilization procedures are not necessary. Laser measuring systems could be of various complexity. Sometimes they contain blood collector and strips. Laser sources are of different sizes and depending on the task, the optimal size will be chosen. Many commercial systems exist and on the other hand scientific equipment development is in full progress. The problems of the sugar concentration measurements can be treated as ones of the most important today considering the pathogen states provoked by sugar concentration in blood, food, medicaments, etc. Low-cost non-invasive analytical devices with the same accuracy as conventional ones are always necessary. Analysing various techniques for sugar monitoring it seems that modern methods of uncertainties evaluation are not performed for all *developed- existing- usable methods* and that can be done in the future.

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PROMOTION AND VISIBILITY OF PROJECTS IN THE FIELD OF ENVIRONMENTAL PROTECTION

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ABSTRACT

Projects related to environmental protection are projects that have wide social significance. Promotional activities within the projects in the field of environmental protection are of particular importance. It is therefore very important to ensure publicity and visibility of such projects. Promotional activities in the field of environmental protection involve the use of standard methods and techniques of promotional activities, which are dimensioned according to the level of the budget. On the other hand, these projects imply more involvement because of their specificity, which includes social responsibility, especially the transparency of information and raising awareness of citizens and special interest groups in the region.

Keywords: promotion, environmental protection, social responsibility, visibility of the project.

INTRODUCTION

Modern business is allocated by the principle of social responsibility. Business subjects must meet the objectives of large number of stakeholders in their environment. According to Drucker (2003, P.110), knowledge based organization requires everyone to assume responsibility for a given realization of the organization for its contribution and its behavior. All members of the organization must fully consider and reflect on their achievements and contributions. According to Galbraith (2000, p 68), there are four factors that require public intervention and regulation:

- Protecting the planet,
- Protecting the most vulnerable in the economy (employed in the manufacturing machine)
- Consumer protection
- System (market economy) contains the destructive tendencies that affect on its functioning.

Projects in the field of environmental protection include the application of the concept of social responsibility on the one hand, and the achievements of modern marketing, on the other hand, taking into account the elements of business practices in profit, and non-profit sector as well as public services. In addition, the appropriate promotion of business in accordance with the principles of social responsibility cannot be achieved without using public relations.

The use of today`s management methods and techniques is not limited to the area of the profit sector. Drucker has observed in late eighties the role of non-profit sector in the development of methods and techniques of contemporary business. According to Drucker, the key to success of a nonprofit organization is not in her function, but in operational organization (Drucker, 2003, P.176). These organizations have awareness about funding, compared to conventional business organization or budget organization of public utility, for making significant efforts to collect them, but careful to spend on the implementation of specific objectives. Therefore they use planning techniques, with special emphasis on the evaluation of performance.

Kotler considering the application of marketing in public sector highlights the need for client access (marketing focus on the citizen) in these organizations, that allows responding to complaints and seeking to develop formal plan with a situation analysis, goal setting, market segmentation, conducting marketing research, brand positioning, the choice of the strategic combination of marketing mechanisms, establishing a system of evaluation, budget and implementation plan (Kotler and Lee, 2008, p.13).

SOCIAL RESPONSIBILITY, SOCIAL MARKETING AND PUBLIC RELATIONS

The concept of corporate social responsibility

Corporate social responsibility is also called corporate responsibility (Corporative Responsibility - CR). According to Gordon (2011), corporate social responsibility is the public opinion about the social and environmental impact of business operations of the organization, as well as voluntary contributions to the welfare of the local community and society in whole. Corporate social responsibility is a commitment to improve the community`s well-being through discretionary business practices and contributions to the resources of the company (Kotler and Lee, 2008, p.3).

Social responsibility in business refers to the obligation of companies and other business organizations to increase their positive impact and minimize the negative effects on society. The organization must be concerned about the reduction of environmental pollution and reducing the destruction of natural resources and to take care about the environment. With respect to consumers, organizations must take care of their proper information, the protection of their health, the protection of their personal integrity, etc. According to the EU Green Paper from 2001, to be socially deliberative means not only fulfilling legal obligations, but also to go beyond mere compliance with laws and invest more in human capital, environment and relations with stakeholders. Today, one can see six community initiatives that work in the area of corporate social responsibility:

1. The promotion of social objectives,
2. Marketing associated with social objectives,
3. Corporate social marketing,
4. Corporate Philanthropy,
5. Volunteer work in the community,
6. Socially responsible business practices.

The public is paying more attention to organizations, expecting them to do something about the community in return. Stakeholders assess how the organization relates to ethical issues, decisions related to the environment and the wider community. This is the current situation in the world. Organizations are accountable to society and the environment. The organizations themselves recognize this trend and are becoming aware of their ethical, economic, environmental and social impact on the community.

Many organizations regularly report on their social responsibilities. It is not enough that an organization is not harmful to the environment, it is necessary to contribute and improve the quality of life. Simply, modern society demands accountability and contribution (Đorđević and Bešić, 2005).

Organizations should take into account the interests of consumers and society, not only about their profit. It should be borne in mind that the profit is an important requirement for long-term survival of the organization, and it is also in the interests of consumers and other public. The solution lies in sustainable development. The concept of sustainable development is based on achieving strong economic growth, but without compromising future projects and the environment. Sustainable development is a balance between the goals of economic development on the one hand and the need for the promotion and protection of the environment, on the other hand.

Social responsibility compels organizations to think about the risks and impacts of their business operations on the environment. Organizations are part of society and must take responsibility for their impact on society of which they are members. Liability applies to all actions and proceedings, and to all the actors in the environment, but also to employees in the organization. While ethics is a matter of each individual in the business, social responsibility refers to the impact of the organization of society.

Social responsibility and social marketing

Promotion of social goals requires that companies provide financial resources or other resources to develop awareness of social goals, or to raise funds to the benefit of the particular target. Marketing associated with social goals means that the company is committed to a certain percentage of revenue realized from the sale of products or services attached to a particular social goal. Corporate social marketing means that the company supports the development and/or implementation of the campaign for improving health, safety, environment, or the well-being of the community. Corporate philanthropy is the practice when a company gives donations directly for a charity or social action, mostly as grants in cash or through donations in goods. Volunteer work in the community means that the company supports and encourages its employees to volunteer in helping local community organizations and their activities. Socially responsible business practice involves a situation where a company at its discretion adopts and implements business practices that support a social objective, which is to improve the lives of the community and to protect the environment.

The modern marketing concept is defined as social marketing, according to Kotler this implies the effort of companies to determine the needs of the target market, and to achieve satisfying customer needs more effectively and efficiently than competitors in a way that maintains or enhances well-being, both consumers and the entire society (Kotler and Armstrong, 1996). This concept is based on three main elements: the welfare of the whole society, to meet the needs of consumers and profit making business. Kotler et al., (2008, p. 16) indicate social marketing as a strategy which tries to find a solution for many social problems. It can be defined as the use of marketing principles and techniques with the intention of targeting willingly accept, reject or modify certain behavior for the benefit of an individual, group or society.

Corporate Social Responsibility and Public Relations

Issues of corporate social responsibility are closely associated, primarily, with the top management, but also with the PR department of the organization. PR profession is a communication activity, which is basically focused on building, maintaining and improving the understanding of the organization and the public. Therefore, the PR department is naturally and directly related to the elements of implementation social responsibility.

The PR department should identify, explain and predict all the changes in the environment that have connections with the elements of corporate social responsibility. In order to successfully meet the requirements of society, PR department should often consult with experts from other fields, for example, doctors, environmentalists, nutritionists, scientists, agronomists, lawyers and others. Also, the PR department has a duty to provide an infrastructure that will support the actions of social responsibility.

The PR department has to answer all the questions relating to the impact of the organization on the environment. In the case of a positive impact, it is useful to inform the public about it. In case of a negative impact, it is necessary to introduce the truth and to present all of the action carried out so that negative influence would not be repeated again. Serious environmental problems belong to crisis situations, in which public relations play an important role. (Nikolić, 2012)

Applying the concept of social responsibility often has a strategic character for the organization. Given the large proportion of PR services in the implementation of the principles of social responsibility, it can be concluded that public relations has great strategic importance for every organization. At the same time, we should not forget that the strategic importance of public relations is reflected through many other PR activities. (Nikolić, 2012)

THE ROLE OF PROMOTION IN THE FIELD OF ENVIRONMENTAL PROTECTION

Promotional activities of projects in the field of environmental protection relies on the methods and techniques of modern marketing and marketing communications, but also goes a step further, taking into account the need of increasing the level of social consciousness. A key factor for the success of the implementation of marketing communication in the area of environmental protection is to establish a certain level of understanding between the holder and stakeholder communication. Promotional activities in the field of environmental protection should be focused on three elements: information, communication, education.

Information itself is the essence of the communication process. Information must be accurate, timely, high quality and affordable. It is especially important to emphasize that Information has to be transparent. According to Goleman (2010, p. 58), the information itself has value, knowledge transfers into market power. The essence of transparency lies in the transfer of information from the informed to the uninformed. Inequality in access to key information between the consumer and the company is called information asymmetry. Good information primarily allows consumers to make smart choices, but also members of other interest groups to respond appropriately. Transparency beyond the third generation of voluntary and statutory conditional disclosure is transparency that goes moving from bottom to top. Communication involves the implementation of marketing communications with stakeholders in the region, with the aim of establishing understanding and raising awareness in relation to the protection and improvement of the environment. Education is directly linked to the process of traditional communication and implies of raising awareness of stakeholders in relation to general environmental issues or in relation to the objectives of a specific project.

The person responsible for communication in the field of environment protection projects has available all the means of marketing communication from personal contacts to direct marketing. What will be the extent of the use of communication methods and techniques, and thus the use of the media, depends primarily on the budget that the developer has. If the budget that allows operation in the field of advertising is defined from the total budget of the project, it is certainly very desirable to effect on the stakeholders through advertisings and thus increasing the level of awareness among citizens. However, some methods of communication single out like media relations, extension, lobbying, etc.

The first step in the communication process is to provide information about the project, which is aimed at all segments of the public. Next is segmented communication, which involves specific target groups, such as scientists and experts, representatives of public agencies and non-governmental sector, which should function as promoters of the primary objective of the project. At this step a special role has organizing smaller events, such as scientific expert panel discussions, workshops, public discussions, study visits, presentations, software solutions, training and seminars. All this needs to be accompanied by publication of certain documents, such as manuals, glossaries and special bulletins, which should be available to the public both in electronic form and in hard copy version. Newsletters are particularly important for maintaining a stable level of communication with stakeholders, both at the level of information and the level of continuous education. Completion of the project should be accompanied by organizing a significant event, such as counseling or conferences, where the scientific and professional public would be informed about the achievements of the project and the perspectives for development, with the obligatory publication of the final document. In addition to these promotional activities, especially important place has the establishing and maintaining functional website, which should contain a complete audio-visual documentation of all documents available in electronic form.

PROMOTION AND VISIBILITY OF PROJECTS WITHIN ROMANIA - REPUBLIC OF SERBIA IPA CROSS - BORDER COOPERATION PROGRAMS

"The Romania-Republic of Serbia IPA Cross-border Cooperation Programme is funded by the European Union's Instrument for Pre-accession Assistance (IPA), the Cross-border Component and co-financed by the partner states of the Programme: Romania and Republic of Serbia. The Programme focuses on increasing the overall competitiveness of the economy in the Romania-Republic of Serbia border area and on improving the quality of life for the border communities in both countries. "(Romania-Republic of Serbia IPA Cross-border Cooperation Programme, Visual identity Manual, 2013, p. 3)

Communication is a very important part of any project. Good communication within the project greatly influences the success of the project. Lately, the IPA Cross-border Cooperation Programme, pays more attention to communication and information aspects of the project. It should be not forgotten that the visibility of the project depends on the results of the project itself.

All the project partners are responsible for the implementation of communication activities, in accordance with the project plan. It is recommended that there is a person who is responsible for information and communication measurements at the project. Also, it is recommended that each project designs its own logo and is put on the website of the project. It is mandatory to use the program logo and the EU logo.

IPA Cross-border Cooperation Programme gives great importance to transparency and visibility of their projects. This requires good communication within the project, increasing the level of information, the interested public, as well as increased publicity and awareness of stakeholders, in order to implement these projects.

The Visual Identity Manual (VIM) is a document that helps project participants to stick to the prescribed rules for visual presentation and identification of IPA projects. VIM is a unique set of rules binding on all partners in the project. At the same time, these rules are practical and convenient to use.

Among other things, VIM provides instructions on how to use the many technical elements of the project: program title, logo and slogan, Logos in various languages, Colors, Backgrounds, Spacing, Recommendations for using the European Union logo, Recommendations for using the Government of Romania logo Recommendations for using the Serbian Government logo, Recommendations for using the Structural Funds 2007-2013 logo Information disclaimers, Fonts, Information and publicity tools, promotional materials, Website, Audio Visual Materials, Photographs, Press Releases, Flyers, Brochures, Newsletters, Banners , Stationery, Self Adhesives, Business cards and PPT templates, Posters, Press Advertisements, CD/DVD Covers, Promotional Items, Tender Announcements, Billboards and more.

CONCLUSION

The impact of organizations is reflected on climate change, safety and health, education, culture and others. Environmental protection has become one of the most important issues of general interest. Environmental protection and management according to the principles of sustainable development becomes a matter of shared responsibility, for governments, organizations, as well as for individuals.

Projects related to environmental protection undoubtedly belong to the group of projects that have a great social significance. Therefore promotional activities of projects in the field of environmental protection are of particular importance. It is very important to ensure publicity and visibility of such projects. The application of the prescribed rules provides a good visibility, transparency of the project, as well as precise and defined way of representing and promoting the project.

Visibility of IPA Cross-border Cooperation Programme is important for the promotion of the project participants, as well for organizations that support financial the projects implemented within the monitored program. However, the visibility of these projects is important for many other reasons: to inform the public, drawing attention to current problems, providing a good example to community members, educating community members about particular aspects of the project, providing security that people concern about current problems as well as pointing the need for all, in accordance with their capabilities, engage in solving common problems and achieve the objectives of wider public interest.

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IMPLEMENTATION OF THE IPPC AND EU DIRECTIVES IN LAW OF REPUBLIC OF SERBIA

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ABSTRACT

Authors of this paper analyze the implementation of the IPPC Directive (Directive 2008/1/EC concerning integrated pollution prevention and control) in the legal system of the Republic of Serbia, which regulates the system for integrated license acquisition , which includes all relevant environmental issues and ensures that facilities have minimal impact on human health and environment. IPPC Directive in the European Union was firstly presented in 1996, and deadline for its implementation was the end of 2007. In the Republic of Serbia the Directive was implemented by the Integrated Pollution Prevention and Control Act (2004), and the final term for its adoption is the end of 2015. This Law regulates conditions and procedures for integrated licensing process for large industrial facilities and other activities that may have adverse impacts on human health, environment or material goods, types of activities and facilities, surveillance and other important issues concerning prevention and control of environmental pollution. Meanwhile, the European Union adopted a new Directive on industrial emissions (Directive 2010/75/EU on industrial emissions - IED, 2010) which fully replaces the IPPC Directive and six other directives relating to the production of titanium dioxide, emissions of volatile organic compounds, waste incineration and large combustion facilities. This paper presents an overview, dynamics of enforcement and implementation of the legal framework of the IPPC Directive in the Republic of Serbia, but also, authors emphasize the innovations introduced by IED comparing to the Regulation of the Republic of Serbia, as well as the dynamics and prospects of its implementation.

Key words: *Implementation, The IPPC Directive, IED Directive, integrated pollution prevention and control, environmental.*

INTRODUCTION

Nowadays, industrial activities play an important role in the economic development of the EU. However, their impact on the environment is important because the largest industrial facilities have a significant share of the total emissions of major atmospheric pollutants. They also have impact on environment, including emissions to water and land, waste generation and energy use. These are the reasons why for a long time emissions from industrial facilities are the subject of regulation within European legislation. In this area, IPPC Directive is applied and it establishes the basic principles for issuing licences and control of the facilities based on an integrated approach and the implementation of the best available techniques (BAT), i.e. the most effective techniques for achieving a high level of environmental protection, considering the costs and benefits. But, since January 2011 the Directive on Integrated Pollution Prevention and Control (IPPC Directive) has been replaced by the Directive on Industrial Emissions (IED), which will enter into force on 7th of January 2014, along with other directives related to industrial emissions. Its aim is to reduce the pollution coming from various industrial sources throughout the European Union. Operators of industrial facilities whose activities are covered by Annex I of the IED are liable to secure integrated licence from competent authorities in the countries of the European Union.

IMPLEMENTATION OF THE IPPC DIRECTIVE IN THE LEGAL SYSTEM OF THE REPUBLIC OF SERBIA

Directive on Integrated Pollution Prevention and Control (IPPC Directive) in the European Union was firstly adopted in 1996. Final term for implementation of this Directive at national level of the Member States was 30th of October 1999 for new facilities and 30th of October 2007 for existing facilities. The IPPC Direcitve represents a regulated system for issuing a comprehensive, integrated licence in order to prevent and limit pollution from large industrial facilities and agricultural activities. IPPC Directive covers a large range of facilities and activities, starting with energy sector, which includes oil refineries, heat facilities and electricity production, production of metals, mineral processing, chemical industry, meat industry, animal breeding, waste incineration and fuel combustion in large facilities. There are 170 facilities in Serbia which are qualified for issuing the integrated licence.

License ensures that all relevant issues concerning the protection of the environment are included in a single document. Integrated approach includes:

1. Operators must take preventive measures to prevent pollution, especially through the implementation of the best available techniques (Best Available Techniques-BAT)
2. One must not cause significant pollution of air, water, soil, noise, odors
3. Waste that can not be avoided and whose generating is inevitable must be reused or disposed in a proper, safe way.
4. Efficient use of energy has to be ensured
5. All measures for the prevention of accidents must be taken i.e. to restrain all the consequences of accidents
6. The area has to be in a proper state after facility closing

Serbia has achieved a high level of transposition of the IPPC Directive, with the adoption of the Law on Integrated Prevention and Control of Environmental Pollution in 2004 which was followed by the adoption of other related laws and regulations in connection with the IPPC Directive and the specific issues related to the environment in 2009 and that is the reason why it is quite a comprehensive legislative framework.

Following the adoption of Act on Integrated Prevention and Pollution Control, which entered into force in 2004, all subordinate regulations which govern the issuance for licence were adopted.

Regulations

Regulation on the criteria for determining the best available techniques for the implementation of quality standards, and for determining the emission limit values in the integrated license

Regulation on the types of activities and facilities for which the license is being issued

Regulation on the content of measurement program for facilities work adjustment which are set by the rules.

Regulation on the establishment dynamic programming of submission of request for issuance of an integrated license, where the exact deadlines for the submission of applications for certain types of activities.

Ordinance

Ordinance on the content, form and manner of filing the application for the issuance of an integrated license

Ordinance on contents and manner of keeping the register

Ordinance on the contents and form of integrated licenses

It should be noted that prior to all activities related to the adoption of laws and subordinate regulations by the Working Group established by the Minister, a preliminary list of existing facilities on the territory of Serbia has been made, based on the Act on Integrated Prevention and Pollution Control and Regulation on the types of activities and facilities for which the integrated license is being issued. All activities and facilities that are not on the preliminary list, and according to the Regulation on the types of activities and facilities for which the integrated license is being issued are subject to the commitment to acquiring an integrated license are obliged to contact the authorities. According to the preliminary list, expected number of operators in the territory of Serbia is 170.

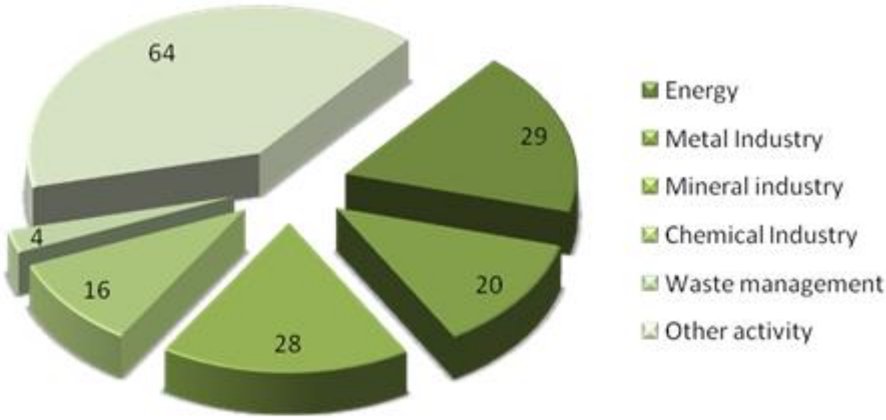

Figure 1. The number and type of IPPC activity in different sectors in RS

The main challenges in this area for further proceedings are mainly related to incomplete national legislation on this specific area, absence of harmonized legislation and incomplete documentation provided by the operator as part of the process of request submission for issuance of an integrated license and insufficient experience with the use of BREF documents and selection of BAT (Best Available Techniques).

One of the problems which often occurs in the process of integrated license acquisition is imbalance of legal deadlines. In fact, the deadline for issuing and obtaining the license is 2015. On that occasion it is expected that the relevant facility or activity already obtained all of the previous licenses, including water license. However one of conditions for obtaining water license is harmonization with the emission limits value. According to the Water Act, operators must adjust their activities and limit values until 31.12.2045. which leads to collision of these two laws and contributes to the fact that the claim for integrated license become incomplete. Also, one of the problems is inconsistent and incomplete application of BAT, which is mainly the consequence of operators inexperience, tight deadlines and lack of financial resources for the implementation of new or modification of existing techniques.

Industrial Emission Directive - IED

While we still struggle to apply current legislation in this area, the EU goes a step further. About 50,000 facilities were covered by the IPPC Directive while IED will include some new activities which would lead to a slight increase in the number of facilities. The European Commission enforced detailed analysis of the quality of issued license that have been given by now, as well as compliance and enforcement procedures adopted by the Member States. Based on two years of data collection as well as of monitoring, examination and consultation with operators four basic problems of applying the IPPC Directive are identified:

1. Insufficient implementation of BAT
2. Constraints in the implementation of environmental protection measures, as well as restrictions in improving the state of the environment
3. Unnecessary administrative burdens due to the complexity and incoherence of the current legislation
4. Insufficient scope and unclear provisions of the existing IPPC Directive that may affect the achievement of specific goals defined by different thematic strategies.

Therefore, new IED Directive is adopted. The aim of the new Directive is to eliminate the disadvantages of the existing legislation concerning emissions from industry. There are 7 Directives which in certain segments overlap and cover similar activities i.e. there are 52000 installations that fall under the jurisdiction of only the IPPC Directive (EU Commission). New IED associates existing IPPC directive and 6 individual sartorial Directives:
Directive 2010/75/EU definitely replaces:

from 7th of January 2014
1.Three Directives regarding titanium dioxide:
- a. Directive 78/176/EEC on industrial waste from the production of titanium dioxide
- b. Directive 82/883/EEC on the surveillance and monitoring of titanium dioxide waste
- c. Directive 92/112/EEC on the reduction of titanium dioxide industrial waste

3. Directive 1999/13/EC on reducing emissions of volatile organic compounds (VOCs)
4. Directive 2000/76/EC on waste incineration
5. Directive 2008/1/EC concerning integrated pollution prevention and control

from the 1st of January 2016
6. Directive 2001/80/EC on the limitation of emissions of certain pollutants from large combustion facilities.

IED entered into force on 6th of January 2011 and the final term for its transposition into national legislation of the Member States was on 7th of January 2013. Final term for a full replacement i.e. cessation of validity of six sectoral Directives is on 7th of December 2014, except for the LCP Directive, which will be abolished on the 1st of January 2016.

Innovations introduced by the EID are based on 5 principles:

1. **Integrated** approach involves a comprehensive view of the performance of industrial facilities which have environmental function which includes emissions to air, water and soil, waste generation use of raw materials, energy efficiency, noise, prevention of accidents as well as taking measures for environmental protection after facility closing, with the aim of ensuring a high level of environmental protection as a whole.

2. Terms that are defined in the license and which include emission limit values should be based on the usage of **BAT**, as defined in the IPPC Directive. However, the concept of BAT has been improved and clarified. Decisions that set up conditions that are not defined by BAT can be made only in specific cases and must be verified and documented. Also, the directive tightens current emission limit values for large combustion facilities in order to ensure the achievement of goals defined by Commission in the Thematic Strategy on Air Pollution.

3. IED contains certain elements of **flexibility** that allow authorities who give licenses to set up less strict emission limit values in specific cases. This measure is applicable only when specific assessment procedures come to conclusion that achieving the emission levels, which are caused by applying BAT technologies, contributes disproportionately higher costs compared to the environmental benefits due to:
- Geographical location or local environmental condition
- Technical characteristics of the facility

However, in case of a situation when it is necessary to make such an exception it is required that the authority in charge of licensing, documents explanations of the reasons for such a decision as well as the results of cost-benefit analysis.

4. Through the IED, facility **inspection** is systematically carried out by the inspection plan which is adopted at the national, regional or local level which includes a general assessment of the significant environmental issues, geographic area covered by the inspection of the Registry of installations

covered by the plan, procedures for routine and non-routine inspections, etc. Based on these plans, programs that include routine inspections which include the frequency of visits that can occur once in a year or once in the period of three years depending on the risk level of the installation , are combined. Facility risk level is determined on the basis of several factors:

- The potential and real impact of facilities on human health and the environment
- Data on compliance with the measures that are defined in the license et al.
- Operators participation in environmental management system (EMAS)

5. The Directive also provides **public participation**. It is based on the principle that the public has a right to participate in decision-making and to be informed about the consequences. Public participation includes providing access to:

- Application for licensing and the possibility of expressing their own opinion about the same document
- License itself
- The results of monitoring discharges
- EPRTR register (European Pollutant Release and Transfer Register) which is available to the public in order to keep the public informed about any major industrial activities and their impact on the environment.

IED directive is much more comprehensive and therefore more extensive than the IPPC Directive, because according to its structure, besides general provisions of the aims and goals of the Directive, the definition, the licensing process and content of the license, BAT, public access, it also contains concrete provisions concerning particular installation and emission limits value for the those facilities (Table 1).

Table 1: Structure of the EID and IPPC Directive

IPPC	***IED***
Chapter I-common provisions	
	Chapter II- provisions for activities listed in annex I
	Chapter III- special provisions for combustion plants
	Chapter IV- special provisions for waste incineration plants and waste co-incineration plants
	Chapter V- special provisions for Installations and activities using organic solvents
	Chapter VI- special provisions for installations producing titanium dioxide
	Chapter VII-committee, transitional and final Provisions
Annex I- categories of industrial activities referred to in article	
Annex II- indicative list of the main polluting substances to be taken into account if they are Relevant for fixing emission limit values	
Annex I list of directives for determination some limit values	Annex III- considerations which should be taken into account generally or in specific cases when determining best available techniques

Table 1-countinued

Annex IV public participation in decision-making	
	Annex V-technical provisions relating to combustion plants (Limit values, monitoring,...)
	Annex VI-technical provisions relating to waste incineration plants and waste co-incineration plants
	Annex VIII- technical provisions relating to installations and activities using organic solvents
	Annex VII- technical provisions relating to installations producing Titanium dioxide
	Annex IX - replaced directives
Annex V –correlation table	Annex X- correlation table

Also, the IED directive is expanded in terms of additional types of installation, which can affect environmental pollution and with its licensing many benefits in terms of protection of human health and the environment can be obtained. This extension applies to:

- Combustion facilities between 20 and 50 MW
- Production of wood-based panels and wood preservation
- Certain activities that are already included in the IPPC Directive and relates to waste treatment and food production activities.

With the adoption of the new IED directive, as stated earlier, IPPC Directive and six sectoral directives cease to be valid. In the Republic of Serbia the Law on the pollution prevention and control is still applied. This law is based on the old IPPC Directive, so that the transposition of the IED Directive into national framework Serbia would include amendments on the set of laws and regulations that, in some way, along with the Law on Integrated Pollution Prevention and Control, regulates the licensing of companies and certain activities.

Table 2 gives a parallel overview of the EU Directives which are being abrogated with the introduction of the IED Directive and the Regulations of the Republic of Serbia which regulate same areas that should be most affected by the change.

Table 2: Parallel overview of the EU Directives and the regulation of the Republic of Serbia

EU Directive	***Regulation of the Republic of Serbia***
Directive 78/176/EEC on titanium dioxide industrial waste; Directive 82/883/EEC on the surveillance and monitoring of titanium dioxide waste; Directive 92/112/EEC on the reduction of titanium dioxide industrial waste	Act on waste management Regulations on the procedure for the management of waste from titanium dioxide, control measures and environmental monitoring on the site
Directive 1999/13/EC on reducing emissions of volatile organic compounds (VOCs)	Act on air protection (article 44) Regulation on the list of industrial facilities and activities that control emissions of VOCs, the limit values of the VOC in a given solvent consumption Regulation on technical measures and requirements relating to the allowed emission factors for VOC, which come from the process of storage and transport of petrol

Table 2-countinued

Directive 2000/76/EC on waste incineration	Act on waste management Regulation on type of the waste for thermal treatment, conditions and criteria for determining the location, technical and technological requirements for the design, construction and equipment of the plant for thermal treatment of the waste and treatment of residue after combustion
Directive 2008/1/EC concerning integrated pollution prevention and control	Act on integral pollution prevention and control Regulation on the criteria for determining the best available techniques for the implementation of quality standards, and for determining the emission limit values in the integrated license Regulation on the types of activities and facilities for which the license is being issued Regulation on the content of measurement program for facilities work adjustment which are set by the rules. Regulation on the establishment dynamic programming of submission of request for issuance of an integrated license, where the exact deadlines for the submission of applications for certain types of activities Ordinance on the content, form and manner of filing the application for the issuance of an integrated license Ordinance on contents and manner of keeping the register Ordinance on the contents and form of integrated licenses
Directive 2001/80/EC on the limitation of emissions of certain pollutants from large combustion plants	Act on air protection Regulation on emission limit values of pollutants into the air

Considering the mentioned specific features harmonization and adjustment were required so with the support of the EU Delegation, a new project was formed in Serbia: “Implementation of legislation in the field of industrial pollution control, chemical accident prevention and establishment of environmental management and verification system (EMAS)”. (IPPC Serbia)

The aim of this project is to build and strengthen the capacity to implement legislation that is harmonized with EU directives in the field of the environment, especially in the integrated pollution prevention and control (IPPC), chemical accident prevention and establishment of Environmental Management and Verification System (EMAS).

With transposition of the new IED Directive in Serbia, it should be provided improvement of the of national legislation, better understanding of the preparation and analysis for licensing, in order to raise the quality of requirements and licenses, as well as specific tools and guidelines for the implementation of BAT.

CONCLUSION

The Directive on Integrated Pollution Prevention and Control (IPPC Directive) represents a regulated system for issuing a comprehensive, integrated license in order to prevent and limit pollution from large industrial facilities and agricultural activities. IPPC in the European Union was firstly adopted in 1996. Final term for implementation was 30th of October 1999 for new facilities and 30th of October 2007 for existing facilities.

Serbia has achieved a high level of transposition of the IPPC Directive, with the adoption of the Act on Integrated Pollution Prevention and Control in 2004. While Serbia still applying IPPC legislation in this area, struggling with the incomplete national legislation on this specific area, incomplete documentation provided by the operator and use of BAT, EU goes a step further. After a comprehensive analysis, EU have identified a need for a new Directive. IED entered into force on 6th of January 2011. with aim to eliminate the disadvantages of the existing legislation concerning emissions from industry, replacing 7 existing Directives which in certain segments overlap and cover similar activities. IED is much more comprehensive and therefore more extensive and brings innovations which are based on 5 principles: integrated approach, improved and clarified BAT concept, flexibility, inspection and public participation. Concerning Serbian IPPC legal framework, IED will certainly provide some changes since the Act on Integrated pollution prevention and control is complex and comprehensive including a number of additional Acts and by lows which should be revised in following period.

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ECONOMICS OF SUSTAINABLE DEVELOPMENT OF URBAN AREAS

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ROD PICKER – A NOVEL SOLUTION FOR SHORT ROTATION COPPICE PLANTATIONS

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ABSTRACT

This paper presents the concept of an industrial machinery designed for fast and precise processing of wooden rods produced in Short Rotation Coppice (SRC) farms. This machinery is called the “ROD PICKER” and is the results of the collaboration between six partners from four different countries: Egedal Maskinfabrik A/S - Denmark, Salix Energi Europa AB - Sweden, Lempe Gbr - Germany, TTZ Bremerhaven – Germany, T.U. Dresden – Germany and U.P. from Timisoara – Romania. In Europe, biomass is undoubtedly seen as an important source of energy. Wood biomass represents approximately 85% of the total biomass production. Consequently a lot of pressure is directed towards domestic forest resources, fact which impacts an already limited growth potential. A viable solution comes from fast growing tree species (Willow, Poplar or Eucalyptus). These trees can be quickly harvested with the purpose of bio-energy production. Producing this type of resource requires a complex industrial process and includes operations of harvesting, sorting cutting, bundling and packaging. Currently, a lot of this work is performed manually. So the need for automation has become an obvious task. The proposed “ROD PICKER” is designed as to automatically perform rod processing activities and thus improve production performance in the SRC farming process. The paper is focusing on the novel solution proposed by the author for the mechanical and computational (electronic) part of the machinery designed, in novel concept, for the automatic harvesting, selection cutting and bounding of the SRC rods.

Key words: *SRC nurseries, rod processing equipment, biomass, energy plants.*

INTRODUCTION

In recent years, biomass has become an important player in the overall renewable energy sources. Regarding this aspect the European Commission (EC) has established several guidelines which need to be met by the year 2020. First, the energy coming from renewable sources needs to reach a 30% value in the overall consumption. This translates to an increase in renewable energy contribution from all member states. If in 2005 renewable resources accounted for 8.5% of the total energy sources, by 2020 the common share of these resources will increase to 20%. Furthermore, in the EU, there is a recommendation for tripling the use of biomass energy in the process of exploiting renewable resources. Biomass represent aproximately one third of total renewable energy sources. Wooden biomass counts for 85% of the total biomass production so a constant pressure impacts the domestic forest resources. On the long term, traditional wood industries will exceed the natural growth potential of existing wood sources. This perspective has caused a change in political vision. Increased attention has been focused on exploiting fast growing trees species like willow, poplar or eucalyptus.

Short Rotation Coppice (or SRC) farms are defined as efficient biomass production sources with a rotation period of under 30 years. High density tree species provide the means of obtaining biomass (bio-energy source) and also contribute to the protection of soil. In the EU, an analysis of the demand for such SRC farms has led to the conclusion that in the next 10 years more than 176,000 hectares are necessary. This means that current plantations will increase by 30 % in size, yearly, for the following decade. Willow and poplar are the predominant species which are being harvested. The basis of any SRC farms resides in the planting material (or cuttings). Presently, after harvesting the wood material during winter months, cutting of plants at specific dimensions is done manually. With obvious limitations, this manual labor is to be replaced by an automated process which integrates the latest industrial technologies with the purpose of increasing biomass production efficiency.

The proposed device is called the "ROD PICKER" and it is destined for automatic processing of harvested rods. This equipment includes operations of cutting, sorting, bundling and packaging of freshly harvested rods. It will be distributed to the SRC farming industry with a target efficiency improvement of 60% regarding wood processing costs. A reduced number of workers will help with the machine maintenance and will perform loading of rods. In the end two key aspects will be addressed by this prototype machinery. First of all, process automation and increased rod processing speed will help farmers obtain better production results. Secondly, the SRC machinery market will benefit from an innovative tool which could help increase the overall wooden biomass production by 30% (Christersson, 1998; Eurelectric, 2011; EEA, 2008; Ionel et al., 2013).

The remaining part of this paper is organized as follows. Section II presents an overview of the system for the rod processing operations. Section III discusses proposed technical approaches, measurement technologies and implementation details. Conclusions concerning both the functionality performance and the future developments are mentioned in the final section.

GENERAL OPERATION PRINCIPLES FOR THE PROPOSED "ROD PICKER" CONCEPT

Implementation Key Requirements

The research and implementation teams, consisting of mechanical, computer science and electronics engineers, identified two key machines which needed to be built in order to achieve the project goals. First, a mobile machine that is powered by a tractor and is destined for harvesting the rods. This process consists in cutting, transportation and hydraulic unloading when the transport platform is full. The second equipment is fixed (placed in the farm center near the place for cold storage) and performs operations of sorting, cutting, gathering, bundling and packaging of the previously unloaded rods.

Figure 1 presents the schematics for the work flow of the proposed solution. The two main units perform different actions which together constitute the rod processing production process. Unit I is mobile and it was designed and implemented at the partner from T.U. Dresden – Germany. Unit II is fixed and it was designed and implemented at the partner from U.P. Timisoara – Romania. All other project partners contributed to this development with design ideas, specific industry requirements, own experience based advice and technical support.

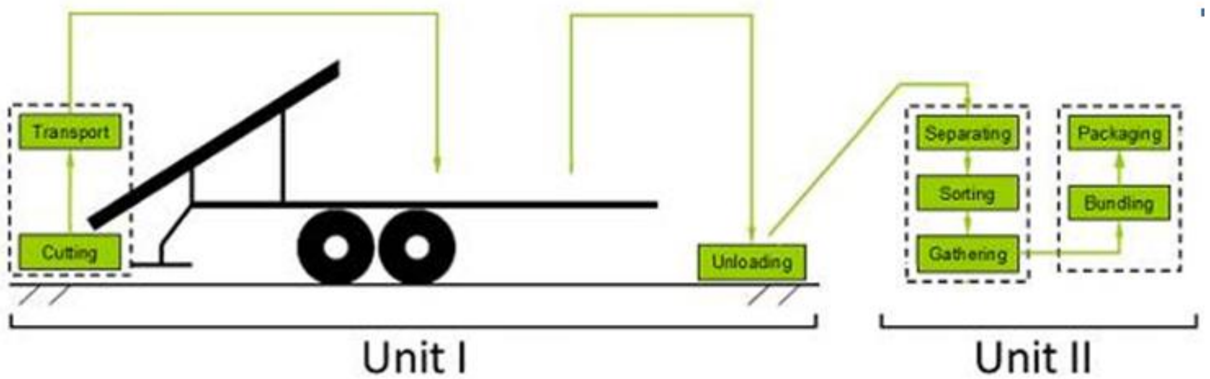

Figure 1. Proposed "ROD PICKER" prototype concept

Figures 2 and 3 present the expected results of using the Unit II multifunction machinery. Freshly harvested rods (output from Unit I) will be prepared for the *separating, sorting, gathering, bundling* and *packaging* stages. Currently these actions are performed manually. The final result, still in study form, should be a collection of labeled boxes, containing the rods as presented in Figure 3 and having all the necessary information automatically printed on a label. This information contains the number of processed meters of wood and an identification box number.

Figure 2. Freshly harvested rods resulted from UNIT I

Figure 3. Bundled rods prepared for shipping

In accordance with the input provided by experienced SRC farmers, the “ROD PICKER” implementation teams established other characteristics which the prototype should contain. The target tree species are Salix spp. and Populus spp. Selected rod diameter will be between 7 mm (minimum) and 25 mm (maximum). The length of the rod will be between 1.2 m (minimum) and 2.3 m (maximum). Consequently, the processing module will start to cut at 25 mm diameter and at 2.3 m length using all rods. There will be two groups of rods: 50 rods when harvesting Salix spp. and 25 rods when harvesting Populus spp.

It shall detect and sort out damaged rods autonomously. Automation with the help of sensor information will remove clippings and damaged rods. In this case, it is possible that some rods will be more curved and with additional smaller branches, the selection (as previously mentioned) cannot be possible in all situations and loses may increase. Rejected cuttings will be stored in a separate container for ulterior energy recovery.

Regarding the efficiency of the proposed machine, some details about the performance of the processing process are:
- Currently, at the Lempe partner, 6 people process 2 boxes/day (one box contains 5000-6000 m, about 3000 rods).
- For the proposed project the team targets more than 2 boxes/day with less than 6 people operating the machine.

Functionality of the Modules

For Unit I, there are several technical features which were discussed. Some minimal characteristics are: it is a trailer mounted device, a circular saw will cut the rods, conveying of rods is achieved by a burling belt and generated waste (clippings) will be collected by a suitable collector.

Unit II is a complex equipment which includes the modules presented in Figure 4. A loader (could be more, because the system is designed in modular a concept and could be extended in parallel for more processing lines) will ensure that the machine is supplied with harvested rods. The sorting and cutting module includes a single buffer module, a single supplying module and a single binding module. After bundling, the rod packets could be put in boxes, in alternative positions, for efficient usage of the space. An operator controls and insures that the process runs as expected.

A secondary cutting unit will be installed between separations and sorting. After passing through an optical analysis system (video inspection) the rods with additional smaller branches or significant curves will be cut off to the right size as well as shape.

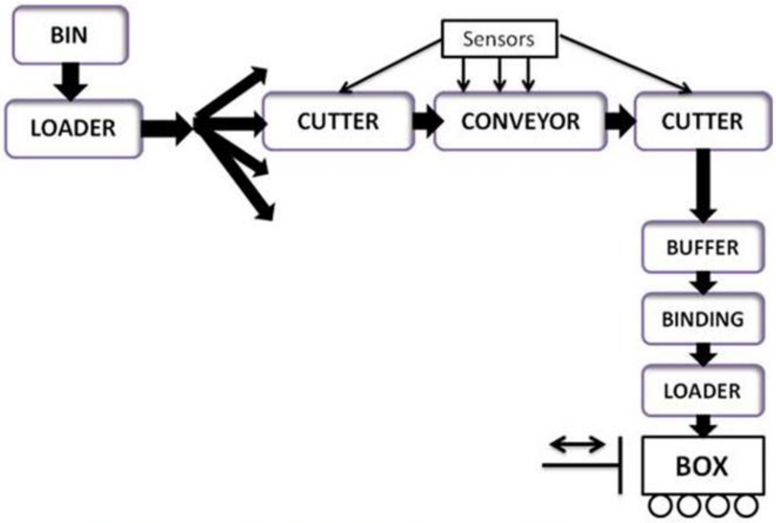

Figure 4. Sorting and Packaging Module Schematics

The first step is a single processing line design. Later the number of lines will be increased (marked with multiple arrows in Figure 4), in accordance with functionality testing and experimental results. A conversion to automatic loading will also be considered if the machinery performs as expected.

The end user benefits from a control panel which displays basic parameters like: species, processing speed, rod length, rod diameter, number of processed rods and meters of processed rods.

The sorting and packaging component for Unit II is presented in Figure 5.

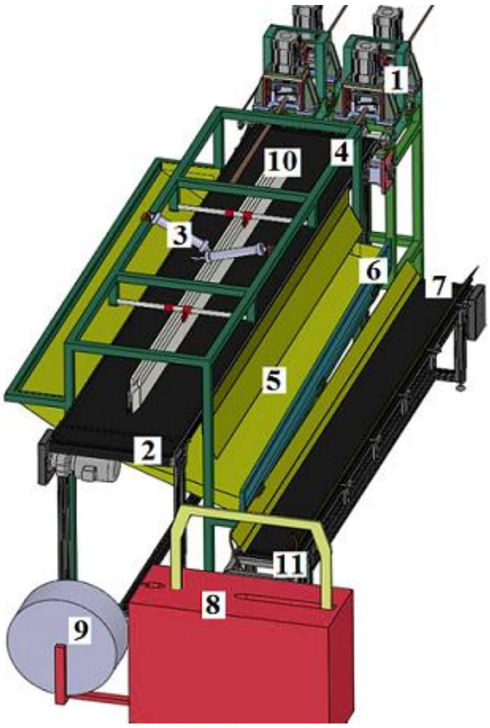

Figure 5. Sorting and Packaging Component: 1 - Measuring and cutting module; 2 - Conveyor and selector; 3 - Air cylinder; 4 - Selector skeleton; 5 - Inclined plane; 6 - Rods stopper; 7 - Buffer conveyor; 8 - Bundling machine; 9 - Band Supplier; 10 - Separator and ejector; 11 - Nippers

The concept for the measuring and cutting module is presented in Figure 6. It includes: cutting units, powering units and measuring units. This part is absolutely new, designed for the first time, based on the production values analysis and end users operation conditions.

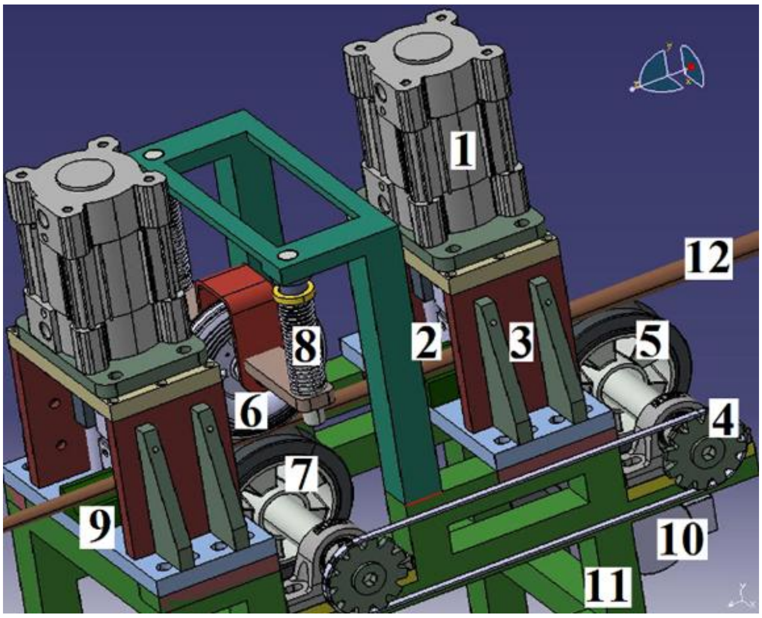

Figure 6. Measuring and Cutting Component: 1 - air cylinder for blade powering, with a full command system (electro-waves, distributor, air splitter, support etc.), 2 - blade and it's support and guiding, 3 - cutting skeleton, 4 – rotary wheels for belt movement, 5,6,7 – rod guiding wheels (fixed and mobile), 8 – fixing spring, 9 - opposite blade ensemble, 10,11 – frame components

The cutting cycle is less than 1 s and allows cutting forces of up to 8 kN. The powering part is used for the rod movement in conditions of adjustable speed. A Control Unit ensures that the functionality of Unit II is in accordance with required specifications. Figure 7 presents the principle of operation for the Control Unit. It includes the Operator Panel KP300, monochrome which was connected to the PLC (S7 - 1200) currently only for minimal functionality and testing purposes. The Main Motor (1FL-5060, 4A, 4 Nm, N max=2200 rot/min, N nom=2000 rot/min) is controlled by a Sinamics V60 Motor Driver. This Driver is supplied by 3x230VAC and a 24VDC industrial power supply

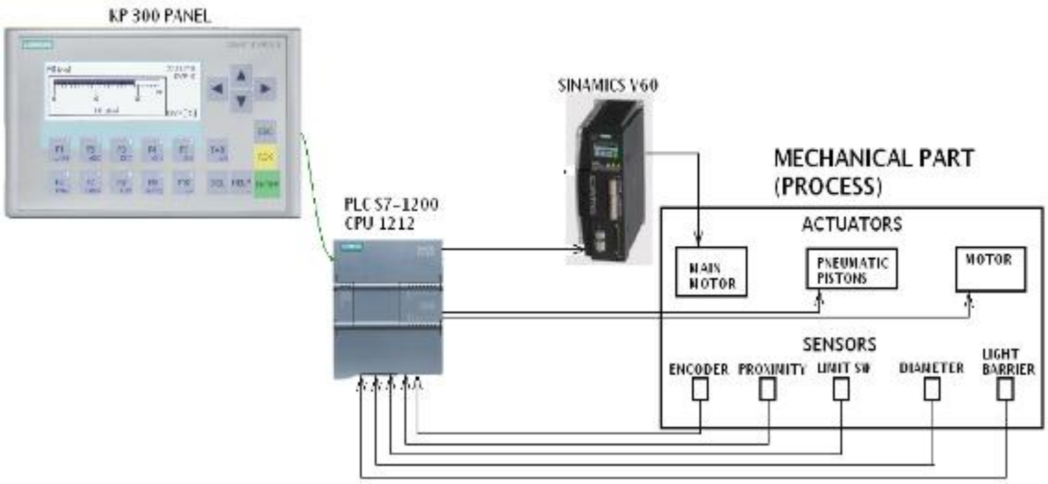

Figure 7.Control Unit Schematics

During the mechanical design activity, it has been discussed about the opportunity of using different types of different sensors and actuators, useful for monitoring the functions of the machine. Furthermore, an extra function of the Control Unit is to periodically perform an auto diagnose of the whole system. This task implies more sensors, increased complexity of the control algorithm and issuing of alarms (lights, sounds, messages on the Operator Panel, accompanied or not by the stop of all operations).

Sensors and Proposed Integration

One of the most important functions performed by Unit II is the function of rod diameter measurement and precise cutting. For this purpose two solutions were discussed.

The first one involves the LeanXCam (Figure 8) device with on board signal processing which can take up to 60 images/s. These images have to be processed and the detection of the target diameter has to be signaled. It will also detect any damaged rods and generate a signal which triggers the cutting (removal) of the unwanted part. Image processing needs to be synchronized with the speed of rod movement along the processing line. A problem which could affect the measurement accuracy of this approach is the environmental conditions in which the cameras operate. For example, dust particles resulting from rod cutting operations might cover the lens and thus cause unwanted image blurring. For solving this issue an automated air cleaning system will be integrated.

A second approach focuses on the Omron ZX-GT28S41 system (Figure 9). In the image presented below one can see the system during the testing and calibration period. The response of this device (proportional to encountered diameter) is in the -4 V to 4V range. The team decided that working with a voltage response instead of current is more appropriate for this project. The device will be installed on the cutting module and tested in parallel with the video cameras. In this way, experimentally, our team will determine which solution is more suitable for the prototype.

Figure 8.LeanXcam Device

Figure 9. Testing of the ZX-GT28S4 prior to integration

The implementation team has studied optical and inductive sensors (different types) for presence and length detection, warning lights for trouble signaling, limiters, switches, industrial power sources and emergency stop buttons. This was necessary since interfacing and communication between the PLC and different sensors is mandatory. The following paragraphs explain the most important sensors which have been considered for the system.

Two types of photoelectric sensors have been studied and will be used for rod passing detection and for self diagnosis purposes. The Omron E3JM (Figure 10) contains a built in relay which switches when an object (in our case the rod) passes through the detection area. The timer function of this sensor will be used for self diagnosis purposes. For example, if for a certain period of time the blade which cuts the rods has not passed in the monitored region this sensor will trigger a malfunction alarm (the blade is jammed). The Omron E3F2 cylindrical and rugged sensor (Figure 11) with beam trough action has also been tested and will be included in the cutting and sorting module. This model of sensor will be used for malfunction detection along the movement line. If the rod movement is continuous and unaffected by a system malfunction it will pass trough presence detection check points, implemented with this sensor.

Figure 10.The E3JM during functionality testing

Figure 11. The E3F2 during functionality testing

Also, the Omron E6B2 encoders (Figure 12) are necessary because the speed of the cutting line must be known. The main purpose of studying this variable is the synchronization between the diameter measurement and the actual precise cutting. Between the moment when the target diameter value is detected and the moment when the cutting system will start the cutting procedure timing is essential. So knowing the speed at which the rods travel is mandatory. A secondary reason for knowing the movement speed knowing/estimating how many rods wills each production line process in a given amount of time. Rod speed and length will be double checked by the Omron E32 area monitoring system (Figure 13).

Figure 12.The E6B2 during functionality testing

Figure 13. The E32 during functionality testing

For safety reasons, the system integrates optical curtain sensors, emergency pushbuttons and a warning light column. We have been able to determine the functionality of these components and to establish what role they will play in the cutting process. If for some reason the system operator decides to abruptly stop the process all it will take is a push of a button and the PLC will stop the motor. These devices will be integrated in the final stages of project implementation. Their functionality will be doubled by the optical sensors, previously mentioned, which will be used for self diagnostic operations

Other devices contribute to the command of the system and to the execution of other operations (for example checking if the system cover doors are closed – safety issue) are presented in the following images. These are common automation components and will be spread on the cutting and sorting module chassis as our work progresses. Inductive sensors (E2A-M12KS04 type) will be used to check the integrity of the system metal casing. Also they can be used (if necessary) for checking the correct movement of the rod pieces selector. The D4B safety limiting switches and the D4BS door switches will be used for chassis integrity verification and will be integrated in the final stage of project implementation

SELECTED EXPERIMENTAL RESULTS

One of the most important components which have been tested is the SIMATIC S7-1200 PLC from Siemens (CPU1212 with 8 DI, 2 AI and 6 DO). The PLC was connected to a 230VAC wall outlet and to an Ethernet connector to a Notebook. Using STEP7 Totally Integrated Automation Portal (TIA), the PLC was connected to Laptop and programmed with some basic examples. The development stand is presented in Figure 14. Figure 15 presents the command connections between the Main Motor, the power supply and the PLC. Testing was started without connection to PLC. The messages on SINAMICS screen were obtained (S2 and S3 messages), and the next step is to make the motion program on PLC (using a library module) and connect to the Motor.

Figure 14. The E6B2 during functionality testing

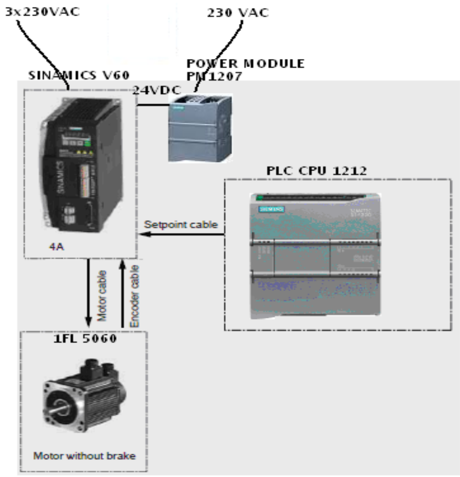

Figure 15. The E32 during functionality testing

For video inspection functionality using the LeanXcam the camera was connected to a computer, and a program was loaded on it. Our team is working on the functions to read the dimension, to send a digital signal when the size is outside the limit and also to detect branches on rod. It was rather difficult to connect it as the camera works on LINUX system and the connection is over LAN. The compatibility with a Windows based PC required difficult setup operations.

Testing of electronic sensor components was performed in order to determine which working scenario is more appropriate for the envisioned task. Overall power consumption (voltage and current requirements) was another study direction for our team. It is important to determine particular power requirements for each sensor in order to be able to integrate these devices with the cutting and sorting module. Each component was studied in order to see how it responds to commands, what type of signals it takes at the input and what type of response it provides.

The cutting mechanism has been tested since knowing the required cutting force is necessary. These results have been presented by Tucu et al., 2013. Figures 16 presents testing of cutting mechanism performed in the laboratory. They were completely cut without damaging the wood structure with a diameter of up to 30 mm. Rods with a diameter larger than 30 mm were not entirely cut. The reason for this is mainly due to the low distance between the blades. The cutting areas were smooth for all three diameter levels and without fraying or chips. In order to create qualitatively high plantlets, this smooth and undamaged cutting area is essential.

Figure 16. Testing of the cutting mechanism (side and front views)

CONCLUSIONS AND FUTURE WORK

This paper presents the design for a machine prototype, called the “ROD PICKER” which will be used in energy plants farms with SRC. The proposed system is currently under development. The project team is the result of cooperation between three private companies, one technology transfer institute and two technical universities. The purpose of undertaking this project is determined by economical factors related to the efficiency of freshly harvested rods from SRC farms. There is an urgent need of automation in the production process for fast growing plants since this contributes to biomass sustainment. An increased speed in production will generate a higher and more efficient throughput. The quantity of fast growing species, prepared for market distribution will increase thus impacting the overall biomass production resources.

Researchers, engineers and experienced people working in energy plants production have agreed upon the functionality principles of the system. The implementation requires knowledge in mechanical engineering, computer programming, sensors, measurement systems or image processing. Experimental results already achieved confirm that the proposed solution is viable.

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CLEAN TECHNOLOGIES AND REGIONAL ECONOMIC DEVELOPMENT

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ABSTRACT

Clean technologies represent the result of innovative action but they also imply simultaneous action in the field of the economy and environmental protection. This sector will represent one of the pillars of global economic development in the future. The clean technologies sector facilitates stable prices, especially in the energy sector, stimulates employment and promotes regional development. Based on available literature, statistical indices and personal research data the authors of the paper present a review of the impact of the clean technologies sector on regional economic development. Special attention is paid to the countries of the West Balkan region and Serbia.

Keywords: *clean technologies, economic development, environmental protection, regional development*.

INTRODUCTION

The most rational is production without any waste, in other words, production in which raw materials and energy are fully used. Such technology is environmentally safe. The idea of "absolute", "closed" and "clean" technologies appeared in the 1980s. Developed countries were not ready to invest in the seemingly non-productive development of these technologies in the early 90s and newly industrialized countries were at the beginning of their economic growth, therefore it was more cost effective to invest in traditional technologies. The development of clean technologies is believed to have accelerated under the influence of six factors – the 6 Cs: **C**ost, **C**apital, **C**ompetition, **C**hina, **C**onsumers and **C**limate (Pernick & Wilder, 2008, p.3). These six factors have brought clean technologies to the centre of attention on a global level.

The notion of clean technology includes every product, service or process which can bring usable value along with (or without) the minimum use of resources that cannot be recycled and/or that produce considerably less waste compared to traditional technologies (Pernick & Wilder, 2008, p.2). Clean technologies include a wide range of products and services, from solar power systems to hybrid electrical vehicles. Such products:

- use recycled materials and power sources or reduce the use of natural resources by using them more efficiently,
- reduce or eliminate pollution and toxic waste,
- offer identical or better performance than traditional products,
- provide investors, companies and customers with fast turnover, reduced costs and lower prices,
- open new businesses in the field of management, manufacturing and development.

Clean technologies cover 4 fields: energetics, transportation, water supply and materials. Revenue from the clean technologies market increased by 11.4% in 2009, reaching a total of 139.1 billion USD (Celan Edge (ed.), 2010). The clean technologies sectors – wind power, bio-fuels and solar energy – cumulatively recorded an increase, whereas the solar panel market recorded a fall for the first time since 2000. In 2009 the bio-fuels market (ethanol and biodiesel) reached a value of 44.9 billion USD, and according to expectations, this market will generate an income of 112.5 billion USD in 2019. The wind power market reached a value of 63.5 billion USD in 2009 and is expected to generate 114.5

billion USD by 2019. The solar panel market (PV panels) generated 30.7 billion USD in 2009 and this market is expected to generate 98.9 billion USD in 2019. Taking into account the aforementioned data, the income value of only three clean technology sectors– solar energy, wind power and bio-fuels will be approximately 330 billion USD.

There are eight leading clean technology sectors (Pernick & Wilder, 2008, p.22) which offer the greatest possibilities to potential investors. They are:

1. Solar energy,
2. Wind power,
3. Bio-fuel, bio-material,
4. Green buildings,
5. Personal transport,
6. Intelligent networks,
7. Mobile applications,
8. Water filtration.

CLEAN TECHNOLOGIES AND REGIONAL MARKET DEVELOPMENT

The hope of the global economy lies in enabling certain regions to bring wealth from the rest of the world. In order to achieve this, these regions have to be equipped with highly educated and disciplined people led by a visionary leader, capable of communicating with the rest of the world (Ohmae, 2007, p. 256). Some of these regions are: Hainan Island (South China, Guangdong Province), Vancouver and British Columbia (Canada), Estonia, Ho Chi Minh City (Vietnam), Sakhalin Island (Russia), Sao Paolo (Brazil) and Kyushu (Japan). Ten regions in the field of development stand out in the clean technologies sector, They are: Austin (Texas, USA), Chicago (USA), Freiburg (Germany), New York (USA), Vancouver (Canada), Hyderabad (India), Copenhagen (Denmark), Portland (USA), San Francisco (USA) and Shanghai (China), (Pernick & Wilder, 2008, p.253).

Austin has the biggest distributor of green energy in the US, in Chicago buildings and public areas are greening according to plan, which all contributes to the promotion of tourism (congress tourism) and retail improvement. Freiburg (Germany, south-west, approximately 200,000 inhabitants) is the centre of the solar panel industry in Germany. Germany is the first country in the world in the usage of solar energy with over 150 factories which produce solar panels and other equipment and Freiburg is the centre of it. In New York, they insist on public transport, the construction of green buildings and the improvement of power efficiency. Vancouver is well-known for the use of bicycles- over 20% of the population ride bicycles to and from work and all of them use ecological products and invest part of the profits from them in environmental protection. In Hyderabad, there are over 100 bio-technological companies in the Genome Valley and a new nanotechnological park on over 350 hectare has been built. Hyderabad has also begun to produce bio-fuel. Denmark is the world leader in the amount of wind power production per capita – over 30% of the total energy need is produced in wind turbines. Half of the biggest land windmill section on Middelgrunden Windmill farm, whose total power is 40 MW and which is 3 km from Copenhagen harbour, is owned by a local wind power cooperation; about 9,000 people are members of this cooperation and they are mostly from Copenhagen. Portland occupies first place in the US for the number of green buildings and it is the first city in the US where all cars bought after 2007 must use biodiesel or ethanol. San Francisco is near Silicon Valley and the owners of large capital there are ready to invest in clean technologies. Shanghai is working on the experimental building of the biggest eco-town, Dongtan, located on the island of Chongming on the river Yangtze – it is a town with 500,000 inhabitants. The town will produce all the energy for its needs and the biggest part of it will come from wind power (wind turbines). The British corporation, Arup, the constructor of this town, believes that this future town should become a blueprint on the global level.

Pernick and Wilder (2008, p.278) propose a six point action plan which incorporates the activities of companies, entrepreneurs, investors, communities and other interest groups in order to build a collective future based on clean technologies:

1. Expansion of investment scope,
2. Development of regional centres of clean technologies,
3. Redirection of subsidies from conventional energy sources to clean technologies,
4. Support for this new economy by giving it large and long-term multi-billion USD funds,
5. Introducing "sinful" taxes and emission quota trading related to hydrocarbon fuels,
6. Education and cooperation in the field of clean technologies.

THE IMPLEMENTATION POSSIBILITIES OF NEW TECHNOLOGIES IN COMPANIES FROM COUNTRIES IN TRANSITION

In Eastern and Central European countries which previously belonged to the realm of socialism the transitional process began more than two decades ago. In some of these countries the process has been completed but in others it is still in progress, like in the countries of the West Balkans.

The competitive ability of companies from transitional countries, especially those from the West Balkans, is exceptionally unfavourable in terms of their reputation on the world market. The ranking of West Balkan countries according to competitiveness in 2008 to 2012 (report on global index competitiveness by the World Economic Forum) is presented in Table1.

Table 1: Ranking of West Balkan countries according to competitiveness in the *period 2008-2012*

Country	**Place in 2008**	**Place in 2009**	**Place in 2010**	**Place in 2011**	**Place in 2012**
Slovenia	42	37	45	57	56
Montenegro	65	62	48	60	72
Croatia	61	72	77	76	81
Macedonia	89	84	79	79	80
Serbia	85	93	96	95	95
BH	108	109	102	100	88

West Balkan countries have not achieved significant results relating to competitiveness (except Slovenia, an EU member, but it serves here as a parameter for comparison – because of its geographical vicinity and historical and economic ties).

Most business organizations from countries in transition in which domestic capital is predominant have considerable financial problems, especially concerning investments in new equipment and new technologies. The global economic crisis has increased this negative influence on the process of investment in business organizations from transitional countries.

According to some opinions (Đorđević, Andjelkovic, & Bogetic, 2001), regardless of their current market position and financial power, the majority of domestic companies should design and define their basic business postulates in a new, more efficient way. The most important transformation is ownership transformation, followed by market, technological and organizational transformation. Ownership transformation is essentially a single one whereby predominantly state capital is transformed into private capital. However, when this is completed and the market economy has been established, organizational and technological transformations become permanent, so changes in this field must follow the changes in the global economy.

The data related to the implementation of integrated management systems tells us the most about the organizational development of business organizations from the West Balkan region. Table 2 presents the number of certified companies from West Balkan countries in 2008 (the data for SA 8000 are from 2009). As can be seen from the table, Romania and Hungary have the greatest number of certified companies when compared to the neighbouring countries. Romania is the first country in terms of the number of certified companies, especially concerning the implementation of the following standards ISO 14001:2004, ISO 27001:2005 and SA 8000.

Table 2: Number of certified firms for 2008 (ISO (ed.), 2009)

Country	**ISO 9001:2000**	**ISO 14001:2004**	**ISO 22000:2005**	**ISO 27001:2005**	**SA 8000**
Albania	43	0	0	4	0
BosniaandHerzegovina	811	60	0	3	0
Bulgaria	5,323	321	23	223	2
Croatia	2,302	343	10	88	5
Hungary	10,187	1,834	135	87	0
Montenegro	160	17	0	9	0
Romania	10,737	3,884	44	347	35
Serbia	2,091	176	0	17	1
Slovenia	1,945	672	16	12	1
Macedonia	271	26	4	19	1

Mahajan (Mahajan & Banga, 2007; Developing countries, 2009) says: "The state does not make business chances. Entrepreneurs make them. Whatever the state does it must stimulate entrepreneurship. On this exceptionally competitive market it is important what entrepreneur has better ideas and who knows how to realize them better. Entrepreneurship is not the monopoly of the French, Germans, Americans, Chinese or Indians. The region of the West Balkans is full of entrepreneurs. The problem lies in the fact that these countries are small. They are faced with the challenge – how to grow further? For further growth they need a global vision; they must turn towards the rest of the world and try to find chances on the global level."

Serbia has all the preconditions to become one of such regions in the near future provided one condition is met: domestic businessmen must urgently change their business philosophy. Capital owners and executives should establish new elements of competitiveness in domestic companies. They should abandon the old-fashioned policies and management techniques and accept the modern ones as well as learn from the experiences of global leaders and those companies from newly industrialized countries which are successful on the global market. Domestic companies are faced with numerous problems during transition, the biggest of which are those related to improving knowledge and organization, the implementation of new technologies and providing financial resources. Ecological consciousness could not be developed and modern achievements implemented on the domestic market because of long-lasting economic crisis, especially when financing such projects was in question.

Recommendations concerning the establishment of centres of clean technologies are: estimation of the existing centres of clean technologies, identification of potential leaders, establishing institutions that will attract clean technologies, starting a qualitative project, engaging local distributors, and establishing an advisory body in the field of clean technologies (Pernick & Wilder, 2008, p.250).

On the other hand, old technologies, poor quality and high prices are to be blamed for the poor competitiveness of domestic products. The manufacturing industry is the least competitive, followed by the metal industry and electronics in which there have been no technological changes for years. Businessmen think that tax and customs relaxations, reducing administrative taxes as well as the prices of electrical energy, gas and petrol are necessary in order to increase competitiveness. It is also necessary to raise the level of technological equipment because the average age of machines in Serbia is 30 years. Compared to other countries in the region it is 12 years behind. The Serbian economy is technologically 29.5 years behind the EU. This was proved on a representative sample of 154 small, medium-sized and big enterprises within six industrial branches with similar manufacturing programs (Serbia towards the EU, 2009).The comparison was made in the textile, food-processing, pharmaceutical, machine, chemical and building material industries. Austria was taken as a benchmark because it has similar natural, social and demographic characteristics to Serbia. The biggest backwardness can be seen in those companies from the textile (35 years), and machine production (34.5 years) industries. Pharmaceutical companies are least behind (21 years). Regionally speaking, equipment, tools and other production means are most backward in South Serbia (41 years), and the best situation is to be found in Backa (18,5 years behind). The situation in Belgrade is 20.5 years behind.

The research results which deal with the analysis of young people's attitudes to their involvement in the entrepreneurial process, as well as with their understanding of the business practice success of domestic companies represent the mindset of future experts and executives. The research has been carrying out for three years in a row (2010-2012) on the territory of Republic of Serbia in 16 towns and municipalities. It included 1990 students oriented towards management. According to those interviewed also, the purchase of modern (clean) technologies is indicated as the most important factor necessary for developing the competitive ability of domestic companies, table 3.

Table 3: Most significant factors in development of Serbian companies competitiveness (Đorđević, Ćoćkalo, & Bogetić, 2013; Bogetić, Đorđević, & Ćoćkalo, 2013)

	Year								
	2010			2011			2012		
	Frequ	Column frequ.	Row frequ.	Frequ	Column frequ.	Row frequ.	Frequ	Column frequ.	Row frequ.
Implementation of QMS	138	23.8%	29.9%	196	30.0%	42.4%	128	17.0%	27.7%
Education	234	40.4%	23.5%	369	56.4%	37.1%	392	51.9%	39.4%
Marketing	132	22.8%	30.6%	131	20.0%	30.3%	169	22.4%	39.1%
Financial support	217	37.5%	29.2%	235	35.9%	31.7%	290	38.4%	39.1%
Innovations	165	28.5%	27.6%	231	35.3%	38.6%	202	26.8%	33.8%
New (clean) technologies	305	52.7%	27.3%	418	63.9%	37.4%	394	52.2%	35.3%
Motivation of employees	269	46.5%	30.3%	297	45.4%	33.4%	323	42.8%	36.3%
Making clusters	101	17.4%	27.2%	141	21.6%	37.9%	130	17.2%	34.9%
Prices	125	21.6%	26.5%	112	17.1%	23.7%	235	31.1%	49.8%
Buyers’ capacity to pay	110	19.0%	30.3%	109	16.7%	30.0%	144	19.1%	39.7%
Institutional state support	194	33.5%	29.0%	246	37.6%	36.8%	228	30.2%	34.1%
Appropriate business ambience	133	23.0%	26.8%	206	31.5%	41.5%	157	20.8%	31.7%
Flexibility	133	23.0%	27.7%	209	32.0%	43.5%	139	18.4%	28.9%
Lack of professional workers	97	16.8%	19.6%	207	31.7%	41.8%	191	25.3%	38.6%

Chi-square test: $X^2 = 268.825$; df = 30; p = .000*

Contacts with the EU as well as the possibility of using European funds intended for improving energy efficiency can positively impact on the development of the clean technologies sector on the domestic market. It is of particular importance to analyse the experiences from neighbouring countries concerning this field, as well as those EU countries which have achieved great results in this fields, such as Spain. Spain is currently one of the European leaders in the field of the implementation of clean technologies and it is ready to invest in the West Balkan region.

CONCLUSION

The clean technologies sector represents one of the main directions of global economy development. The development and implementation of clean technologies is viewed as the greatest economic and technological progress in modern history (Pernick & Wilder, 2008, p.275). The clean technologies sector serves to stimulate employment since this type of production requires a greater number of new jobs than in traditional production. This sector also provides possibilities for rapid regional development.

Business organizations from transitional countries are faced with numerous problems, the biggest of which are those related to improving knowledge and organization, the implementation of new technologies and providing financial resources. Ecological consciousness could not be developed and modern achievements implemented on the domestic market because of long-lasting economic crisis, especially when financing such projects by the EU was in question.

Because of their geographical vicinity and historical and economic ties, West Balkan countries together with other neighbouring countries such as Slovenia, Hungary, Bulgaria and Romania (members of the EU), represent the region which could achieve global competitiveness by using new technologies in the near future.

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CONCEPTUAL MODEL OF ECOLOGICAL MAINTENANCE DEVELOPMENT PROJECT OF THE ECONOMY IN UNDEVELOPED LOCAL COMMUNITY

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ABSTRACT

Undeveloped local community are faced with the contradictory demands in the area of economy and ecology. The dilemma is, ecological development at any price or preserving the acceptable life environment. The municipality of Mali Zvornik is undeveloped with expressive removing of young population toward the big centres. At the same time it owns great potentials which are needed to be preserved, the untouchable, protected natural environment, before all. The conclusion is that the connecting of these two extremes, the development of touristic offer leaning on the ecological tourism, might be the solution. This area is highly economic profitable, demanding no disturbance nor devastation of natural environment. The idea lies in defining the limits in preserving ecological encirclement. Optimal conclusion searching and limited factors demanded a systematic access. Concerning the facts, next directives took place: a) the projectmust have the economical maintenance; b) disconnecting or minimize negative influences; c)characteristics that will animate, including the spacious social encirclement; d) the development of local community potentials through introducing and using the new technologies; On the basis of all conclusions, the touristic capacity is justified, leaned with all its contents on Zvornik lake potentials. We decided to a unique project of a floating hotel. Except its architectonic unique, the appearance that fits into the environment, it had to satisfy two more aims, complex modulation and ability to adapt itself, to personify according the user demands. The object is justified as a self-floating platform with additional individual objects for a quest sojourn as an autonomous sailing objects. The basic demand for the complex, was not to be "turned to itself", but to animate and include great number of citizens from the local community. Concerning that the complex itself is on the water surface of Zvornik lake, which is a sensitive eco-system, also itself, the necessity, to respect the special technological and technical demand, is intruded. These demands are reflected in the selection of the acceptable technology and materials, also I use of technical subsystems which will tend to minimize and disconnect all negative influences. According to the analysis, by realization of this project, the economical success would be achieved, and also the knowledge that taking on investment in ecological aspect of development.

***Key words**: environment, ecological tourism, architectonic, floating hotel.*

LOCATION AND RESOURCES

Local communities, especially in undeveloped areas, are met with the contradictoy demands in the area of the economy and the ecology. The are forced to solve the dilema, economic development at any price or preserving the acceptable life environment. The decision about development of the economy at any price, often means to agree to destroy the health nature environment for the sake of the development. The Municipality of Mali Zvornik meets the same situation, to preserve the population by the development of the economy or to vanish undeveloped and be left by the citizenswho are searching for a work. The area handles the great potentials in reatively good preserved ecological environment.

The Municipality itself is located on the west of the Republic of Srebia in the basin of Drina river, surrounded by the untouched nature. In spite of all economic potentials Mali Zvornik is undeveloped municipality with very expressive striving for moving out of the young population toward the big centres. It falls into the municipalitiess of high level of unemployment and it is in insignificant economic development, at this very moment. According to the statistic informations, the number of the inhabitants, between the two censuses is reduced about 7% and the unemployment is about 30% of working capable population. At this very moment the economy of Mali Zvornik is leaned on the electric power production, stone exploitation and the processing of lumber. Besides this, there is a great number of citizens who are occupied with some form of extensive agriculture. On the other side it possesses the potentials which is necessary to be preserved and the potential of untouched, preserved nature environment, before all.

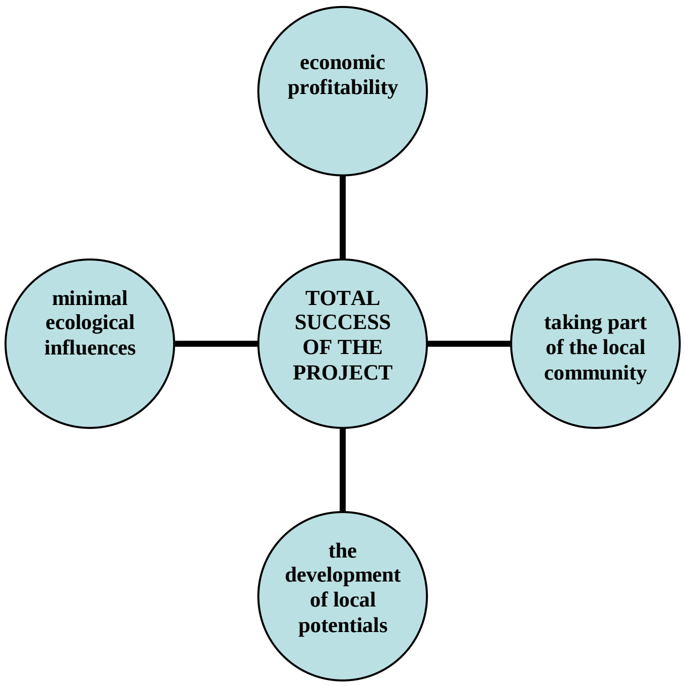
The envoronment of Mali Zvornik presents the unused wealth, geothermal water of Radaljska Banja, the flow of the Drina river, the Zvornik lake and forest of Boranja mountain.

THE ANALYSIS OF POSSIBILITIES AND INFLUENCE FACTORS

Trying the reconciliation of the two extremes, it comes to a conclusion that the solution might be in a development of touristic offer which is, before all leaned on the ecological tourism. By analysing the possibilities of the development of this economic area, it is clear that along with good plans and projects, this area is highly economic profitable, demanding no disturbance nor devastation of natural environment. So, the idea was to define the limits which were reflected on preserving the ecologocal encirclement and by using the possibilities which the environment offers and where the idea is realized. The idea of searching for optimal solution and limited factors, demanded the systematic planing access and solution searching

Ideological directives of the project

Concerning mentioned facts, the following directives take part:
a) the project must lave profitability, economic maintenance,
b) exclusion of or minimize all negative influences on ecological stability of the environment,
c) characteristics that will animate the wider social encirclement to take place in the project
d) total potentials development of the local community.



Picture 1. Ideological directives of the project

Profitability and economic maintenance

The idea of the project is to give the contribution to the local community economic development, where it will be achieved. So, if the project is going to survive and be successful, it must be economic profitable. Economic contribution to the local community is reflected in three level:

a) achieved money profit through the tax of the community or achieved profit
b) new jobs
c) using the local potentials, more exactly, indirect income of the citiyens by giving services and sales of local products

Exclusion or minimize negative influences on stability of the environment

The essence of the ecological turism idea is preserving the natural environment, with presents, in this case, the „exploatated“ resource. Any grip that a man take in some natural environment, leaves an influence on it, unavoidable. So, the first and main task which should be achieved was the task of expeling, more exactly, minimiye the negative influences of the project on natural environment and ecosistem in which it would be realized. Minimizing the influences, in the case, was not reflected only to functioning of the system itself, after the realization. The method of total ecologic quality was applied. A concern about the ecologic influence, by this method, is moving from the functioning, of the completed system itself to the previous preparations and realization of the project itself, through the choice of solution, tehnical and tehnological acts with minimal risk.

Characteristics that will animate the expeling in ralization and functioning of the project of wider social environment

The value of the project, for the local community well-being, will be increased, unless the idea of realization and functioning of the project become reality by expeling the wider social environment. It is come to a conclusion by estimate that possibilities of the local community lie in health food production, production and knowledge in the area of processing the lumber, exixtence of the potentials of hunting and fishing turism, also the preserved ethnologic and historical inhernitance.

So, on the basis of the that, the idea, during the realization, is to use cited possibilities. Using it in realization and functioning, the large number of citizens is included and the idea of economic progress for a wide community is fulfilled.

Development of the local community potentials through introduction and using new technologies

The sensse of this idea lies in juncture of traditional and new tehnologies and through it to realize the growth of local community potentials and increasing the tehnologies level of knowledge. Through the training of the members of local community for production and maintain the technological new system and using new materials and tehnologies, the local community potentials are increased and open the possibilities for realization of acquired knowledge on new projects in the scope of Mali Zvornik or total market, generally.

From that aspect, during the justify of the project, it is proceeded from the idea to product, if possibile, the larger number of components and technologic systems in the scope of local possibilities.

Also, the condition to participate in realiyation of the project by other side, will be the plugging in the local manpower and training of these people for maintaining the technological progressive systems after the realization of the project.

The results of ideological directives and existing possibilities

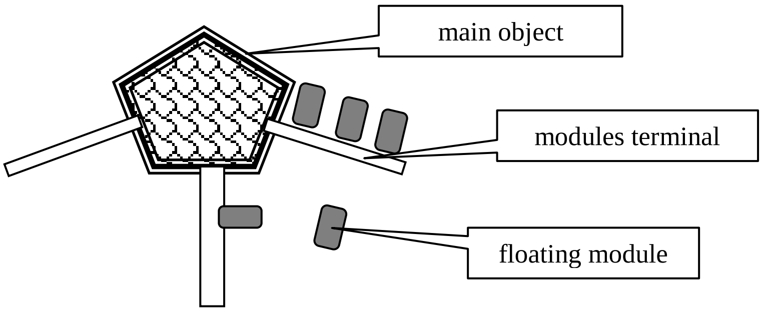
On the basis of directives of the project, the existing possibilities and available potentials of area of Municipality of Mali Zvornik, are analyzed:

- On the basis of analyze, the followed conclusions are intruded the project must be connected to the Zvornik lake as the most recognizable locality and as an object of the largest touristic potential. The leaded presents the most recognizable locality of Mali Zvornik and such as it is, it makes the problem of marketing easier. Also, the leaded locality encircles the great area of Mali Zvornik and with such characteristic makes the unite of the differences, possibile, in the most part of the teritory. The locality itself owns the necessary and asked qualities which are related on the ecologic tourism.
- Usage of progressive tehnologies, materials and scological conscious managment of the projectand working of total system, reduces negative influences on natural encirclement maximal, with thestriving of total elimination.
- In realization of the project to a greatest extend and in the subsequent work of total system, it is needed to plug in the potentials ond resources of the local community, social as natural resources: the idea of expeling of local potentials, first of all, refers to using of existing production capacities and knowledge which are owed in the limit of local community. The project will be turned also to the using of other natural and hystorical resources which exist in the limit of the community, hunting turism, spa turism, hystorical monuments and localities which will be presented thorugh the integral offer.
- The plan must possess unity and originality that will contribute economical profitability, more exactly, the maintenance. Unity and originality of the project will contribute its recognition.Recognition, itself makes the choice of the partners easier or the financiers of the project, considerning it is about touristic project, which hasspecials users for a consumers, also it makes possible exact determination of the target group of users and their needs and wishes.
- The ideological solution and realization must picture the system turning towards the encirclement and nature in which the object is located. The conclusion refers first of all, to an obligation that technical and economical system itself, by it appearance, doesn’t disturb the appearance of the environment, where it is located and tehnical and arhitectonic to be the part of that encirclement. Its appearance, functioning and other must picture that nature in which it will be located.

IDEOLOGICAL MODEL OF THE OBJECT

On the basis of conclusions, the touristic capacity is justified, which contents leans on potentials that Zvornik lake possesses, first of all, also its direct environment. As far as this part of unity and originality is concerned, we decided for an unique project of the floating hotel. By its architectonic unity, the appearance that fits into the encirclement, it must fulfilled twomore aims. These are modularity of complex and possibility of adapting to the users demanda, more exactly, the possibility of personalization the ways of using by the users. Modularity enable enlargment or reduction of the object capacity with no disturbance of its basic function and with the aim of preserving optimal capacity, more exactly, the economy of operating the affairs. Personalization the ways of using is directed to the users choice, so they could, themselves, in a great deal, choose, by thier own choice, the locations of moving, staying and the way of using the modules.

The object, itself is justified as a self-floating platform on which is added individual objects for stay of the gusts. These individual object presents autonomus floating objects with all accompanying contents. This way of solution the project problem, enables the existance of free adding-widening capacity possibilities with no disturbance of the basic architectonic entirety functioning.



Picture 2. Ideological shema of object

Modularity of object is justified on two levels. The first level of modularity is a possibility of adding the module terminals which enable the widening of the system capacities, with no disturbance of its functionig, while the other level predicts adding of floating lodging units or added terminals.

Picture 3. Ideological solution of modular structure

This plan enables maximal flexibility of using the object and enables the choice of optimal capacities for work in aim of reducing the expences. By working out this idelogical plan, the followed structure is dezigned, given on the picture number 3.

Technical caharacteristics and limitations

To fulfill its role and the sense of exsistance, it is very important, for the complex itself, to respect the ecologic aspects of its constuction and functioning.

Concerning that the complex itself is located on the water surface of the Zvornik lake, which is sensitive ecosystem itself, the necessity to respect special and technological demands is intruded. These technological demands is refkected in the choice of acceptable technologies and materials, also in use of technical subsyistems, which will strive, by its work, to minimize or expeling of negative influences.

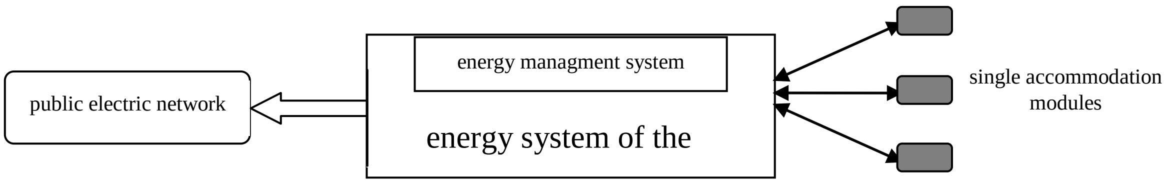
The choice of materials and technologies

Considering the leaded, as an owerpowered materials are chosen: wood, glass and metal and also a technologies of its treatment and protection which do not disturb the life environment. On the occasion of the selection the technological acts of treatment and preparation the materials, the choice of means of protection and aesthetics is also made, leaned on usage of substances which do not cause the damage to the natural environment. First of all, the usage of means which demand usage of organic solvents mineral oils and other harmful substances is expeled. The special attention is paid on the fact that the great number of materials will be in the contact with water and for that reason the regular choice manner of metal protection from corrosion is neccessary, also as it is lumber elements from the process of decay. For example, for treatment and protection of lumber surfaces is chosen the process of drying the lumber on high temperatures till the limit of carbonization that enable maximal reduce of hydroscopy. In the protection of metal surfaces the choice of the means, on the basis of water solvents is done, also in use of electroprotection of metals.

The technology of object construction predicted that the greatest number of technical grips could be carried out on land, so that on the water surface, could fold up the total structure, with minimal number of grips, and only the grips that refer to a process of folding up the structure.

Energy subsystem of the facility and modules

As the main energy source for functioning of the facility and providing mobility of modules is selected eletricity. The complex, partial and fully mobile modules are largely autonomus in energy production because it stipulates the use of solar panels to produce electricity and solar collectors for hot water preparation. According to the weather limitations, the number of sunny days, and also a number of days with reduced insolation, it was necessary to achieve energy complex connection and with the electric network. This connection is realized in two directions so the object, in case of need, could manage the „withdrawal“ from the public system, but also in cases of excess energy, it could be reversing on the public network. Idea here was focused on the minimization of costs. Autonomy of the acommodation of the module is supplied by use of electricity. This came from the limitations related to the use of organic fuel, also the limitations related to a noise pollution of ecosystem.



Picture 4. Complex electrical system

So, for the power of floating modules is selected the usage of electric motors that is supplied through electric power battery sistem and solar panels system located on each model. Supplement energy source has been constructed in such a way that, during the night, when the modules are located near the building nut, make the connection to the power facility. A special problem in functioning of the facility was the solution of warming-cooling problem. The idea of using the building is not limited to the operation and use the facility during the summer months but anticipates that the facility is open all year. Is was neccessary to make a selection of warming and cooling system that will act a target at the lowest cost. For this system is made a selection which imlies the use of heat-pumps system. The solution is imposed because in the complex environment is virtually unlimited amount of suitable fluid-lake water. In addition to these two system, in the functioning of the complex is chosen a partial use of natural gas. Usage of this energy source is limited to use in specific acommodation modules, primarily because of existance of potential users desires for self-catering. Energy storage is accomplished by using standard, replaceable gas tanks, located on the modules, related to the installation-on the devices.

Managment of waste materials

Special attentions is directed to a system of managment of waste materials. Here is the main problem a problem of fecal waste, also the other types of organic waste materials that appeares in functioning of such facilities. Problem of these types of waste materials at two levels. Solution of removing the waste materials at the central facility and in the second level-removing the waste materials on individual mobile modules.

Waste materials on the central facility level were resolved by linking the facility with public utility installations. The bigger problem is appeared in designing the solution of waste materials on acommodation modules. It is proceeded from the assumption that each module must provide 48 hours autonomy in movement and stay out of the nut („queen bee“). On the basis of this requirement, shall be design the subsystems temporary storage of the waste materials in the hermetic vessels within the modules, themselves. After reaching the home cell, the waste material is transported through the system of home cell to a public utility installation. It should be noted that the managment of waste materials is planned through the very functioning of the whole system. Here are considered the use of other methods of sorting waste materials which will be included in the recycling system within existing plants in Mali Zvornik (PVC materials, glass, used vegetable oils and other). This level of managment of waste materials will be involved in improving the quality of operations in ecology area and waste managment through the stuff training. The idea is to implement the standard that provides a system of environment managment ISO 14001-2004.

VISUAL QUALITY AND DESIGN OF THE OBJECTS

One of the basic requirement in solving this complex was that the complex „is facing himself“. Disturbance of the natural environment is possibile, by technical and tehnological influences, and by the visual structure inconsistency with the environment. When designing the whole system, it is proceeded from two ideas. The object is located on a water surface and it is facing nature by its idea. In accordance with the above, the design task is set. It is applied the disegn which is based on the design of floating objects where are maximal used natural materials, primarily wood, glass and metal. The whole idea of the disegn is leaned on maximal facing the object to outer space and to a water where it is located.

Picture 5. Appearance of the building from the shore

In the interior design it was postulated , by use natural materials, also the maximal usage of natural light which turns the interior to the outer world as well as the connection between certain areas and external space of environment.

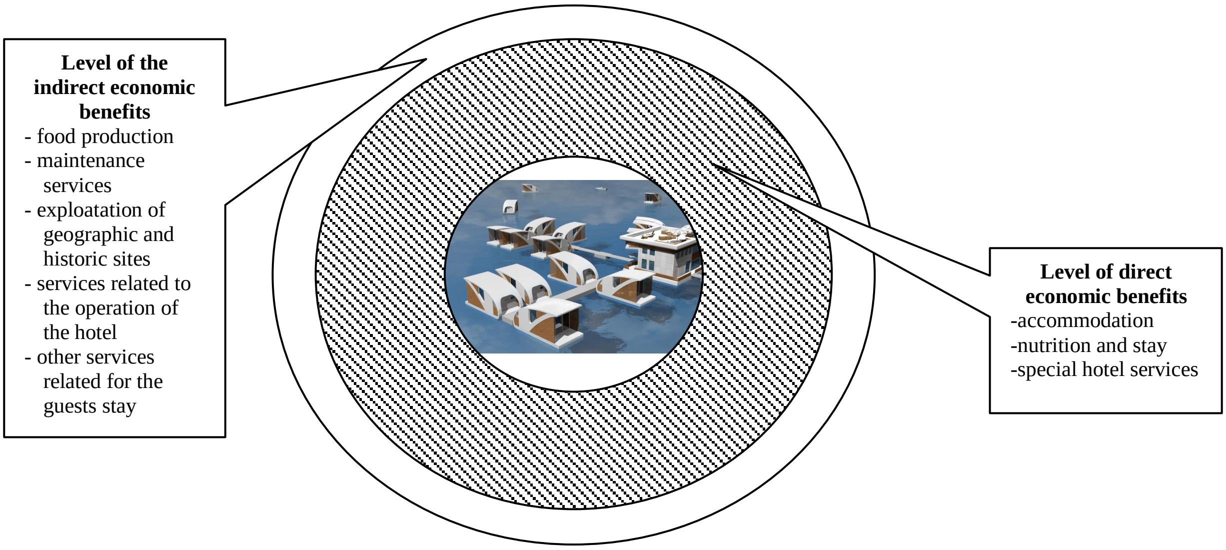
Picture 6. Interior central facility

A special challenge was to design a movable accommodation modules. Here the problem is related to the need that, on relatively small area, makes accommodate of required autonomous technical sysems and at the same time preserve the idea of disegned faced to the natural environment. Accommodation of the technical systems is carried out in the floating part of the building, while the whole surface of the building above the water level, was used to design a living space. This area is divided into indoor and outdoor living space. Visually, with glass surfaces (windows), both of these spaces are connected with the environment. By design idea these two areas are connected, and the external area is faced, by its appearance to surrounding area. The result of such solution is given appearance as in picture 6.

Picture 7. Design a movable acommodation modules

PLACE AND ROLE OF THE MODEL IN THE ECONOMIC DEVELOPMENT OF LOCAL COMMUNITY OF MALI ZVORNIK

It already stated tha, apart from the economic avail and success, the role of mentioned idea also is the inclusion the large number of citizens from the local community in many aspects. In addition to the direct benefits, economic success, it would allow participation by the idea the large number of citizens, who would give the other services in total functioning of the complex.



Picture 8. Structure of the economic usefulness of the object

The idea is that through training and needs expression of the facility at Mali Zvornik, propagated and introduced organic way of the producing the quality food. According to the characteristics of the surrounding area of the Zvornik lake, this type of production may be organized around the facility, so that the object will be supplied with healty food exclusively from the local sources. The benefit of this idea is two fold. The local population would be ecomically stimulated to deal with this type of production and realization through consuption of the food by the guest,, eould be the mode of promoting it, outside of the local market.

Altrough the training and work with advanced tehnical systems and maintenance, it is estimated that there will be an increase in the potentials of the local workforce wich could be realized through market. At least origination it is expected a positive influence on other services, offered by the local community, which initiated the development of the most underdeveloped parts of Mali Zvornik (other types of tourism, exploatation of the other geographical, historic localities rural tourism services, etc.) The second level of economic benefit, stands out the possibility of presentation of historical and geographic localities, which are unique in many ways. Primarily, these are historical sities of the king shelter „Stone girl“, archeological sities and other medieval town which, until now, were not know to a wider range of visitors.

Implementation of this project, according to certian analyzes, which were done, it would be achieved econimc success, which would be reflected in the increased volume of local community income. Therefore, the availability of funds for investment in the economic area, would increase. A very important fact is that the success of the project lead to the increase of ecological awareness in the whole community level. Also, the idea, itself, will launch the cross-border cooperation of Mali Zvornik and Zvornik in Bosnia and Herzegovina, with the aim of mutual activities for preserving the ecological resources. It must be emphasized that in all aspects of environmental influences, insisted on applying the strategy of „zero tolerance“. Although, even more important is the fact that the success of this project was a proof that the investment and care of the environmental development aspects is a justified venture, which can run the economic development.

In the end it should be noted that the idea of the hotel structure is in the intellectual property rights protecting process an that the project is evaluated as a unique idea bu Investment fund „Dijaspora“ that is interested in its realization.

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SUSTAINABILITY OF RECYCLING IN VIEW OF ENERGY EFFICIENCY IN THE END-LIFE VEHICLE (ELV)

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ABSTRACT

This paper presents an analysis of the recycling of motor vehicles. Motor vehicle recycling industry contributes to sustainability, environmental protection and energy saving. Recycling of cars includes a variety of procedures, which allow obtaining products (metals, plastics, rubber, glass), suitable for the manufacture of new products. Using recycled materials saves energy and natural resources. Recycling creates less air and water pollution than primary production of raw materials. Recycling saves storage space, create new jobs in companies engaged in the collection, production and distribution of raw materials.

Keywords: *sustainability recycling, motor vehicles, energy saving.*

INTRODUCTION

Large amounts of old cars, is a big problem in all countries of the world. To ensure the successful recycling of motor vehicles is necessary to create an appropriate legal framework and basic infrastructural requirements, which undoubtedly contribute to its development through attracting investments and building technology resources in accordance with the regulations. The introduction of system solutions in the field of automobile recycling contributes to the renewal of the fleet and reduce pollutant emissions and energy consumption (Bian et al., 2010; Aleksic et al., 2011). With the start of mass production of cars and waste from the car, which ended his life, the idea emerged that certain parts of such cars can be re-used (as spares). However, the number of these parts are so small that they appeared large dump cars. These landfills affect the environment, and on the other hand represent a large amount of raw materials that could certain technological processing be re-used for different purposes. Thus, in recent years in developed countries (the U.S., Japan, etc.). There are large corporations that take on the responsibility that this job entails. One of the major contributions of this new industry is to reduce environmental pollution. On the other hand, recycling of cars has been hiring large numbers of workers. These problems occur in all parts of the world so it will be necessary for the company for recycling cars. (Trumic et al., 2008; Puric et al., 2011; Milic and Jovanovic, 2011).

ANALYSIS OF RELEVANT KNOWLEDGE

Energy consumption for the production of secondary raw materials from the recycling process produced significantly lower than those used to obtain material from mining primary production (Ilic, 2002; Krinke et al., 2005). Recycling of used motor vehicles (ELV) in high-income countries is very successful, especially after the introduction of the shredder in the recycling process of used cars. The rate of recycling in developed countries more than 90% of the used motor vehicles. ELV Recycling helps protect the environment (Hempfl, 2010; Jovanovic et al., 2008). ELV recycling reduces the minerals from natural sources and generates a source of raw materials for the production of new products derived from recycled materials (prawns, et al., 2005; Tadic et al., 2010). Removing environmentally harmful components and materials, specialty oils, brake fluid, antifreeze, air bags, mercury, freon and similar substances require special treatment and expertise in areas such waste dismantling. In Germany, centers for dismantling vehicles covering a circle with a radius of 50 kilometers. In Serbia there are about 1.4 million passenger cars and light commercial vehicles. The estimated number of annual waste produced by 120.000 cars a year, which means that a larger number of equipped recycling operators. (Junbeum et al., 2007; Medic, 2011). Recycling of used motor vehicles in the world, is an efficient process which recycles more than 75% of the cars, along with the rate of used cars collected by 95%. In the United States, is recycled about 11 million units, representing a $ 5 billion of revenue. Automobile Recycling Industry in the United States employs more than 40.000 employees in more than 7.000 companies. In the EU, the number of recycled car reaches 9 million per year, equivalent to 2.2 million tons of waste. As in the U.S., profit mainly by selling used parts and metal. Based on the data (Tolmac et al., 2011a), the number of used cars in the Republic of Serbia, is approximately 100.000 per year. Taking this estimate of the number of used cars, as well as the percentage utilization of certain materials per vehicle, obtained 68.000 tons of ferrous metals, nonferrous metals 6.000 tons, 8.000 tons of plastics and composites, 1.400 tons of fluids, 5.000 tons of rubber, 3.500 tons of glass, 1.000 tonnes of textiles, 1000 battery tons and 6.100 tons of other waste from the used car. In the Republic of Serbia, during the process - recycles 14% of used motor vehicles, because the capacity for industry remains underdeveloped. In the domestic market ELV recycling, demand for secondary raw materials is high, and the level of recycling of 14%, should increase to European levels by 75%. On the basis of the ELV recycling system, we need new investment of over 20 million, in several plants shredder and mobile Balir presses, and increase the efficiency of the (Subaru and Pavlovic 2006; Djordjevic and popcorn, 2004).

ANALYSIS OF AUTOMOBILE RECYCLING TECHNOLOGIES

In Serbia, there are over a million vehicles whose average age is over 10 years. The collection and disposal of waste vehicles mostly depends on supply and demand. Parts with use value is extracted in smaller amount, depending on their age and condition of end. The automobile recycling facilities in the world it is possible to recycle about 80% by weight of the car. The process of recycling cars is complex because of the variety of materials that are part of the car. Middle-class car, on average, consists of 76% metal, plastic 8%, 4% rubber, fluid 6%, 3% glass and other materials 3% (Trumic et al., 2004). Apply two car recycling technologies, which differ in the way of sorting the material that make up the car. The first technology is based on optical separation, and other technology uses multiple methods (grinding, gravity separation methods and special). A third possibility is that the whole car pressed in one piece, using mobile Balir presses (Trumic et al., 2008).
Further classification of non-metals and non-ferrous metals in fruiting material, achieved through a combination of gravity and special separation methods (electrostatic, optical, etc.)., (Trumic, et al., 2009).

RESULTS AND DISCUSSION

Recycling of motor vehicles (Tolmac et al., 2011), is still in its infancy. The research within the project of technological development is defined by a model of integrated and sustainable recycling of motor vehicles at the end of the life cycle (Pavlovic et al., 2011). Thus the set basis for the development of new industries and thus create real conditions for intensive employment in jobs recycling. These tasks include collection and transportation of waste motor vehicles, their removal, selection of components and materials, recovery of components for reuse, crushing shells and chassis, separation of materials, recycling materials, the final disposal of waste. All this requires a different structure of professional personnel, various recycling technologies and the different composition of objects and corresponding requirements for their location (Bian et al., 2010; Afgan et al., 2009). Serbia is not guided effectively solve this problem. The project aims to (Pavlovic et al., 2011) to localize potential waste motor vehicles, which can be recycled or used for energy. The most important thing is to determine the scope and structure of the permanent disposal of motor vehicles, especially hazardous waste and suggest measures for their removal or safe storage (Pavlovic, 2009; Pavlovic and Subaru, 2006).

The project (Pavlovic et al., 2011), is predicted to form an appropriate centers for the breakdown of used motor vehicles by the respective regions. The significance of the project is big, because it provides savings in the form of recycled materials.

Obtaining metals from recycling leads to saving power generation, such as: steel 74%, aluminum 95%, copper 85%, lead 65%. Getting metal recycling reduces water consumption by 40%, reduces water pollution by 76% and air pollution by 86%. In developed countries (35 to 45)% of the new steel is obtained by recycling (Stojanovic et al., 2004). Recycling is the future to solve the problem of waste motor vehicles, in terms of sustainable development. A clear example that proves the previous statement is given in Table 1 (Tolmac et al., 2011b; Trumic et al., 2008):

Table 1: Saving energy by using recycled materials

Materials	**(%)**
Copper	85
Lead	65
Zinc	60
Aluminum	95
Iron and steel	74
Magnesium	98
Titanium	58
Paper	64
Plastic	80

As can be seen from Table 1, the energy savings by using recycled materials is very important. The investment costs for the construction of waste treatment plants and metal production only (16 to 20)% of the cost to build a plant for processing the raw materials - minerals. In addition, manufacturing technologies based on the processing of secondary metals are much easier and more acceptable for the environment as the example of iron and steel clearly seen in Table 2

Table 2: The benefits of using iron and steel from waste materials

Benefits	**(%)**
Energy savings	74
Saving material from ore	90
Reducing air pollution	86
Reduction of water consumption	40
The reduction of water pollution	76
Reduction of mining waste (tailings)	97

CONCLUSION

Motor vehicle recycling is based on the principles of sustainable development (Pavlovic et al., 2011). The establishment of this model in Serbia, in addition to environmental and economic effects of providing a high level of employment, which is very important for social policy. Thus, the number of employees in the entire cycle of recycling of motor vehicles at the end of the life cycle ranges from 6.000 to 20.000 employees. Number of employees varies as a function of:

- ELV available number in the current year,
- the degree of recyclability,
- the level of motor vehicle dismantling,
- available recycling technologies,
- new products from materials provided by ELV.

Since the operators are to be deployed on the territory of Serbia, so that citizens in their old cars can be submitted at the nearest recycling center which will be issued and a receipt which can be realized certain benefits when purchasing a new car. In this way, the action will involve all those involved in the recycling of batteries, waste oil, antifreeze, glass, plastic and everything that makes a car, and it is necessary to invest a total of over 20 million Euros (Medic 2011; Kozic and Sudarević 2005; Gareth and Shahin, 2006).

Metals and energy consumption in the world has a great trend. The reserves are rapidly being depleted. Scrap metal is a very important secondary resource, whose collection and return of the reprocessing process significantly reduces the consumption of primary raw materials, extends the life of the reserves and reduce environmental pollution. Re-use of metals from waste and general reuse of other materials has great economic justification.

ACKNOWLEDGEMENTS

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III International Conference
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ADDITIONAL INFORMATION TOWARD INTER MUNICIPAL AGREEMENT EFFECTIVENESS

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ABSTRACT

Does information from the Feasibility study cost-benefit analysis for IPA and Structural Funds (FS) sufficient for successfully realization of inter municipal infrastructure projects in Serbia in past ten years? On the empirical basis in Serbia, it looks, not. All regional landfills in Serbia, based on the model envisaged in the FS, have not been constructed in accordance to the inter municipal agreement, i.e. the model was not followed by the municipalities, from the very beginning of the construction. It seams that municipalities involved into regional landfill project, haven't accepted it as their own ownership, from the very beginning. It looks that all necessary information have not been presented to the municipalities' before signing inter municipal contract and, the most important is: what is the source of the investment, preferably from what budget line investment will come, what is the benefit for the municipality. Moreover, this information have not been envisaged to be calculated into the FS. This paper consist the basis elements for those, necessary information as a missing part for the inter-municipal agreements related to the communal services providing at regional level.

Key words: *Inter municipal (regional) development; inter municipal agreement effectiveness, risk management.*

INTRODUCTION

Considering Low on communal solid waste management of the Republic of Serbia ("Sluzbeni glasnik RS" 36/09), a significant number of lows and by-lows including revised Strategy for solid waste management for the period 2010-2019 have been adopted. Regarding The Low, the management of communal solid waste is under responsibility of the municipalities and cities in Serbia. Regarding the Strategy, the construction of 26 common landfills covering the territory of more the one local self government (LSG), i.e. Regional Centres for communal solid waste management, have been envisaged. Those Regional landfills should present the places for communal solid waste of all LSGs involved disposal, instead of municipalities' landfills, which are, at the moment below the minimum of technical requirements, and consequently have to be closed, in order to decrease it's negative environmental impact.

Base on the Low on Local Self Government, the activities on collection of solid waste management is under responsibility of the LSG units in Serbia and can not be transferred into the new entity. Therefore, forming regional centre for communal solid waste management (envisaged in The Strategy), is not an institutional framework for the new communal service, but the way of the solving of two basic LSG's issues related to the place for communal solid waste disposal: closure of the existing LSGs' illegal landfills and the expanding of the time of communal disposal into the existing legal landfill.

Until April of 2012, five Regional Centres for communal solid waste management was constructed on the territories of the following LSGs: Kikinda, Lapovo, Leskovac, Jagodina and Uzice as well as two sanitation landfills on the territories of LSGs: Gornji Milanovac and Vranje. Regional landfills have been built into the territories of the LSGs: Pirot and Pancevo, but have not been operational, yet. The constructions of the following Regional landfills: Sremska Mitrovica, Nova Varoš, Inđija and Vršac, are in progress.

The planning and technical documentation are in the phase of preparation for the following Regional Centres for Communal solid waste management: Smederevo, Zaječar, Subotica, Zrenjanin, Ub („Kalenić") and Novi Sad. The preparation of the project documentation for the Regional Centres Subotica and Kalenić is in ending phase, part of the costs will be covered from EU funds .1

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The information for the inter municipal agreement
(Regional centre for communal solid waste management Zrenjanin2)

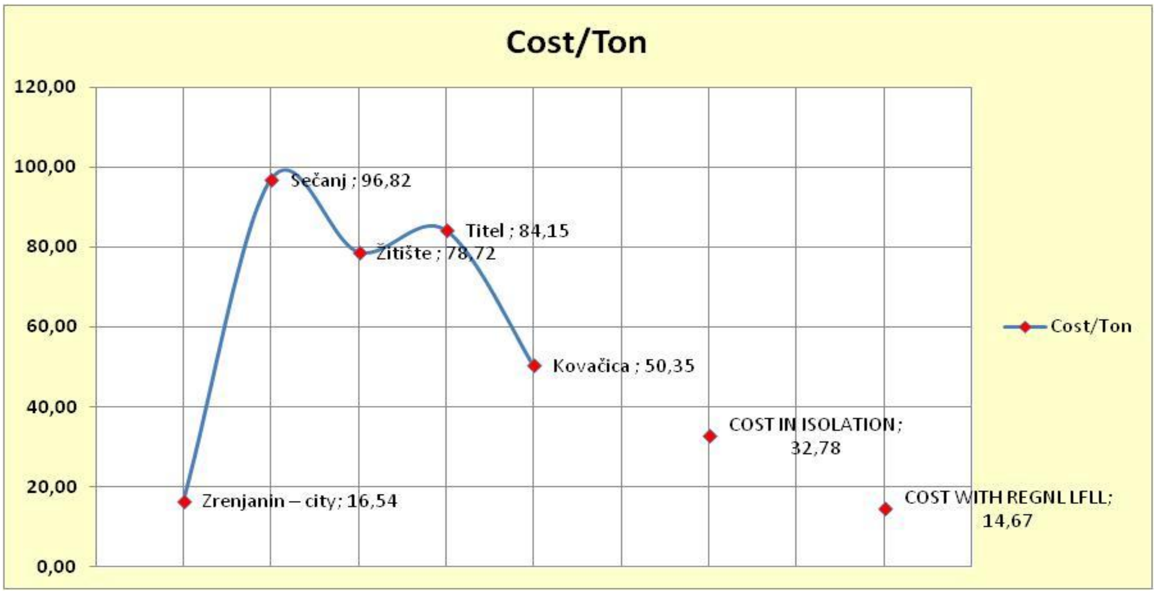

*Figure 1.Ccommunal solid waste collection and deposit costs of the municipalities included into the Regional solid waste centre Zrenjanin*3

Based on the experiences from the common work with LSGs on the activities of data collection and input into SLAP4 project pipeline, it follows that the basic cause of Regional Centres for communal solid waste management construction and operation delay is the fact that local transfer stations are not constructed besides it was agreed into the inter municipal agreement (contract). The LSGs, incorporated into the Regional Centre for communal solid waste management by inter municipal contract, not fulfil it's obligations. So, why is it so? The main cause is that the *complete information* for inter municipal agreement (contract) in such project, is missing. The consequence is that inter

1 Pavlović-Križanić T, Mehandžić D, Jezdić B, Vujadinović P, Spirić D, The manual for inter municipal cooperation in communal solid waste management, guidelines, the model of the agreements and contracts, Belgrade, 2012
2 On the meeting of the MISP programme Steering Committee (www.misp-serbia.rs) held on August 2012, the project Regional Centre for solid waste management Zrenjanin (from SLAP project pipeline www.slap.skgo.org) was selected for the EU non financial support in terms of the preparetion of the Feasiblity study including cost/benefit analysis (based on the Guide to Cost Benefit Analysis of Investment Projects, EU Commission, July 2008). The municipalities included into this Regional Centre (envisaged also into the National Strategy for solid waste management) are: Zrenjanin, Titel, Kovačica, Sečanj, Žitište
3 The presentation of MISP programme, December 18th 2012
4 SLAP IS is unique national online data base of public municipal infrastructure projects (project pipelne), managed by Standing Conference of Towns and Municipalities, Belgrade. The main goal of SLAP is to offer adequate support to LSG in Serbia in planning and infrastructure projects identification, as well as, support in apply for financial support necessary for the Feasibility study preparation and projects' construction (the source: www.slap.skgo.org). The author is SLAP manager starting from 2007, it's creation

municipal contracts have not been presented to mayors on satisfactory quality level, and whole LSG administration doesn't accept obligations from the contract.

In the model of Agreement on common performing of communal solid waste management it is said: "The payment of the service of communal solid waste disposal onto the Regional landfill is performing based on the amount of metric tons of waste disposed, the amount Regional public utility company (in the form of "Ltd.") will charge to the local public utility companies of the LGS involved, which perform by their side, the service of communal solid waste collection from the citizens and it's transport to the regional landfill. The parties are agreed that payment of the service of disposal together with waste collection, transport will perform it's public utility companies". So, what are the additional information missing? The information on *possible sources of financing* for each LSGs involved. Is the activity *communal solid waste collection in each LSG* positive, financially before regional contract, and if so, what part of it will be used to pay the invoice for the services to the regional landfill? The information/answers on those questions are missing and not covered by the Feasibility study prepared based on the Guide to Cost-benefit analysis of investment projects - Structural Funds, Cohesion Fund and Instrument for Pre-Accession, European Commission, July 2008
.

Table 1: The comparation of the content of the Feasibility study according to Serbian low and EU Commission rules

EU GUIDELINES	ПРАВИЛНИК
	1. Подаци о наручиоцу и ауторима студије
	2. Увод
1.CONTEXT ANALYSIS AND PROJECT OBJECTIVES	3. Циљеви и сврха инвестирања
2.PROJECT IDENTIFICATION + 3.2 3.3 3.5	4. Опис објекта
opsti podaci + 4.1.3 Changes in working capital	5. Анализа развојних могућности инвеститора
CBA je metodologija	6. Методолошке основе израде студије
3.2technology; 3.3Production plan	7. Техничко-технолошко решење у идејном пројекту
3.1Demand analysis	8. Тржишни аспекти
3.5Scale, location ...	9. Просторни аспекти
3.6 Enviromental aspects	10. Еколошки аспекти
4.1Total investment cost; 4.2Total operating costs	11. Економски трошкови
4.FINANCIAL ANALYSIS (4.3; 4.5; 4.6)	12. Добити - користи
4.FINANCIAL ANALYSIS (4.3; 4.5; 4.6)	13. Финансијска ефикасност са оценом рентабилности и ликвидности
5.ECONOMIC ANALYSIS	14. Друштвено-економску ефикасност
6.RISK ASSESMENT	15. Анализа осетљивости и ризика инвестирања
4.4 Sources of financing	16. Анализа извора финансирања, финансијских обавеза и динамике
3.4 Personell requirements	17. Анализа организационих и кадровских могућности
	18. Закључак о оправданости инвестиције

THE CONCLUSION

Each LSG has obtained by this information, *before* inter municipal (agreement) contract on regional landfill construction signing, in order to accept it. What part of the price of the *existing* service of communal solid waste collection and disposal in LSG "goes out to the Regional landfill company" and whit what quantity of waste? Since the maximum price of this service is constant, the consequence is that for each LSG the costs are different i.e. the financial result (according to experience in larger LSG positive). Therefore, the price of communal solid waste transport into the regional landfill can not be the same for all LSG involved into the regional landfill, but different because it is part of existing financial result. By that way, the existing structure of the cost price (covering the all costs) of the communal service in LSGs is not changed, the part of the positive financial result is dedicated for the payment of new service called: "transport and disposal of solid waste after primary selection into regional landfill", the service performed by Regional landfill operator. As final result, the amount of communal solid waste left to be disposed at LSGs' landfill is decreasing, leading to the closure of illegal landfills. This information is not incorporated (covered) into the Feasibility study in Serbian nor in EU low, so it is need to be a topic of separate calculation and included into inter municipal contract on Regional communal solid waste management. In practice, this topic, now in Serbia is sensitive, even political topic, the reason more why those information have to be precisely defined (calculated), presented, discussed among mayors *before* signing inter municipal contract.

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SLAP, System of Long listed Advanced Infrastructure Projects (www.slap.skgo.org).

III International Conference
„ECOLOGY OF URBAN AREAS" 2013

ECOLOGY - CONCEPT OF SUSTAINABILITY

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ABSTRACT

Humanity now confronts many existential crises, including environmental crisis as one especially important. Until now, man has not been able to create an ideal system of civilization and to avoid crisis situation of the system. Environmental awareness is a necessary foundation for future, sustainable development of the environment. Along with the knowledge and skills it provides a foundation to move into larger systems, broader goals and more sophisticated understanding of the causes, consequences and connections that exist in the environment. Protection and improvement of human environment is a significant global problem of modern society. Its solving initiates, including finding ways to rational and complex use of natural resources, how to conduct an active demographic policy and developing and improving international cooperation in the field of scientific research. A new attitude to the environment, as well as the transformation of the spirit of the modern world of work is becoming imperative. The concept of sustainable development offers the possibility of harmonious development.

Key words: *ecology, sustainable development, pollution, environment.*

INTRODUCTION

Pollution and environmental protection for decades are very important problem of mankind, regardless of the current stage of development of the productive forces of society in some parts of the planet. Existing problems are imposed to Science and Operations by emphasized timeliness and acuteness and more clearly leads to the conclusion that there is almost no healthy environment, that many of the elements of it are threatened, that the degree of self-regulation of some facilities is insignificant and that a disturbed environment for almost anything and never can not be restored to its original condition. Despite the significant regional differences in the vulnerability of the environment, especially its natural components, plans, programs and actions for its protection and improvement are the global problem. Modern society needs to understand the warning of scientists and experts on environmental conditions more quickly and better, ie. the fact that the free, authentic and unspoiled environment is becoming less and vulnerable, degraded and devastated more. The second one is expanding at the expense of the first one faster than most might think, faster than the science of the end of our century could determine and forecast. Disturbance of the ecological balance is the result of human labor activity by which man "appropriates" the nature, and creates products. It does not only disturb the ecological balance of the ecosystem, but it is also a threat to the integrity of the man and his existence. In this, the twenty-first century, society is faced with the following global issues:

- damage to the biosphere and its ecosystems
- a huge number of people - more than 6 billion with a forecast to double by 2020
- exhaustion and reduced quantities of many sources of mineral and energy resources,
- pollution and degradation of media air, water, soil
- global climate change,
- destroyed species of flora and fauna, and further endangering biodiversity
- homelessness ¼ of the world's population
- impairment of human health and the threat to life

- large quantities of waste in all three states.

The survival of human societies in the past often has been threatened by natural disasters, epidemics, wars, famines, and other influences always limited by space. In contrast to the existential crisis of the past, the present crisis does not originate from the natural disasters that are spatially limited, but a global ideological imbalance in the material sense of the whole of civilization. Until now, man has not been able to create an ideal system of civilization and to avoid crisis situation of the system. Approaches to solving this problem are different in science. Some of the approaches can be:

- the transition from the economic system of continual growth in inpatient status,
- building environmental awareness among the people,
- the introduction of social programs
- application of technical measures (etc. filters, electric cars, etc..)
- self regulation of nature's ability and inventive power of man to find every problem promptly and adequately addressed (Petrović, 2006).

ENVIRONMENT AS A SYSTEM

The environment as an area of research, attracted the attention of scholars and practitioners from different fields from the early 20 century. They often explore in detail the various subsystems of the spatial environment, which reflect and specify the scope and objectives of their study. The environment is often considered as a system of interrelated systems: the natural environment, social environment, living environment, cultural environment, informational environment. Depending on the scale and purpose of the research, it is possible to observe the environment of each person (eg cabin space travel), family (eg apartment houses with associated detached), a group of people (the population of the urban district), the whole of humanity. Practical need to observe and specify the scope and objectives of their study:

- anthropogenic environment, which is regarded as a natural environment with the changes caused by human activities,
- quasi-natural environment as a system rebuilt by humans (culture), natural landscape created by man, including plantations and park-type,
- urban environment as a combination of natural conditions and construction and architectural form, which creates conditions for economic and environmental and human activity along with it affect the social organization of man,
- dwelling environment consisting of living conditions in residential areas, complex, which includes physical, chemical, biological, social and psychological factors. It is formed by external influences, in terms of space (traffic noise, chemical background, etc..), The impact of structures and their protective treatment, environmental factors, activities, and social factors (relationships within the family, between neighbors, tenants, etc..),
- cultural environment consisting of the conditions for the existence of materially and spiritual aspects of life, which includes the subject results of human activities, national and ethnic characteristics established for centuries, as well as human resources and skills,
- middle settlements, urban areas, urban and rural, as well as a combination of man-created life conditions: roads, sidewalks, houses, sanitary infrastructure, meso-climate city, etc..,
- a work environment consisting of physical, chemical and biological conditions in production facilities.

Forming the external natural and anthropogenic influences, influences the overall industrial zones, transport, etc.., Conditions in the workplace, the conditions in the community with social and psychological environment in the collective,

- social and psychological environment that covers the relations between people, which include the degree of attention of each other, respect for each other, or vice versa, contempt, indifference or interest in relation to a common cause and the success of each member of the group, the unity or diversity of tastes, aspirations, priorities,

- social and economic environment that covers the relations between people (and their groups) between them, and they create the material and cultural values that affect humans. It includes social, psychological, social, demographic, cultural, ethnic, economic and other factors.

DEVELOPMENT OF ECOLOGICAL AWARENESS

Although concern about the protection of nature has always existed, the development of environmental awareness comes first with the appointment of the theory of the environment that is associated with the second half of the eighteenth century. Benthamite theory was based on the desire to improve the living conditions and hygiene in workers' settlements, mostly built in the vicinity of industrial plants and mining sites. Lack of Benthamite theory was reflected in the approach of providing only more efficient conditions. Climbing nature has resulted in pollution and environmental degradation. The middle of the twentieth century is characterized by the further course of intensive industrial development of many countries in the world, as well as the development of industrial and municipal infrastructure. So R.Karson has launched a new movement for the protection of the environment which was a call to humanity to reduce the use of pesticides in agriculture. However, She did not observe that global environmental problems suggested by theories of the seventies and eighties of the twentieth century, reached a climax in the developed countries of the world. Theory of growth was based on the total population as it inevitably leads to increased production and consumption, resulting in increased consumption of natural resources, increasing pollution and environmental degradation.

The first United Nations Conference on the Environment was held in Stockholm in 1972. and was a turning point in relation of the humanity to the environment. The decision was made- Stockholm declaration that pointed to the alarming state of environmental quality and highlighted the necessity of monitoring of its quality, resource depletion, pollution consequences on human health, nature, flora and fauna. Fifth June as the first day of the conference in Stockholm, declared World Day of Environment. In the period since 1972. until the nineties of the 20th century, there was a greater number of theories and movements of the environment that have not exceeded the limits of the theory of growth and Stockholm declaration. Let us mention some theories: the theory of organic growth, the theory of transformation of the international order, steady-state theory, the theory of levels of life, the theory of post-industrial age, the theory of decentralization of the social system.

World Commission on the Environment in 1987 presented to the public report "Our Common Future" based on intergeneration and intrageneration justice that meets the needs and provide good living conditions in developing countries. The report was based on a new concept of global economic and environmental policies and which one of the most important results is the decision "Business Charter for Sustainable Development" that industrial companies gives guidance on the basic components of environmental management. In 1992, Conference was held in Rio de Janeiro, where for the first time was pointed to the link between development and environmental protection. This is certainly worth noting and action program "Agenda 21", which makes recommendations to strengthen the company in environmental and development policies, and the "Decree of the Council of the European Union" of 1836/93 on the voluntary participation of industrial companies in the European Community for environmental management and environmental testing.

Note that in Kyoto in 1997 50 countries have signed the United Nations Framework Convention on Climate Change, aimed at preventing and reducing the emission of toxic gases, primarily carbon dioxide, which is considered the main cause of rising temperatures on Earth, and the creation of the "greenhouse". So far the protocol was ratified by Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Spain, Sweden and the United Kingdom of Great Britain, Northern Ireland, Norway, Malta, Romania and Slovakia. One certainly important step is the fact that the protocol is ratified by Japan, one of the world's major polluters (Đukanović, 1996).

NATURAL RESOURCE MANAGEMENT

In contemporary literature it is widely accepted classification of human resources, physical and natural. Natural resources are the geological and biological values that are directly or indirectly use, or can be used, and have real or potential value. Management of natural resources means adjusting system measures and market conditions at the national level, taking into account the priorities in the conduct of investment policy, taking care of training of personnel and organization of work, the introduction of the practice of scientific information, the application of new technologies and, finally, the long-term development planning so as to respect the principles of sustainable development in accordance with the above definition Bruntlendove Commission.

There are two categories of resources:

- Non-renewable resources: geological resources (mineral resources-ore metals, non-metals and energy resources - coal, oil and gas), land
- Renewable resources: wildlife, the water, air, sunlight, wind and tidal energy. Renewable resources have the power of regeneration, but if the intensity of the pace of recovery does not exceed the rate of use, the use of these resources may be limited in time. Non-renewable resources are formed in the distant geological past and for creating them there were millions of years. Of course, with this kind of resources we can talk about the most rational exploitation more than on sustainable use.

Sustainable use of natural resources requires strict planning and management of existing reserves in terms of the economic development. Sustainable use of renewable resources is required and it must be strictly managed and controlled, while for non-renewable resources modern approach in their sustainable use is very important and generally it is considered that sustainable use is impossible.

Basic concepts in the assessment of natural resources reserves are proved reserves-which include deposits that have been discovered to be exploited.
- Conditional Reserves-the deposits that have been discovered but their exploitation is not economical.
- Hypothetical-reserves are those that can be assumed to in the future will be found in areas that are now only partially tested and activated.
- Speculative-reserves are located in the as-yet uncharted areas, which is assumed to have a favorable geological conditions.

The quality of the estimated proven reserves depends on a number of factors:
- economic factors
- available technology and technology
- demand for resource
- cost production and processing of resources
- price-products obtained from them, and
- political factors (Rajović, 2007).

More than a decade ago, the World Commission on Environment and Development known as Bruntlendov Commission published a report" Our Common Future", which points to the danger to the people and the planet, policy of economic growth without taking into account the possibility of regeneration of the country. The Commission defined sustainable development as" development which meets the needs of the present without compromising the opportunities for future generations to meet their own needs". World leaders, at the Earth Summit in Rio de Janeiro in 1992. adopted the recommendations of Bruntlendov Commission, and one of the results of the summit was Agenda 21 which provides recommendations for the sustainable management of land, water and forest resources.

Management means adjusting system measures and market conditions at the national level, taking into account the priorities in the conduct of investment policy, taking care of training of personnel and organization of work, the introduction of the practice of scientific information, the application of new technologies and, finally, the long-term development planning so as to respect the principles of sustainable development in accordance with the above definition of Bruntlendov Commission. Planning is one of the most important and valuable spectrum problems which is to be addressed. In terms of time, on a semi-operational plans dealing with what to do in the next few days, and the other half can be a strategic plan for the planning horizon of 100 years or more. In spatial terms, the planning and decision-making are limited to local areas of a few acres, but in the vast spaces of several hundred thousand acres. Finally, in terms of organization, planning decision-making can be of the highest ranking executives, directly to low-skilled workers in the field. (Bojan Srđević)

All measures aimed at preserving renewable resources can be divided into:

- legal measures prevent the free-access and uncontrolled use of resources,
- quantitative restrictions - restrictions effort (eg, limitations of technical characteristics of boats, size of network, etc..) and
- quantity restriction-exploited resources (eg regulations on the maximum amount of catch, the time allowed hunting, etc..)
- economic measures - fiscal measures (taxes and subsidies) and the system of individual transferable quotas (based on the assessment of the resources of the state population provides a maximum annual harvest for some species, and in that the resource users allocated an annual quota. Only those quantities for which there is a permit may hunt).

Measures aimed at the preservation of non-renewable resources are: fiscal measures - taxes and subsidies, and recycling.

THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Be rational with resource! The essence of the concept of sustainable development includes interactions between the environment and the mutual coherence and complementarity of development policy and political environment, which respect the principles of ecological systems. The concept of sustainable development is focused on the conservation of natural ecosystems and the environment and the rational use of natural resources.

For sustainable development goes further claim that the feedback loops in the environment, and environmental and social framework. Sustainable growth means that further growth is not threatened by negative feedback, or from bio-physical, or social world. Preservation of the environment has to be taken as a prerequisite to, the growth of welfare, as characterized by sustainable development.

It can be concluded that three basic principles of sustainable development are based on ecological sustainability and socio-cultural sustainability and economic viability. Ecological sustainability ensures that development is compatible with the maintenance of ecological processes, biodiversity and natural resources. Socio-cultural sustainability ensures to increase oversight of man over his own life, and economic sustainability provides a successful economic development. It is clear that this is a concept that has its global and international background and content, but also internal and regional character. The intertwining of global, regional and national, and local dimensions of sustainable development is one of the main features on sustainable development.

CONCLUSION

To the creation of man and his relation to nature, in the living world there was a mutual and harmonious relationship and dependence in ecological balance. Disturbance of the ecological balance is the result of one's work situation, in which a man "appropriates" the nature, and creates products. When it comes to a disturbance of the ecological balance of the ecosystem, it is also a threat to integrity of a man and his existence. Knowledge of environmental laws, processes and phenomena in nature enriches human nature to look at the whole. Decorating according to his needs he must not lead to interruptions in the process of it, or to disrupt the functional balance that exists between living things and their environment. This can be avoided only if you are familiar with environmental laws and if people behave in line with them. Thus, environmental awareness is a form of life that respects and harmonizes with the natural laws of the circulation of matter, energy expenditure and the renewal of life, while encouraging only necessary take from nature for the provision of basic human needs. Therefore, environmental ethics is an environmental man's relation to the environment, which is related to the moral relationship between human / natural and technosphere / biosphere. A new attitude to the environment, as well as the transformation of the spirit of the modern world of work is becoming imperative. The concept of sustainable development offers the possibility of harmonious development.

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MULTICRITERIA DECISION MAKING FOR SUSTAINABLE ENVIRONMENTAL PROTECTION

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ABSTRACT

Air, water and land pollution, and particularly waste management, are considered in this paper as the issues related to environmental protection. The increasing public concern about environmental quality forces the development of evaluation models and the implementation of improvement strategies. The decision making methodology for sustainable environmental management should include estimation of cumulative, interactive effects over time caused by current and foreseeable actions, and searching for a balance of the ecological, social and economic dimensions. The main aim is to capture all relevant foreseeable impacts in their most appropriate and representative units. Practical decision problems are often characterized by several noncommensurable and competing (conflicting) criteria, with no solution satisfying all criteria simultaneously. The multicriteria decision making method VIKOR could be applied for ranking alternatives and selecting compromise solution from the set of alternatives. Indicators of sustainable environmental protection should be identified constructing a hierarchy with the following main criteria: economy (costs and benefits), protection of natural environment, social acceptability, and institutional. Multicriteria decision making for municipal solid waste management in the region of Novi Sad is presented illustrating alternatives generation, formulation of criteria functions, evaluation of alternatives in terms of criteria, application of the VIKOR method and the proposition of final solution.

Key words: *environmental protection, multicriteria decision, compromise, VIKOR.*

INTRODUCTION

Urban ecology is considered as the scientific study of the interaction of people with their urban environment. The study of urban ecology carries increasing importance because, within the next forty years, two-thirds of the world’s population will be living in expanding urban centers (Niemela, 1999). Methods of studying urban ecology involve chemical and biochemical techniques, temperature recording, and management and public participation. Chemical techniques may be used to determine pollutant concentrations and their effects. Temperature data and heat mapping can be used for studies of various factors that may be affecting the environment. Long-term ecological research sites are funded by the governments that have collected reliable long-term data over an extended period of time in order to identify long-term climatic or ecological trends (Grimm et al. 2008).

Humans are the driving force behind urban ecology and influence the environment in a variety of ways, such as modifying land surfaces and waterways, deforestation, and growing pollution. A large demand for chemical use by industry, construction, agriculture, and energy providing services have a substantial impact on environmnet, resulting in phenomena such as acid rain, eutrophication, and global warming. Wastes from large urban centers can drive biogeochemical cycles on a global scale. Due to the pressures of population and technology, the biophysical environment is being degraded, sometimes permanently. Formal environmental protection was stimulated by the United Nations Conferences. Following this, the governments began establishing environmental protection agencies. Their jurisdiction is similar and covers pollution control, land/water use, and waste management. The increasing public concern about environmental quality forces the development of evaluation models and the implementation of improvement strategies.

Air, water and land pollution, and particularly waste management, are considered in this paper as the issues related to environmental protection. The concept of sustainable management is presented in Section 2. The multicriteria decision making methodology is introduced in Section 3. Section 4 considers four issues related to environmental protection. In Section 5, multicriteria decision making for municipal solid waste management in the region of Novi Sad is presented, illustrating alternatives generation, formulation of criteria functions, evaluation of alternatives in terms of criteria, application of the VIKOR method and the proposition of final solution.

SUSTAINABILITY

The concept of sustainable development includes estimation of cumulative, interactive effects over time caused by current and foreseeable actions. Also, a balance of the ecological, social and economic dimensions should be taken into account. Sustainability concept may be considered as an extended concept of robust optimality and Pareto-optimality, integrating effects on/of economy, social environment, natural environment, culture, and politics. A method for conflict resolution has been developed based on compromise solution. A hierarchy of criteria should be constructed defining indicators for each criterion. Indicators can provide crucial guidance for decision-making in a variety of ways. They can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process. They can help to measure and calibrate progress towards sustainable development goals.

The UN Commission on Sustainable Development proposed framework and the core set of indicators including social, economic, environmental, and institutional dimensions of sustainable development (Indicators, 1999, 2007). The following is an example of the hierarchy: Consumption and production patterns, Waste generation and management, Waste treatment and disposal, Management of radioactive waste. The indicator “Generation of hazardous waste” is linked with and may apply to the following themes: Consumption and production patterns, Health, Atmosphere, Land, Oceans, seas and coasts, Fresh water, Global economic partnership. It is explained as follows

Generation of hazardous wastes

Sub-theme: Waste generation and management Core indicator

Brief definition: The total amount of hazardous wastes generated per year through industrial or other waste generating activities, according to the definition of hazardous waste as referred to in the Basel Convention and other related conventions.

Description: The indicator provides a measure of the extent and type of industrialization in a country and the nature of industrial activities including technologies and processes generating hazardous wastes. The generation of hazardous wastes has a direct impact on health and the environment. Normally, long-term exposure is required before harmful effects are seen. Reduced generation of hazardous wastes may indicate reduced industrial activities in a country, introduction of cleaner production in the industrial processes, changing patterns in consumers’ habits, or changes in national hazardous waste legislation.

The projects generally aim at treating “sustainable environmental management” in a user oriented, transparent and structured way, attempting to make the concepts familiar to non-sophisticated entities, such as local authorities, that very often however have a critical saying in respective planning decisions. The concept proposes a balanced approach, whereby important development work is then accompanied by case studies, seeking to validate the project developments in practical and diverse areas. The expected results include the successful deployment of practical, innovative and easy to use tools, suitable for supporting management, especially adapted for the local authority level. Their successes are validated by demonstrating the merits of the approach and solution, when practically used at the project pilot sites.

MULTICRITERIA DECISION MAKING

Practical decision problems are often characterized by several noncommensurable and competing (conflicting) criteria, with no solution satisfying all criteria simultaneously. Applying multicriteria decision making (MCDM), the solution (compromise) can be determined, which can help decision makers to reach a final decision. The compromise ranking method (named VIKOR) is introduced as one applicable technique to implement within MCDM, and it is presented in the Appendix.

The use of multicriteria (or multiattribute) approach, as a framework for sustainable environmental protection, has several desirable properties: the main aim is to capture all relevant foreseeable impacts in their most appropriate and representative units, establishing the hierarchy of indicators as a systematic way to perceive the entire set of indicators, and the relative importance of indicators can be used (such as weights). The indicators could be noncommensurable, such as: quantitative economic indices (monetary units), quantitative technical (engineering) measures (kg, sec, m), and qualitative indices (grades or scores). Indicators of sustainable environmental protection should be identified and a hierarchy will be constructed with the following main objectives: economy (costs and benefits), protection of natural environment, social acceptability, and institutional. In many cases, linkages among objectives lead to potential conflicts. For example, high GDP growth is generally considered a positive sign of economic development, but it is often associated with higher energy consumption, exploitation of natural resources and negative impacts on environmental resources. Such cases reinforce the need to interpret results in a balanced and integrated manner.

For each main objective the indicators for second levels will be identified. For example, social acceptability could include: personal and family health, perceiving risk related to environment degradation, awareness of new management type, willing to contribute to environmental protection. The set of criteria (objectives) is constructed defining indicators for each criterion (Figure 1).

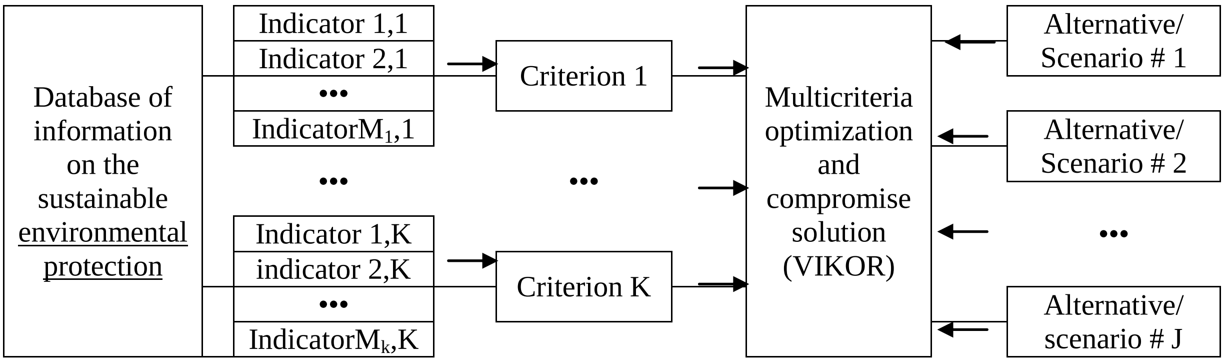


Figure 1. Elements of multicriteria decision makinf for sustainable environmental protection

The alternatives of environmental protection should be evaluated in terms of formulated criterion functions. The VIKOR method could be applied for ranking alternatives and selecting compromise solution from the set of alternatives (see Section 5 and Appendix).

ENVIRONMENTAL PROTECTION

Environmental protection is a practice of protecting the natural environment on individual, organizational or governmental levels, for the benefit of both the natural environment and humans. Due to the pressures of population and technology, the biophysical environment is being degraded, sometimes permanently. Formal environmental protection was stimulated by the United Nations Conferences. Following this, the governments began establishing environmental protection agencies. Their jurisdiction is similar and covers pollution control, land/water use, and waste management. Protection of the environment is needed due to various human activities. Air, water and land pollution, and waste production are some of the issues related to environmental protection. Protecting air, water and land from negative impacts of wastes became a goal of environmental protection. Wastes from urban centers, especially large urban centers in developed nations, can drive biogeochemical cycles on a global scale.

Air quality

The concentration of population and industrial development in many urban areas have led to deterioration of the urban environment and increasing public concern about environmental quality, forcing the development of evaluation models and the implementation of improvement strategies. One type of models includes quantifiable measures with data obtained through monitoring or surveys, and the other is generally based on people's preferences.

There are studies of multicriteria analysis of environmental quality in large cities. The results indicate air quality as main public concern. The deterioration of air quality in metropolitan area is caused by different pollutant sources, which are divided into two categories: mobile pollutant sources, which are emissions from motor vehicles; and immobile pollutant sources, such as factories, construction work, etc. (Tzeng et al. 2002). The alternatives are the measures to improve air quality, for example, increasing the traffic flow efficiency, reducing traffic flow during peak hours, encouraging the use of low-pollution fuel, improving and encouraging travel by mass transportation, elimination of old vehicles, etc. The alternatives were ranked according to the established criteria, for example, implementation costs, cooperation of government administration, social equity, acceptance by non-polluters, acceptance by polluters, and amelioration of air quality. The expert evaluation approach could be used, since quantified information for the improvement strategies is difficult to obtain. Experts may judge the effects of each measure of improvement strategy. The top ranked alternatives in (Tzeng et al. 2002) are the use of low-pollution fuel and establishing rigid standards for the immobile polluters.

Sustainable land use

Land is very important resource, but this resource has been poorly managed and not protected in recent decades. The physical, chemical and biological condition of the soils has deteriorated owing to irrational land use, common practice of clear-felling of forests, disregard of soil protection measures, improper cultivation techniques on slopes and hilly areas. Unprofessional fertilisation, atmospheric acid sedimentation, the use of different acidic by-products and wastes, and the lack of liming caused an increase in soil acidification. Applying chemicals in agriculture we pollute soil and water sources (surface and underground). There is no appropriate methodology for evaluating sustainable land use, encompassing all biophysical and socioeconomic criteria. The future projects should improve the state of the art emphasizing that the land is not only commercial products but, rather, a heritages that must be protected, defended and treated as such. This could contribute very much sustainable land-use. However, the existing scientific, economic and legal instruments are currently beset by serious methodological shortcomings, hampering the implementation of strategies. There are diverse conditions and needs in the countries that require different specific solutions in sustainable development. This diversity should be taken into account in the planning and execution of measures to ensure protection and sustainable use of natural resources. Decisions should be taken as close as possible to the locations where natural resources are affected or used. Priority should be given to measures adjusted to regional and local conditions.

A particular example is presented in the article (Opricovic and Tzeng, 2002). A multicriteria model is developed for analyzing the planning strategies for reducing the future social and economic costs in the area with potential natural hazard. The developed multicriteria decision making procedure consists of generating alternatives, establishing criteria, assessment of criteria weights, and application of the compromise ranking method (VIKOR). The alternatives are the scenarios of sustainable hazard effects mitigation, generated in the form of comprehensive reconstruction plans, including the redevelopment of urban areas and infrastructures, multipurpose land-use, and restrictions on building in hazardous areas. The plans have to be evaluated according to the criteria representing: public safety, sustainability, social environment, natural environment, economy, culture, and politics. The multicriteria model treats all relevant conflicting affects and impacts in their representative units. The evaluation of alternatives is implicated with imprecision (or uncertainty) of established criteria, and the fuzzy multicriteria model is developed to deal with “qualitative” (unquantifiable or linguistic) or incomplete information. The application of this model is illustrated with the post-earthquake reconstruction problem in Central Taiwan; including the restoration concerning the safe and serviceable operation of “lifeline” systems such as electricity, water, and transportation networks, immediately after a severe earthquake.

A similar approach could be applied for the other area with potential natural hazard (flood, tornado, or drought).

Water management

The surface and underground waters available for utilisation has decreased significantly, and their quality has deteriorated (Miloradov et al., 1995). Pollution of subsurface waters can mainly be characterised with the high concentration of nitrates, which is due to the lack of sewage network in settlements and large animal farms and improper fertiliser and manure use. Waters in many countries are under increasing pressure from the continuous growth in demand for many different purposes (Miloradov, 1992). More and more water is needed for irrigation, requiring large systems. Applying chemicals in agriculture we pollute soil and water sources (surface and underground).

The EU's Water Framework Directive (2000) stipulates that a programme of schemes is to be laid down in a management plan for each river basin by 2010 which will ensure all ground water and surface water is of a “good status”. For the purposes of environmental protection there is a need for a greater integration of qualitative and quantitative aspects of both surface waters and groundwaters, taking into account the natural flow conditions of water within the hydrological cycle. The article 16 of WFD defines Strategies against pollution of water. The European Parliament and the Council shall adopt specific measures against pollution of water by individual pollutants or groups of pollutants presenting a significant risk to or via the aquatic environment, including such risks to waters used for the abstraction of drinking water. For those pollutants measures shall be aimed at the progressive reduction and, for priority hazardous substances, at the cessation or phasing-out of discharges, emissions and losses. The article 17 defines Strategies to prevent and control pollution of groundwater. In order to identify the impact of human activity on waters the following is necessary:

- Estimation and identification of significant point and diffuse source pollution, from urban, industrial, agricultural and other installations and activities.
- Estimation and identification of significant water abstraction for urban, industrial, agricultural and other uses, including seasonal variations and total annual demand, and of loss of water in distribution systems.
- Estimation and identification of the impact of significant water flow regulation, including water transfer and diversion, on overall flow characteristics and water balances.
- Identification of significant morphological alterations to water bodies.
- Estimation and identification of other significant anthropogenic impacts on the status of surface waters.
- Estimation of land use patterns, including identification of the main urban, industrial and agricultural areas and, where relevant, fisheries and forests.
- Assessment of the susceptibility of the surface water status of bodies to the pressures identified above.
- Use the information collected above, and any other relevant information including existing environmental monitoring data, to carry out an assessment of the likelihood that surface water bodies within the river basin district will fail to meet the environmental quality objectives.
- Utilize modelling techniques to assist in such an assessment.
- For those bodies identified as being at risk of failing the environmental quality objectives, optimize the design of both the monitoring programmes and the programmes of measures.

This could contribute very much sustainable water use. However, the existing scientific, economic and legal instruments are currently beset by serious methodological shortcomings, hampering the Directive's implementation. There are diverse conditions and needs in the Community that require different specific solutions in sustainable development. Decisions should be taken as close as possible to the locations where waters are affected or used. Priority should be given to measures adjusted to regional and local conditions. The success of these projects relies on information, consultation and involvement of the public, including users (Solomon, 2010).

There were attempts to implement WFD in Serbia. The experience is presented in the Monograph (Miloradov, 2008a) and in the paper (Miloradov and Prohaska, 2010).

Waste management

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials. Widely accepted hierarchy of priorities is as follows:

- prevention of waste material being created
- reduction by appropriate technologies and products
- separation of waste materials
- reuse of waste materials
- recycling of waste materials by reprocessing into new products
- incineration or thermal treatment to generate heat or electricity
- composting to decompose organic waste material, recycling as compost/fertilizer
- disposal of waste in a landfill.

The aim of this hierarchy is to extract the maximum practical benefits and to generate the minimum amount of waste.

The waste is produced by different human activities. Waste represents a considerable loss of resources both in the form of materials and energy. Reducing the material intensity of production and consumption of goods and services is essential to environmental protection and resource conservation. Reductions in intensity of material use can be achieved by more efficient use of natural resources in production and consumption, by recycling used and waste material, and by shifts in consumption patterns to less material intensive goods and services. The treatment and disposal of the generated waste may cause environmental pollution and expose humans to harmful substances and bacteria, and therefore impact on human health. The optimization subject is the proportion of waste generated (collected) which is recycled, composted, incinerated, or landfilled on a controlled site. The proper treatment and disposal of waste is important from an environmental and social viewpoint but can be an economic burden on industries, municipalities and households. The amount of waste recycled and composted reduces the demand for raw materials, leading to a reduction in resource extraction. There may also be a benefit of increased income generation for the urban poor through recycling schemes.
Environmental performance at waste management is achived by consuming less, emitting less, reuse, achieving financial objectives, protecting the environment, complying with all rules and regulations.
There are several projects related to waste management in Serbia, for example, the project of regional hygienic landfill for municipal solid waste with recycling center in Sremska Mitrovica, Serbia (Miloradov, 2008b), or the project of regional landfill in Indjija, Serbia (Miloradov, 2009).

Here, a special focus is put on the waste management, with an illustrative example. The task is to decide on the proportion of municipal solid waste generated (collected) which is recycled, composted, incinerated, or landfilled on a controlled site.

ILLUSTRATIVE EXAMPLE

Multicriteria decision making for municipal solid waste management

Municipal solid waste management in the region of Novi Sad is considered. The waste generation is constantly increasing due to several factors such as growing population and industrial development, as well as changes in the consumer habits.

The objective is to develop the methodology to assess the efficiency of alternative programs both environmentally and from the economic and social perspectives. The parameters for optimization model are the percentages of waste which are recycled, composted, incinerated, and landfilled on a controlled site. The amount of waste recycled and composted reduces the demand for raw materials, leading to a reduction in resource extraction. There may also be a benefit of increased income generation for the urban poor through recycling schemes.

This model will help decision makers optimize the performance of their waste management programs. The alternatives are generated combining the parameters for optimization of waste treatment, and they are presented in Table 1. For example, 100 % of disposal means total collected waste goes to landfill, or 54 % of incineration means the percent of total waste treated by incineration. Constraints are seen as high-priority objectives, which must be satisfied in the alternatives generating process.

Table 1: Set of alternatives

Activities		Alternatives									
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Disposal	%	100	1	3	4	85	34	98.5			0
Recycling	%	0	48	29	24	15	43	1.5			8.3
Composting	%	0	17	40	18	0	0	0			0
Incineration	%	0	35	27	54	0	23	0			91.7
Origin		Bulg.	Germ	Aust.	Denm	Serb.	EU	ESNS	S1NS	S2NS	S3NS

Alternatives A1 to A5 are based on data for origin countries, and represent management for Novi Sad with similar activities, A6 is EU projection 2020, ESNS is existing system in Novi Sad, and SxNS are for three management scenarios for Novi Sad (Stanisavljevic, 2012).

The formulation of the optimization criteria is based on the indicators. The indicators could be grouped to:

Social: health, security, education, equity, housing, and population
Environmental: atmosphere, land, rivers, seas, fresh water and biodiversity
Economic: economic structure and consumption/production patterns
Institutional: institutional framework and institutional capacity

For example, indicators for the operation cost as an economic criterion are:

Operation costs for disposal of waste in a landfill (well-managed and hygienic), €/Ton
Operation costs for recycling of waste materials, €/Ton
Operation costs for composting (recycling as compost/fertilizer), €/Ton
Operation costs for incineration to generate heat, €/Ton
Operation costs for incineration to generate electricity, €/Ton.

The operation cost is formulated as follows:

$$f_4 = \sum_a c_a W p_a / 100$$

where: c_a is unit operation cost for a-th activity, W total yearly waste, p_a is the percent of waste W treated by the a-th activity.

The most relevant indicators could be chosen through a selection process that included opinions from experts, literature review based on relevance and applicability to different waste program settings.

The following criteria could be established:

*f*1. Contribution to the environmental protection, Grade
*f*2. Final disposal in a landfill (after treatments), % of collected waste
*f*3. Investment costs for space and equipment, €
*f*4. Operation cost of activities, €/year
*f*5. Produced energy by incineration, kWh/year
*f*6. Value of all products of treatments, €/year
*f*7. Recycled waste materials, % of collected waste
*f*8. Energy for treatments, MWh/year.

Three questionnaires are designed in order to collect information related to the opinion and preference of decision makers at national, regional and local levels, and the data for existing system from managers.

The alternatives are evaluated according to all established criteria, and the VIKOR method could be applied for ranking alternatives and selecting compromise solution from the set of alternatives. Based on these results, the final solution will be proposed including implementation plan and institutional support.

CONCLUSION

Environmental protection is considered as a practice of protecting the natural environment on individual, organizational or governmental levels, for the benefit of both the natural environment and humans. Protection of the environment is needed due to various human activities. Protecting air, water and land from negative impacts of wastes became a goal of environmental protection.

The decision making methodology for sustainable environmental management should include estimation of cumulative, interactive effects over time caused by current and foreseeable actions, and searching for a balance of the ecological, social and economic dimensions. Compromising is necessary when goals are clearly incompatible and mutually exclusive, decision makers have equal power, and partial satisfaction maybe better and feasible. In negotiations, the parties realize the potential of a compromise and can assess main features of the agreement established by mutual concessions. Compromising can be supported by a multicriteria decision making methods and tools, such as the VIKOR method. The VIKOR method assumes all parties acting as one rational decision maker in compromising, and the preference is expressed by the weights of criteria. The obtained compromise solution could be approved by the decision makers because it provides a maximum group utility of the “majority” and a minimum individual regret of the “opponent”. The main contributions of VIKOR to conflict resolution are: consideration of the decision making process in addition to the result; the use of criteria which is more meaningful for decision makers than utilities; search for the set of compromise solutions rather than one solution; and, interactivity which allows decision makers to participate in and control the decision process (by weights).

The main activities for the implementation of the solution will take place in the context of environmental protection project led by local authorities. Priority should be given to measures adjusted to regional and local conditions. It is necessary to establish an integrated monitoring and management system in order to maintain high status of environment. Also, the success of the project relies on information, consultation and involvement of the public.

A more general ecosystems approach to environmental resource management and environmental protection aims to consider the complex interrelationships of an entire ecosystem in decision making rather than simply responding to specific issues and challenges. The decision making would be a collaborative approach to planning and management that involves a broad range of stakeholders across all relevant governmental departments, as well as representatives of industry, environmental groups and community. To apply the VIKOR method, the management alternatives should be evaluated in terms of established criteria for the stated management problem.

APPENDIX - The VIKOR method

The VIKOR method was developed as a multicriteria decision making method to solve a discrete decision problem with noncommensurable and conflicting criteria. This method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision.

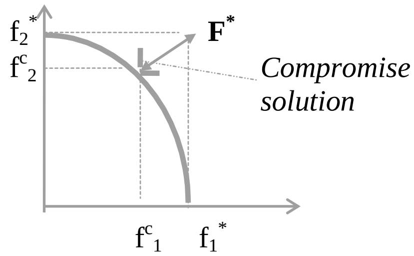
The VIKOR characteristics are matched with a class of problems as follows.

- Compromising is acceptable for conflict resolution.
- The decision maker (DM) is willing to approve solution that is the closest to the ideal.
- There exist a linear relationship between each criterion function and a decision maker’s utility.
- The criteria are conflicting and noncommensurable (different units).
- The alternatives are evaluated according to all established criteria (performance matrix).
- The DM’s preference is expressed by weights, given or simulated.
- The VIKOR method can be started without interactive participation of DM, but the DM is in charge of approving the final solution and his/her preference must be included.
- The proposed compromise solution (one or more) has an advantage rate.

The compromise solution $F^c = (f_1^c, ..., f_n^c)$ is a feasible solution that is the “closest” to the ideal solution F^* (the best values of criteria).

$$\min_{x \in X} Q = || F^* - F(x) ||; \quad F(x) = (f_1(x), f_2(x), ..., f_n(x)$$

$$Ideal: \; F^* = (f_1^*, f_2^*, ..., f_n^*); \quad f_i^* = \underset{x \in X}{ext}\, f_i(x)$$



Here, compromise means an agreement established by mutual concessions, represented by

$\Delta f_i = f_i^* - f_i^c$, $i = 1,…,n$.

The alternatives are evaluated according to all established criteria, resulting in performance matrix $| f_{ij} |$, where f_{ij} is the value of the i-th criterion function for the alternative A_j; n is the number of criteria; J is the number of feasible alternatives.

The alternatives are ranked by the values Q_j, j=1,...,J in decreasing order.

$$Q_j = v(S_j - S^*)/(S^- - S^*) + (1-v)(R_j - R^*)/(R^- - R^*) \tag{1}$$

where:

$$S_j = \sum_{i=1}^{n} w_i (f_i^* - f_{ij})/(f_i^* - f_i^-) \tag{2}$$

$$R_j = \max_i [w_i (f_i^* - f_{ij})/(f_i^* - f_i^-)] \tag{3}$$

$f_i^* = \max_j f_{ij}$, $f_i^- = \min_j f_{ij}$, if the i-th function represents a benefit;

$f_i^* = \min_j f_{ij}$, $f_i^- = \max_j f_{ij}$, if the i-th function represents a cost;

$S^* = \min_j S_j$, $S^- = \max_j S_j$, $R^* = \min_j R_j$, $R^- = \max_j R_j$;

w_i are the weights of criteria, expressing the DM’s preference as the relative importance of the criteria; v is introduced as a weight for the strategy of maximum group utility, whereas 1-v is the weight of the individual regret, here $v = (n + 1)/ 2n$.

The VIKOR software proposes the best ranked alternative as a compromise solution, or a set of compromise solutions if several (M) alternatives are “in closeness” (close to the best ranked alternative)

$$Q(A^{(M)}) - Q(A^{(1)}) < DQ \text{ for maximum } M, \quad DQ = 1/(J-1).$$

The VIKOR method is an effective tool in multicriteria decision making, particularly in situations where the decision maker is not able to express his/her preference at the beginning of system design. The obtained compromise solution could be accepted by the decision makers because it provides a maximum group utility of the “majority” (represented by min S, Equation (2)), and a minimum individual regret of the “opponent” (represented by min R, Equation (3)). The compromise solutions could be the base for negotiation, involving the decision makers’ preference by criteria weights.

The basic ideas of VIKOR had developed by Serafim Opricovic, in his Ph.D. dissertation in 1979, and an application was published in 1980. The name VIKOR appeared in 1990 at national symposium (from Serbian: VIseKriterijumska Optimizacija i Kompromisno Resenje, that means: Multicriteria Optimization and Compromise Solution, with pronunciation: *vikor*). The paper (Opricovic and Tzeng, 2004) contributed to the international recognition of the VIKOR method, it was identified by Thomson Reuters *Essential Science Indicators*^{SM} as the most cited paper in the field of Economics and Management (*Science Watch*, Apr.2009; http://sciencewatch.com/dr/erf/2009/09aprerf/09aprerfOpriET).

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THE UTILIZATION OF RECYCLED PULYETHYLENE TEREPHTHALATE (PET) AS A MATERIAL IN THE BUILDING INDUSTRY

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ABSTRACT

The development of consumption society has been followed, among others, with the mass production of plastics materials since the 1950s. The PET has taken a dominant place in the bottle production, which has caused the increase in its production. The enormously large amount of PET has been produced during the last few decades with the trend of an increasing production, yet only a small amount of it has been recycled. Thus, a significant amount of PET waste has been generated causing various ecological problems. There has been much research on the utilization of the recycled PET waste since the 1990s. Some of these studies show that PET can be used as a construction material. It can be used as an aggregate or as a binder in the polymer mortar and concrete, furthermore its fibers can be used in the production of fiber-reinforced types of concrete. This paper shows some of the leading world research results and the consumption of construction materials in Serbia with the possibility of their reduction.

Key words: *plastic, PET, aggregate, binder, construction material.*

INTRODUCTION

The modern society faces an increasing problem of waste management. The necessity of introducing the system waste management was recognized in England in the 15th century, yet it presents a serious challenge even six centuries later. One of the major challenges in the waste treatment presents the constant change in morphological characteristics of waste. This paper considers the recycled polyethylene terephthalate (PET) from plastic bottles, as a potential material in the building industry. PET bottles experienced the mass production during 1970s when the process of blow molding was introduced. Their characteristics (low weight, high strength, low permeability of gases and pleasant aesthetic appearance) enabled them a strong market position. Thus, the worldwide consumption of PET bottles was 15 million metric tons in 2007 (Reis et al., 2011). In the plastics waste stream PET flow is the second-largest flow, right after polyethylene (Siddique et al., 2008).

During the production of PET various hazardous components are created, among them dioxins as the most hazardous ones. Therefore, PET materials should be reused as many times as possible before dumping. Due to the long period of its degradation the discarded PET material is not considered as a hazardous one, yet its increasing amount causes faster dump filling and aesthetical ecosystem degradation, especially many negative effects may be provoked by its dumping in the large water areas. One of the major problems is known as the “Great Pacific Garbage Patch”. There are both, ecological and economical reasons for the promotion and implementation of reuse, recycling and recovery of PET waste. Furthermore the EU legislation covers this issue with the Directive 2004/12/CE, where the objective is to reclaim or incinerate (using energy recovery) at least 60 wt% of packaging waste and to recycle (55-85) wt% of it (Al-Salem et al., 2009). Thus, many industrial recycling processes have been developed. Some of them are: sorting, mechanical recycling, chemical recycling and energy recovery by different types of incineration or fuel production processes. The chemical recycling may be of the special interest because some of the products are unsaturated polyester resins that can be used as a binder in construction industry (Reis et al., 2011).

Many researchers have conducted their research during the last few decades on the use of plastic waste as an alternative material to natural materials used in the building industry. Various studies have been done with different plastic materials, yet many scientists agree that PET may be used as a substitute for aggregates or binders and its fibers can be used as a concrete reinforcement material (Wona et al., 2010). This paper presents the mechanical characteristics obtained through many worldwide studies, of concrete which contains a certain amount of PET as a compound material.

The production of aggregates, binders as well as reinforcing fibers is shown in Figure 1 schematically.

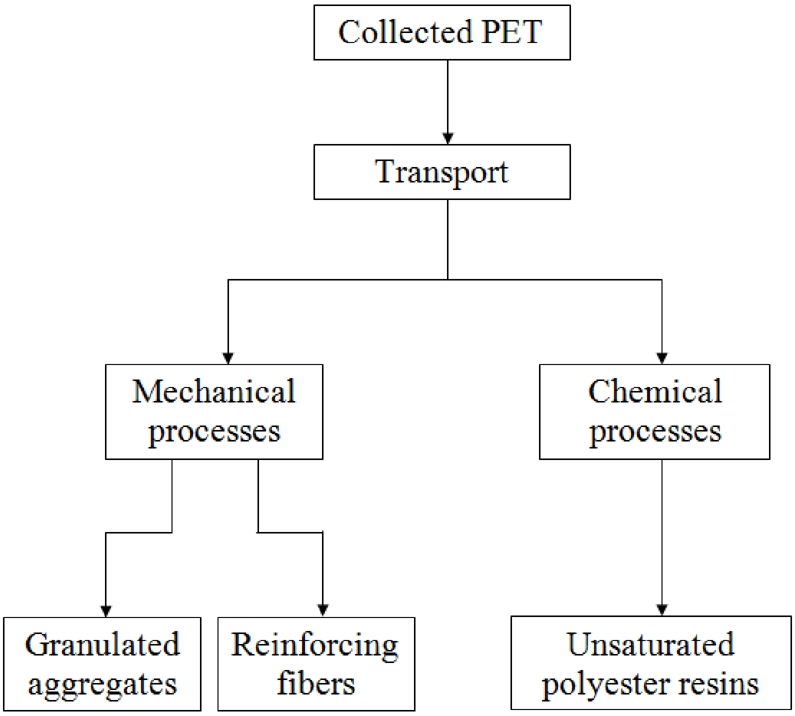

Figure 1. Production of building materials from PET from MSW

In some ocations it is necessary to combine mechanical and chemical processes as well as thermical ones, for example in proceses of industrial production of reinforcing fibres.

THE MUNICIPAL SOLID WASTE AS A SOURCE OF THE SECONDARY PET GENERATION

The thorough study was conducted in Serbia in the year of 2009 (Vujic et al., 2009) with the objective to determine the real morphological structure of the generated municipal solid waste (MSW). Average results of the generated amounts of plastic materials are presented in Table 1.

Table 1: Generated amounts of plastic waste in Serbia

MSW, t	PET, %	Hard plastics, %	Plastic bags, %	Plastic waste, %
2056746	3,99	4,37	6,65	15,01
	PET, t	Hard plastics, t	Plastic bags, t	Plastic waste, t
	82064,16	89879,80	136773,61	308717,58

Based on the results given in Table 1, there is about 82064 tons of generated and collected PET waste in Serbia per year, which presents a significant amount of material which may be used for further use.

THE MOST OFTEN USED CONSTRUCTION MATERIALS IN SERBIA

The construction industry uses a vast variety of materials in its processes. These materials are often products of very complex, economically and environmentally challenging processes. This chapter primarily treats the consumption of aggregates and binders in the construction industry. Relevant pieces of data are given in Tables 2 and 3.

Table 2: Annual consumption of binding materials in Serbia (The Republic of Serbia Statistical Office, 2010, 2011)

No.	Name	Consumption	
		Year	Amount
1	Quicklime, t	2010	1293
		2011	1472
2	Hydrated lime, t	2010	8951
		2011	7644
3	Plasters, t	2010	1294
		2011	1041
4	Portland cement, t	2010	158022
		2011	158715
5	Other types of cement, t	2010	121395
		2011	114279
6	Plastic binding materials, t	2010	7935
		2011	9959
7	Cement mortar, m^3	2010	35787
		2011	33289
8	Fresh concrete, m^3	2010	658554
		2011	737136
9	Asphalt, t	2010	1036240
		2011	1182482

Table 3: Annual consumption of aggregate materials in Serbia (The Republic of Serbia Statistical Office, 2010, 2011)

No.	Name	Consumption	
		Year	Amount
1	Crushed stone or marble, m^3	2010	139115
		2011	112448
2	Gravel, m^3	2010	1812119
		2011	1637911
3	Aggregates for concrete, m^3	2010	1901536
		2011	1997997
4	Pebble, m^3	2010	2055870
		2011	1918973
5	Sand, m^3	2010	970577
		2011	1154448
6	Terrazzo, t	2010	10262
		2011	9962

THE USE OF RECYCLED PET WASTE AS AN AGGREGATE IN CONCRETE AND MORTAR PREPARATION

In order to achieve the eco-sustainable building various studies have been conducted on using the recycled PET material as an aggregate in concrete preparation (Reis et al., 2011; Al-Salem 2009; Iucolano et al., 2013; Saikia et al., 2012; Remadnia et al., 2009). When preparing the material to be used as an aggregate, one should take a serious consideration about the initial conditions of PET. Preparation processes depend on these conditions. According to a review on using plastics as aggregate (Saikia et al., 2012) the most commonly used processes for producing plastic aggregates are: shredding, grinding, crushing, milling, sieving and washing. When using the PET aggregate a serious problem may occur due to its surface repellency to water. This causes weak adhesion forces and serious loosing in toughness. In order to improve inner bonds a propeller crusher is used for the aggregate preparation (Remadnia et al., 2009). This enabled researchers to control size limit with crushing and to facilitate matrix-aggregate adhesion due to the irregular shape and rough surface texture. Yet, a problem of creating and sustaining strong bonds among plastic aggregate and cement matrixes remains the open research topic. Each improvement in this area will result in the improvement of concrete performance in terms of increasing the compressive and splitting tensile strength as well as its elasticity modulus (Saikia et al., 2012).

Grain properties (bulk density, grain size distribution, specific gravity, water absorption) of plastic aggregate can be determined by slightly modified standard procedures for sands. As an example, the standard sieving method is used in order to determine grain size distribution of plastic aggregate (Saikia et al., 2012). The sieving equipment is presented in Figure 1.

Figure 1. Standard set of sieves on a vibrating machine

A significant difference is observed among stone or sand based aggregates and plastic based aggregates primarily because of their different structure. Natural aggregates have inorganic, while plastic based aggregates have organic origin, which reflects to their mechanical and thermal properties. According to numbers given in (Saikia et al., 2012), PET has a very low thermal conductivity (0.13-0.24W/(mK)) compared to, limestone (1.26–1.33W/(mK)) and sandstone (1.7/(mK)), which are the most common natual aggregates. The specific heat capacity of PET (1.0–1.1 kJ/(kgK)) is higher than those of limestone (0.84 kJ/(kgK)) and sandstone (0.92 kJ/(kgK)). These characteristics make mortars and concretes produced of PET originated aggregates better heat insulators than those made of limestone or sandstone.

In general, the use of plastic aggregates increases the porosity, water permeability and ductility of concrete. Still it significantly reduces its density, toughness and elasticity modulus. Related research results are presented in the literature sources (Reis et al., 2011; Iucolano et al., 2013; Saikia et al., 2012; Remadnia et al., 2009; Hasanbeigi et al., 2012).

Laboratory studies were conducted under the strictly defined conditions, so it is necessary to conduct thorough research on field in order to realize the real concrete behavior under exposed to natural surroundings.

THE USE OF RECYCLED PET WASTE AS BINDING MATERIAL

Binding materials are one of the basic compounds of every type of concrete or mortar. One of the most widely used binding materials is cement. The process of cement production is very demanding one, in terms of material and energy consumption. It makes the cement production industry one of the greatest consumer of natural raw materials and fossil fuels. Thus, carbon-dioxide is produced due to fuel combustion and limestone calcination. About 5% of the current anthropogenic CO_2 emission comes from cement industry (Hasanbeigi et al., 2012). There are three cement factories in Serbia which maximal annual production is approximately 3 100 000 tons of cement. According to data given in (Dejaa et al., 2010) the average emission of CO_2 per ton of produced cement in modern factories is 0,631 t/t. After applying this value on the Serbian production of cement the annual emission of CO_2 from cement industry is 1 956 100 tons of CO_2. After comparing the annual consumption (Table 2) with the production of cement it is obvious to conclude that Serbian cement industry does not work with the full capacity or that significant amounts of cement are exported. However, the production of CO_2 is significant so its reduction is a necessity.

There is a potential for CO_2 reduction by using the alternative binding materials to classical cement. Some research papers (Reis et al., 2011; Al-Salem et al., 2009; Iucolano et al., 2013; Jo et al., 2008; Mahdi et al., 2010) present studies on using PET material and its related resins as a binding material in the building industry. Unsaturated polyester resins are known as the most often used binding material which originates from the recycled PET (Reis et al., 2011; Mahdi et al., 2007; Mahdi et al., 2010). Concretes and mortars which contain plastic based resins as binders are known as polymer concretes and polymer mortars respectively. It is shown that aging effects are present in polymer mortars and concretes causing the decrease in the fracture parameters (toughness and energy) and inrease of the brittleness (Mahdi et al., 2010; Ochi et al., 2007). It is noted that a composite material made of recycled PET aggregate, unsaturated polyester resins and natural sand stone is suitable to be used in the surroundings that are exposed to dynamic and impact loads. Thus, the application of polymers is limited by their characteristics, which make them suitable as a material for pavements, median barriers, sewer pipes etc.

THE USE OF PET FIBERS AS A MATERIAL IN CREATING THE FIBER-REINFORCED CONCRETE AND MORTAR

Scientists have recognized the possibility of using fibers made of recycled PET bottles as a material which may improve characteristics of concrete or mortar, especially their ductility and early age crack generation. The advantages of PET fibers compared to the use of welded steel wire mesh can be observed from the economical and ecological points of vew. Moreover, the advantages are also related to the increase of structural durability that can be achieved. Many researchers agree that the use of circular fibers has more advantages than the use of lamellar ones and that the optimal amount of fibers in concrete is 1 wt%. In general, fibre-reinforced concrete or mortar shows excellent performance in tensile and crack resistance. However, as the strength of conventional PET fiber is low and its alkali resistance is questionable, it has rarely been used as a concrete-reinforcing fiber (Ochi et al., 2007). The process of the industrial production of PET fibers uses recycled PET pellets and consists of three stages: melting, extrusion, and drawing into fiber while the bulk material is warm. Thus, the polymer chains align along the longitudinal direction of a fiber causing the increase of its strength. In order to obtain optimal characteristics of PET fibers a process of their production, under strictly controlled conditions, was developed in Japan and, thus created fibers were tested (Ochi et al., 2007). The outcome was promising for the future use of PET fibers in the concrete reinforcement. Besides the fact that quality fibers were produced in the latter process one more applied process has to be highlighted. Intends were made on fibers which prevented possibility that fibers may be pulled out from a concrete. Thorough experiments are conducted in order to examine the characteristics of fibers. The bending stress experiment shows that PET fiber reinforced concrete can be compared with the steel fiber reinforced one (Ochi et al., 2007). Furthermore, it has been shown that PET fibers have not had a significant role before the first crack has appeared. After it, the strength increases proportionally to the fiber content (Ochi et al., 2007). The compression stress experiment shows that compression characteristics do not change significantly (Ochi et al., 2007). In the pull-out experiment, it is shown that adhesive strength of PET is similar to the polypropylene (Ochi et al., 2007). The concrete produced by Ochi et al. was used in the mining industry for building the gateway support and in road building industry for building the narrow pavements and pathways. Still from the economic aspects the produced fibers have almost no advantage to the steel fibers.

Besides the research concerning the industrial production of PET fibers some new studies are done, that treat the simpler method of producing fiber directly from PET bottles, primarily by shredding. One of those studies is conducted by Dora Foti (2013) where the use of PET fibers is presented as a useful in preventing the appearance of brittle and sudden fractures of material. The main asset of this and related papers is the simply and cost-effective production of reinforcing fibers. Still, these fibers have the tensile strength of 160 N/mm^2, while those produced by Ochi et al. have almost three times higher tensile strength. After the number of experiments Dora Foti (2013) has shown that shredded fibers are promising materials, still further research in necessary in order to examine their behavior under the real working conditions. It is presented that shredded fibers may be used as mono or bi-directional reinforcements for concrete slabs and pavements, thin layers of mortar for masonry structures etc.

The question of a durability of the PET fiber reinforced concrete and mortar has been studied thoroughly from various aspects. Degradation of fibers in alkaline environments is noted as one of the main problem. Silva et al. (Silva et al., 2005) observed PET fibers degradation in Portland cement-based materials and noted the reduction of material toughness with time due to the degradation of fibers inside mortars. More thorough research was conducted by Won et al. (Wona et al., 2010) where material was exposed to different chemical environments. While alkaline and sulfuric acid environments degraded both physical structure and mechanical characteristics, material was almost unaffected with the salt environment.

Further studies are needed in order to decrease the production costs of fibers from PET bottles, as well as those regarding the long-term durability of PET fiber-reinforced concrete.

THE POSSIBILITY OF RECYCLED PET UTILIZATION IN SERBIA

Polyethylene terephthalate, with its ratio of about 4% of the complete amount of collected municipal solid waste in Serbia is a significant source of materials which can be easily reused and recycled. Still in order to increase the efficiency of the recycling process it is necessary to improve the primary and secondary selection from bulk materials. That would reduce the recycling costs significantly. Serbia, as a country with large capital investments is a fertile ground for the use of recycled PET as a building material. Based on the presented application of PET in building industry it can be deducted that central and southern parts of Serbia may be suitable for the use of PET-fiber reinforced concrete. One of the most potential uses may be for the PET-fiber reinforced concrete in the building of narrow pavements, with the special concern about its chemical environment. After comparing data given in Table 2 and 3, the consumption of aggregate materials overcomes the generation of PET from MSW. In order to organize the wide use of recycled plastic materials in building industry in Serbia thorough research is needed. This paper only gives an insight to the potential use of recycled plastics materials.

CONCLUSION

Many scientists agree that there is a possibility of using the recycled PET as a construction material, yet it is necessary to conduct more experiments in order to find the optimal ratio of compounds. The wide use of mortars and concretes which contain plastics as their intrinsic compound material is limited both, with their properties and with the current legislation acts. It is necessary to conduct the legislation changes in order to enable wide use of construction materials. Serbia faces a problem of the inefficient solid waste collection and separation, thus obtaining secondary PET is rather difficult. Yet, there are potentials in using plastics materials in building industry in Serbia, only thorough studies are needed in order to get the real field data.

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POSSIBILITY OF USAGE OF WIND AS ENERGY

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ABSTRACT

The present work presents new and contemporary methods of acquiring green energy through the wind, i.e., considers all possibilities and capacity of our country to enter into a process of introduction of green technologies, primarily in terms of energy of the wind. In this manner we will try to achieve ecological and energy-wise cost effective potentials.

Key words: *green energy of the wind, wind generator, installed capacities, research in Serbia.*

INTRODUCTION

The beginning of 21st century is characterised by intensive increase in consumption of all kinds of energy worldwide, especially fossil fuels, anticipating that it could soon become completely exhausted. This has led to an increase in price of petroleum, gas and other energy generating products that started in the second half of 20th century, as well as to a global concern with regard to future sources of energy and mankind development.

Another characteristic of this period is continuation of increase in concentration of detrimental gases (primarily CO_2) in the atmosphere as a consequence of intensive consumption of fossil fuels, despite a generally accepted agreement on emission reduction – the Kyoto protocol of 1997.

These two reasons, a constant increase in consumption and price and intensifying of the greenhouse effect, with limited or prohibited atomic energy usage, made developed countries, primarily the countries of the European Union, resort to higher usage of renewable energy sources at the end of 20th century.

In that period of time the European Union used merely 6% of energy acquired from renewable sources (hydroenergy and biomass) whereas as much as 79% was from the fossil sources (Figure 1)

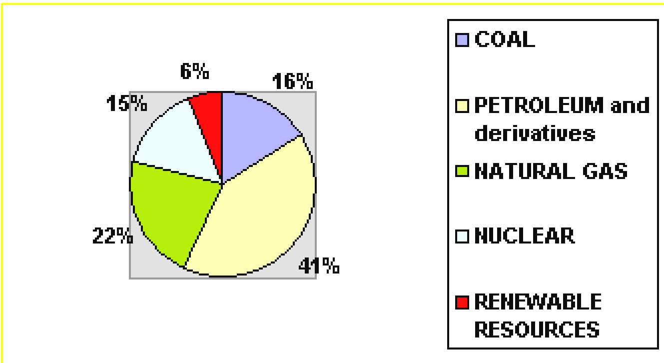

Figure 1. *Distribution of primary sources of energy in the EU (year 1998)*

As a consequence of such orientation, a directive 2001/77/EC was issued by the EU, which on the basis of status as of 1998 determined that, by 2010, the share of „green“ energy in total consumption of energy shall increase from 6% to 12%.

This decision was of crucial importance for sudden development of usage of all kinds of renewable sources.

Nevertheless, the possibility for increase in usage of hydro energy by construction of large hydroelectric power plants was very limited, for a simple reason that all significant rivers had either already been used or their usage was not cost effective due to economic, ecological or other reasons. This was the reason that attention of researchers, constructors and investors and others turned toward the energy from the wind. As a result of this orientation, intensive development in technology followed, primarily of wind electrical power plants, at a speed comparable only to the progress of computer industry.

The newest plans for development of energetics in the EU at a meeting in Brusseles at the end of 2008 show significant increase in share of wind electrical power plants, from 14% in 2005 to 35% in 2020 but also a sudden increase of solar electrical power plants from negligable 0.3%in 2005 to significant 13% in 2020.

Worldwide, primarily in the USA, Canada, Latin America and China, the capacities for acquiring electrical energy from wind energy are quickly increasing. This increase is followed also by large investments, by the state as well as by private investors. It has been forecast that fast development in the next five years will triple the facilities worldwide.

WIND ENERGY

Definition of Wind and Measurement of Wind Speed and Power

Wind energy is the kinetic energy of streaming air. The quantity of energy is mostly dependant on speed of the wind, but it is also at a constant level, dependant on air density, which is influenced by temperature and pressure of air and by elevation. Wind speed is influenced by configuration of terrain and one very interesting parameter which defines the wind is wind blasts. Wind blasts is the speed of the wind in duration of several seconds. Wellknown in Serbia is the northwest wind, *kosava* characterised by frequent blasts of high intensity. For example, when the medium speed is ten meters per second the blasts reach the value twice as high, while the direction remains the same.

The wind is air in movement. This movement is reduced by uneven heating of the Earth’s surface by the Sun. Since the surface of the Earth is composed of very different types of land and water, they absorb the Sun’s warmth in various ways.

During the day the air above ground gets warm much faster than the air above water. Warm air above ground expands and moves up, whereas the heavier cold air comes in its place creating the wind, whereas at night a reverse process takes place. It may be said that energy of the wind is merely another form of energy of the Sun. It is estimated that a little less than 3% of energy of the Sun that reaches the Earth turns into the wind.

The speed of the wind is measured using the anemometer or anemograph. In so far meteorological practice most used is the Fuss’s anemograph, which measures direction and mean and current speeds of the wind. All three parameters are recorded continually on an anemograph ribbon.

The detector part of the anemograph is normally positioned 10m above ground, on a pole within meteorogical station grounds. In recent times the measurement of data on the wind is conducted using digital devices for gathering data because standard meteorological data on the wind are not sufficiently good for implementation in wind electro-energetics.

THE HISTORY OF USAGE OF WIND

More than five thousand years ago, Egyptians used the wind for movement of ships on the river Nile. Later on, in mills for milling of wheat and other grains. Those mills had vanes that resembled round oars. Persians used energy of the wind also for movement of water. A number of centuries later the Dutch improved the basic construction of windmills by introduction of propeller-shaped wings using canvas stretched onto them. They used windmills for grinding and pumping out the water in conquering the land below the sea level. Colonists in America used windmills for grinding grains, drawing water from deep wells, but also for cutting timber in sawmills. Around 1920 Americans use small windmills as well as electrical power generators, and at the same time on Crimea, at the shore of Black Sea the first multikillowatt wind generator in Europe is erected. Sporadic usages of windmills for various purposes, continued until the big energy crises in 1970’s. It is then that the awareness of the lack of petroleum changed the energetic image of the world and suddenly increased the interest in alternative energy sources. This opens up a path for windmills to be reintroduced as generators of electrical energy.

WIND GENERATOR

What is a wind generator?

The wind turbine is a device for conversion of kinetic energy of the wind into mechanical energy. If mechanical energy is used directly in machines like pumps or machines for grindng of grains, those are wind powered mills. If mechanical energy is converted into electrical energy, then it is a wind generator. Wind generators start producing electrical energy at windspeeds of around 3m/s up to 25m/s. Production is cost efficient if the wind blows more than 2800 hours per year at an average speed over 6m/s (one year has 8760 hours). Wind generator consists of propeller arms, a transmission mechanism, an electrical generator, a support column and a transformer via which connection to electrical grid is performed. Nowadays most common are wind generators with three blade propeller, of 1MW-6MW power. These wind generators have transmission system-gear box and the electrical generator itself positioned on top of the support column. The entire construction is moved using a wind direction sensor and servo motor so that the propeller is at all times positioned perpendicular to the direction of blowing of the wind. The most complex part is the mechanical box which turns the slow and irregular movement of the propeller into fast movement of the constant frequency generator.
Low power generators of 300W-2KW are used for accumulator charging from where electrical energy is applied for various purposes. Larger generators are connected to electrical distributive grid and currently in the world are built wind generators of power of 1MW-3MW. The diameter of rotor is up to 100 m and the weight of one blade of the propeller is up to 20 t. The height of the column on which the wind generator rests is up to 130 m. Total weight of a wind generator together with the column is around 200 t. The price of small windmills up to 2KW is over EUR1200 per killowatt, whereas the price of large windmills, especially if several are erected at one location, is significantly lower and ranges around EUR700 per killowatt.

Wind Generator Operation

Wind power is influenced by: configuration of terrain, natural or artificial obstacles and orography. Operation of wind generators can be significantly increased if it is positioned in between two obstacles or two mountain slopes (the tunnel effect). Speed may increase over 30% relative to the environment. One of usual placements of windgenerators is on top of hills where density and speed of streaming air are increased.

Operation efficiency is dependant on average wind speed and frequency. Due to discontinued nature of the air, the degree of utilization of wind generators is lower than that of conventional power plants and it ranges between 20% and 40% versus the installed power. The wind varies greatly, with changes in speed occurring also dependant on the season of the year. In our environment the winds are strongest in winter, when there is highest consumption of electrical energy, thus the wind generators can be used as ceiling capacities.

Parameters important for production of electrical energy are: wind speed, defined direction, speed frequency, stillness frequency, air density. Typical variation of wind is normally described by Wiebull distribution. By adding of each speed multiplied by probability of its occurrence a mean speed is acquired within the observed period.

INSTALLED CAPACITIES

Installed Capacities in EU and Worldwide

Current installed capacities amount to 58982 MW (data at the end of 2006) 69% of which pertains to Europe. The largest number is present in Germany. There, in 2004 installed were 16629MW, whereas today it surged to 19627MW. In Spain in 2004 there were 8263MW, whereas now it is 10941MW. In Great Britain in 2004 it was 888MW whereas now it is 1953MW. The largest leap was recorded in France with 386MW in 2004, now it grew to 1500MW, and in Portugal from 522MW to 1188MW during the same period. With regard to Eastern European countries, there is a large increase in Poland – from 63MW to 107MW. Lithuania, with over 80MW installed capacities, is not falling behind (Figures 2 and 3). The USA, after the initial leadership during the eighties, by elimination of a „tax free“ stimulation in 1990’s, loses its primacy but reports a systematic revival in recent years. While in 2004 they had installed 6725MW, now they have 10492MW, with dynamic growth from California moving to the East Coast. With 5345MW, India is leading among Asian countries, followed by China with 1260MW, Japan with over 1000MW, whereas Taiwan and South Corea have over 120KW...

As far as African countries are concerned, biggest progress was made by Morocco with 64MW, whereas in South America programs are only beginning to develop so Brazil from 24MW in 2004 now has 79MW installed wind generators.

Figure 2. Installed capacities of wind power plants in Europe (the end of 2007)

STATUS IN COMPARISON WITH THE OTHER COUNTRIES IN THE REGION

At present, most significant capacities are installed in Hungary, Croatia, Romania and Bulgaria. In the Western Balkan’s countries (Serbia, Bosnia and Herzegovina, Montenegro, Macedonia, Albania) at this moment there are no installed wind power plants, although initial activities are ongoing.

It should be noted that the situation is quickly changing, which is illustrated by the status from a couple of years ago and the trend of development until 2008. It is clear that in Hungary, Bulgaria and Croatia the installed capacities have been increased more that ten times, whereas at the Balkans nothing has changed whatsoever in that respect.

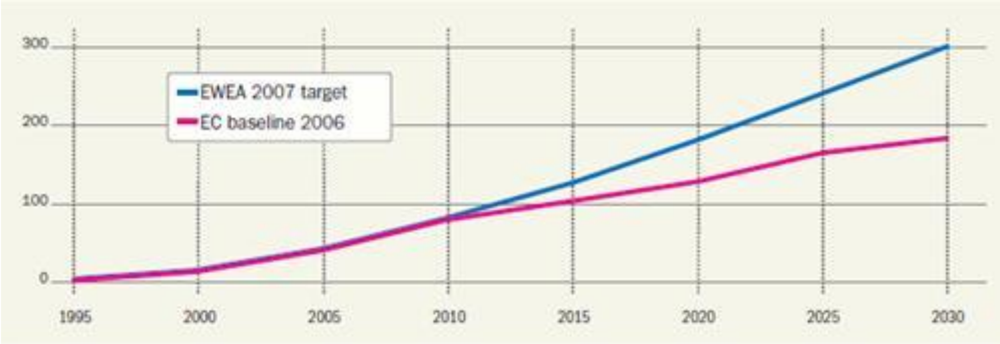

Figure 3. Projection of growth of installed power of wind power plants in EU according to European Committee (red line) and according to the EWEA association (blue line)

ENERGY POLICY IN SERBIA

Legislature

The basis of the nergy policy in the Republic of Serbia is comprised of a framework enacted by the Law on Energetics in 2005. Thereby the possibilities for demonopolisation of the energy sector were opened up as well as of intensive utilisation of renewable sources of electrical energy. By ratification of a contract on founding of energetics community Serbia accepted, among other, the obligation to implement the Directive 2001/77/EC pertaining to the promotion of electrical power production from renewable sources of energy and the Directive 2003/30/EC pertaining to usage of bio-fuels and other fuels from renewable energy sources.

Until now Serbia has enacted below legislature in the filed of renewable energy sources, which postulates the objectives:
* Law on Energy
* Strategy of development of energy of the Republic of Serbia until 2015.
* Program of fullfillment of strategy of energetics of Serbia from 2007 to 2012.

In order to fullfil the defined objectives it is necessary to complete the existing regulative with the following sublegal enactments which enable realisation of plans in this area are:
-act on definition of status of preferred consumers
-encouragement measures for producers that have the status of preferred producers (feed-in tariffs).

Electrical power producers in power plants that use renewable sources are considered the preferred producers of electical power. It is unclear whether these categories of producers should meet also the criteria of energy efficiency. The Law on Energetics postulates that the preferred producers of electrical energy: 1) have the right of priority at organised energy market compared with the other producers who offer electrical power on equal conditions, as well as 2) have the right to subventions, tax, customs and other facilities in accordance with the law and other regulations by which these forms of payment, subvention and other encouragement measures are regulated. The said law also determines the procedure for submittance of request for acquiring the status of a preferred producer of electrical energy, as well as the obligation of the government of Serbia to pass an act pertaining to conditionso for acquiring the status of preferred producer. This act on acquiring the preferred producer status has not yet been enacted.

PLAN OF USAGE OF RENEWABLE SOURCES

As the Law on Energetics defines, the energetics policy in Serbia is enforced by realisation of strategy of development of energetics of the Republic of Serbia, by program of fullfillment of said strategy and the energetic balance. By draft of program of fullfillment of strategy of development by the Republic of Serbia the construction and usage of basic sources of electrical power, with energy among them, were envisaged.

It is estimated that energy potential of renewable sources of electrical power in the Republic of Serbia amounts to over 3,83 million toe (toe-tons of equivalent petroleum) a year of which around 5% is the share of energy of wind.

Finally, the program outlines a plan for construction of capacity and production of energy and bio-fuels in facilities that use the OIE (basic sources of energy) in which the construction of first wind power plants is forecast for 2009 of the capacity of 2MW followed by further construction up to 8MW/year until 2012 of the capacity of 26MW altogether. This plan determines the electrical power and OIE (26MW wind power plants and 61MW small power plants).

RESEARCH OF WIND ENERGY IN SERBIA

Wind Energy Potential

In the Republic of Serbia there are favourable locations for construction of wind generators at which 1300MW of wind generator production capacities could be built and approximately 2300GW of electrical power produced in the future. Most favourable locations for usage of wind are:
 1. The Panonian Plain, north of the Danube and Sava.
This area is favourable for construction of wind generators for the reason that road infrastructure had been built, there is the electrical grid, big centres of consumers of electrical energy are in the vicinity, and the like.
2. Eastern parts of Serbia - Stara planina,Ozren,Vlasina,Crni vrh etc.

In these areas, systematic measurements of wind potential are currently conducted at several locations in Vojvodina, along the right bank of the rivers Sava and Danube, and it is on Vlasina that those measurements have gone the farthest. At selected locations for more than a year systematic testing was performed and the possibility of accummulation of electrical energy through a reversible hydro power plant was studied. By measurement it was determined that average wind speed is 8m/s which is very favourable for usage of wind generators (Figure 4).

Figure 4. Overview of speed and energetic potential of wind at the 50m elevation expressed in W/m²

Foreign and local investors started undertaking preparatory actions for erection of multiple wind power plants at several locations in Vojvodina. First columns for measurement of wind potential have been installed. The height of the measurement columns is 50 m and their installation enables a one-year program of wind parameters (speed, direction, frequency and power of blast), at selected locations after which a study of justifiability will be worked out. A measuring column is equipped with four calibrated wind speed gauges, two of which are placed on top, one at 40 meters and another one at 30 m. After the completion of measurement, a location will be precisely determined at which the largest volume of energy can be produced, so that the first windmill farm could be built. It is almost certain that it will be at a location close to riverbanks of the Danube, known for powerful blasts of *kosava* and large number of windy days per year. Our meteorologists developed a method of air streaming modelling recognized worldwide, primarily in order to ensure more accurate weather forecasts. Nevertheless, the modelling found application also in wind energetics. Using this model, areas in Serbia which are interesting for wind energetics are roughly anticipated. A numerical model is made for them for determination of impact of all obstacles and a measuring place of one or several measuring columns determined. It is estimated that the first windmill farm will have the capacity of around 20 MW, and its construction will, according to preliminary calculation, cost around EUR16 million.

SUMMARY

Usage of wind energy for acquiring of electrical power undoubtedly has future in Serbia. The wind is a free and renewable source and wind generator farms do not consume any fuel in the production of electrical power, and neither waste or detrimental gases are generated. The areas with these devices can be normally used without restrictions in agriculture.

Nevertheless, currently in Serbia there are not installed generators of a significant power but only several smaller ones primarily at agricultural households to cover own needs.

Until recently, there was almost no mention of wind power plants in Serbia, and then the interest of private investors in building pollution-free sources of electrical energy suddenly grew. It is estimated that currently energy permits for construction of 2000 „wind generators“ are pending or have already been issued (an issued permit is not binding for the investor to build the generator). In Greece there are energy permits issued for around 1000MW, whereas the power of installed ones is 100MW, which tells us that there is a long way from concept to realization.

The question arises whether Serbia is ready for usage of wind energy. Legal regulation, i.e., provision pertaining to encouragement for usage of renewable sources of energy, has not been finalized. It is also needed to determine who will be responsible for the balance, i.e., who in the system would replace those power plants when there is no wind.

Current price of electrical power locally is around 4 Euro cent per killowatt-hour, whereas the anticipated price of electrical power acquired from wind power is around 10.5 Euro cent. There is the question of who will pay the difference in price, whether the consumers like in Germany (every consumer pays a fixed amout of 2 Euros for „green killowatts“), or the state. According to expert projections, if 500MW were built, in wind power plants, and launched at the market in Serbia at a feed-in tariff, the price of electrical power would increase for all consumers by 6%. The feed-in tariff, i.e., stimulative price should remain guaranteed and unchangable over a period of 12 years. It needs to be made possible for every investor to return invested financial means within twelve years, with all expenses that are incurred during that period covered.

Sudden increase of interest in energy from the wind in Serbia may be explained perhaps also by new directive of the EU by which it is made possible for member countries of EU to build, in countries bordering the EU, the capacities for production of electrical power from renewable sources from where that green energy would be directly transferred to them.

This would be calculated as the capacity of that country of the EU that invested in the building of such power plant. Nevertheless, a question arises about what is the benefit to those countries bordering the EU. They practically have no benefit whatsoever, except for the hiring a small number of people, and that green resource would be consumed that later on will be more than needed in order to meet the prescribed obligation for production of this energy once they enter the EU.

Therefore caution should be exercised with regard to whether this resource should be given up to someone else or kept for our own needs once that conditions, here I am referring primarily to economic conditions, are in place.

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NOISE AND VIBRATIONS IN URBAN AREAS

III International Conference
„ECOLOGY OF URBAN AREAS“ 2013

ENVIRONMENTAL ASPECTS AND NOISE IN THE OPERATION OF A WATER JET CUTTING MACHINE

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ABSTRACT

Noise is an important problem of modern civilization, because the sources of noise are becoming more diverse in nature and stronger. It harms the human body and causes both physical and mental problems, resulting in high risk hearing damage. Working with machines, in manufacturing facilities, workers are exposed to high noise levels, which should not be higher than the maximum allowed limit of 80 dB. This paper deals with noise levels that are part of technological process of operating a water jet cutting machine. Analyzing the results obtained by measuring it was found the noise level is (was) between 75 and 100 dB(A), and depending on the work method, or workpiece position on the table.

Key words: *ecology, noise, water jet.*

INTRODUCTION

For the purpose of making life easier, man has invented and surrounded himself with many devices and machines. Unfortunately, these machines produce noise levels. Man wanted the machines to be as efficient and as inexpensive as possible. Noise emerged as a phenomenon accompanying the operations of machines. At first, that did not seem to be worrying, but when health problems resulted from noise, this phenomenon became an environmental problem which had to be addressed in an appropriate way. Robert Koch said in the second half of the 19th century: „The day will come, when noise will become one of mankind’s great enemies, and we will have to fight it as we did with the black death or cholera“.

Noise can affect human health in the following ways:

6. partial or total loss of hearing ,
7. neurovegetative reactions of organisms (stress),
   tiredness and reduction of work capability,
8. errors in communication and voice conversation and errors in audibility of conversation,
9. psychological reactions (uncomfortable feeling) and
10. disruption of rest and sleep.

Negative influences of noise may cause high blood pressure, mental stress, heart attack or hearing damage.
“According to available data, in the U.S. over 50% of the working population are exposed to a noise level higher than 80 dB(A) at their workplace, and almost 20% of the working population are even exposed to levels above 90 dB(A). In Europe, more than 30% of the working population is exposed to noise levels dangerous to health. The amount of individuals with hearing damages is as follows:

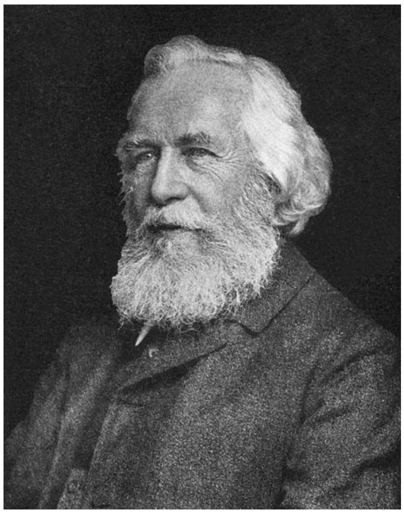
11. In the U.S., 20% of the working population
12. In the EU, 7% of the working population

Hearing damage caused by noise is classified as a professional illness, in Europe and in Serbia. Of the total number of registered professional illnesses in the EU, 32% refers to hearing damages caused by noise”[1] . In developed countries, the problem is clearly identified, and noise is pointed out as a major factor which critically affects the population.

ECOLOGY

Ecology (from οικος, "house"; -λογία, "study of" was practically founded by Charles Darwin, who in his book "Origin of species" in 1859 described many details from the field of ecology, starting with adaptation and natural selection to the fight for survival, not using and not defining the term ecology itself. The term itself was first introduced by scholar and biologist Ernst Haeckel. In 1868, in his work "The Natural History of Creation", Ernst Haeckel (Table 1) writes: "Under ecology we understand the sum of knowledge which refers to the economics of nature: the study of the totality of the interaction of any life form with the environment surrounding it, organic or inorganic, and most of all friendly or unfriendly relationships with animals and plants with which it comes into contact directly or indirectly. In one sentence: Ecology is the study of all complex relationships, which Darwin calls conditions and a fierce battle for survival." [2].

Table 1: Ernst Haeckel



Ernst Haeckel was born in 1834, in Potsdam and died in 1919 in Jena. He was a professor of zoology at the university of Jena, a prominent Darwinist. He wrote a series of monographies on maritime invertebrates. He established the gastrea theory, formulated the biogenetics law. He mapped a genealogical tree of all life forms. He is the founder of ecology which he defined as the economics of nature, the research of all the relationships of organisms with its organic and inorganic environment and as a study of the complex relations which are the condition for the battle for survival.

SOUND

Mechanical waves, the frequencies of which in the interval between 20 Hz and 20 kHz create a special feeling in the human ear, are called the sound. The sensitivity of the ear is at highest at frequencies between 1 and 3kHz. Mechanical waves, the frequencies of which are below 20 Hz, are called the infra-sound, the frequencies above 20 kHz are called the ultrasound. Sound waves spread in all three aggregate states.

The velocity of sound through solid environments is several thousand meters per seconds (through glass this velocity is 5500 m/s), through water 1450 to 1550 m/s, and through air, depending on temperature, from 330 to 400 m/s.

The properties of a soundwave are:

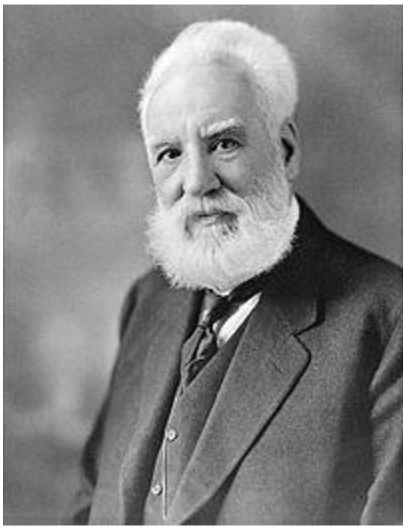
- ***Intensity of sound*** (objective intensity of sound) is equal to the energy which the soundwave transports per unit of time through a unit area perpendicular to the direction of its movement, i.e. it is equal to the power of the soundwave per area unit: $I= E/ (tS) = P/S$. The unit for the intensity of sound is W/m^2.
- ***Subjective intensity of sound*** is the consequence of an "imperfection"of the human ear which reacts differently to sounds having the same objective intensity, but different frequency. In simple words, sound having higher frequency is percepted as being more intesive, although that does not have to be the case necessarily. The subjective intensity of sound can be determined: $L=10\log (I/I_O)$, where I is the objective intensity of sound and I_O the audibility threshold.
  The audibility threshold is the lowest sound intensity that the human ear is able to register and it is assumed that this value is $I_O=10^{-12}$ W/m^2 at a frequency of 1000 Hz.
  The pain threshold is the maximum sound intensity that the human ear is able to register and it is approx. 10 W/m^2. Sound intensities above that value cause pain (figure 1).
  The audibility area is the area between the audibility threshold and the pain threshold [4].
  The unit for measuring the noise level is called BEL. Since this is a big unit, its tenth is used – deciBel (dB). The unit was named after a Scottish scientist Alexander Graham Bell (1847-1922) founder of the "Bell" phone company (Table 2).
- ***Height of complex sound*** is determined according to the frequency of the basic tone. If the tone is clear, the human ear percepts it as higher if its frequency is higher. For example: the highest tone sung by female opera singers (soprano) can have a frequency of 2300 Hz, whereas the lowest tones sung by male baritone have a frequency of approx. 45 Hz.
- ***Sound colour*** is determined by higher harmonics [4].

NOISE

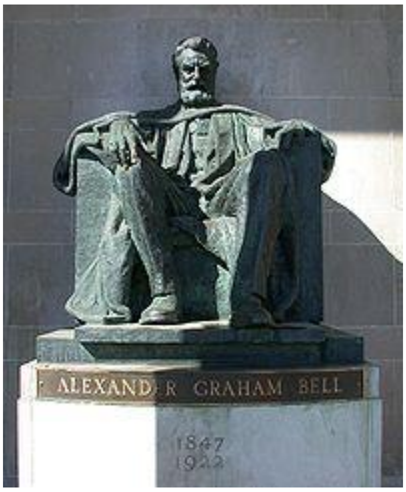
Noise is an unwanted and uncomfortable, aperiodical sound or a disrupting sound, opposite to a comfortable sound.
Depending on its influence on the human body, noise can be divided into 4 intensity levels:

- **First level** – noise intensity between 40 -50 dB, causes mental reactions;
- **Second level**- noise intensity between 60 – 80 dB, causes deterioriation of the vegetative nervous system;
- **Third level** – noise intensity between 90 – 110 dB, causes hearing loss;
- **Fourth level** – noise intensity over 120 dB, causes damage of hearing and the hearing device (depending on the age and condition of the nervous system). Noise of 150dB causes mechanical damage to a hearing device, and above 170 dB it causes death.

Table 2: Alexander Graham Bell



Alexander Graham Bell



Alexander Bell statue in Brantford

Alexander Bell (1847-1922) was a scientist, inventor and the founder of the telephone company “Bell” and was born in Edinburgh, Scotland. He was educated at the Royal High School in Edinburgh, which he graduated from at the age of 13. At age 16, Bell secured a position as a "pupil-teacher" of elocution and music, in Weston House Academy, at Elgin Moravshire, Scotland. From 1866 to 1867 he works as a teacher at the Somersetshire College in Bath, England. According to some sources, his interest in acoustics began back in Scotland; he wanted to find a way to help his mother who was deaf. In 1870, he leaves for Canada, where he works on devices that enable remote communication. In Boston, United States, 1876 he submitted a patent which dealt with the "method and apparatus for transmitting vocal and other types of sound in a telegraphic way…, using electrical waves, similar to air vibrations, which accompany the mentioned vocal and other types of sound.”, the telephone. He is one of the founders of the American National Geographic Society, and thus became its second chairman. He received numerous honors. The French government gave him the Legion of honour, the French Academy of sciences awarded him the Volta prize of 50,000 Francs, the London Royal Society of Arts awarded him the Albert medal in 1902, and the University of Würzburg, Bavaria, a honorary PhD. In his honor, the unit for intensity of sound was named “Bel”

Various measures are used for noise protection, they can be general and individual.

1. General measures include a series of measures designed to avoid or reduce noise using insulating (insulation of noise source), absorbing (coating of sound sources with materials absorbing sound) coatings,
2. technical measures (manufacturing devices which produce less noise, new car engine technlogy)
3. Individual measures include the use of personal protection equipment (earpads, ear covers, obligatory breaks during working hours), as well as coresponding laws on noise protection.
4. Ecological protection measures include using the best layout in order to reduce the amount of noise. In residential areas, noise problems can be avoided by putting roads outside of residential areas or by using underground roads. Noise can aslo be reduced by planting high trees or protection barriers. That is the so-called screening of noise.(Tables 3 and 4), (Figure 2)

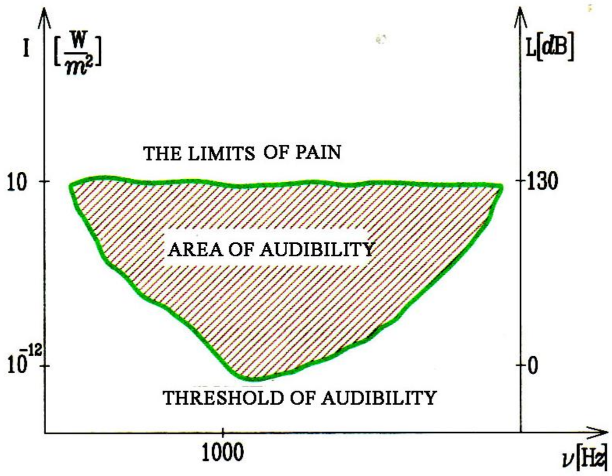


Figure 1. Area of Audibility

Table 3: Maximum allowed noise levels in open space

Noise zone	Purpose of space	Max. allowed noise levels in dB(A)	
		day	**night**
1	Zone for recreation, rehabilitation and treatment	50	40
2	Zone only for living	55	40
3	Predominantly residental zone	55	45
4	Predoninantly business zone with residential parts	65	50
5	Industrial zone, warehouses, services etc.	Noise should stay under 80 dB(A)	

MACHINES FOR HYDRODYNAMICAL PROCESSING

Machines for hydrodynamical processing, i.e. hydraulic machines for WJM (WJM – Water Jet Machining) work based on the prinicple of material erosion under the influence of a high pressure water jet, and are used for cutting material and making holes (Figure 2).

For this kind of workpiece processing, a jet created by water under a pressure of approx. 400 MPa through a nozzle with a diameter of 0,1 to 0,4 mm, with a speed of about 1000 m/s. In order to increase cutting efficiency, abrasive agents are added to the water jet. Water jet cutting does not produce harmful gases or liquids, no hazardous material or fumes are produced, there is no zone of thermical or mechanical stress.

With WJM, a jet of clean water is used as a toll for shaving off material. It is created when a fluid flows under high pressure through a nozzle with a very small diameter, thus producing a jet particle velocity which is two to four times bigger than the velocity of sound. Therefore, from an energy point of view, the water jet can be considered a „rigid body” acting on the workpiece material which enables its cutting, similarly to any other tool of that type.

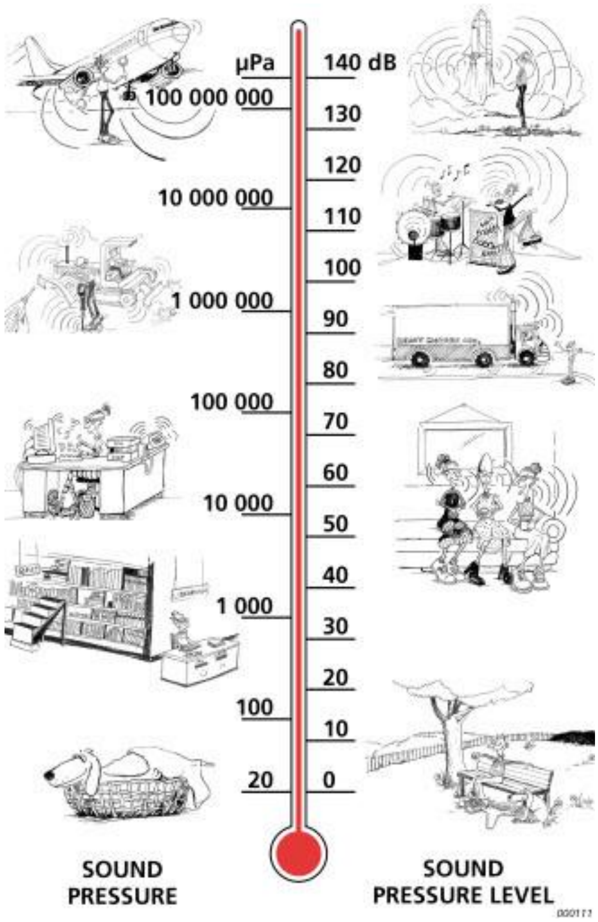


Figure 2. Illustrated sound pressure-noise level diagram

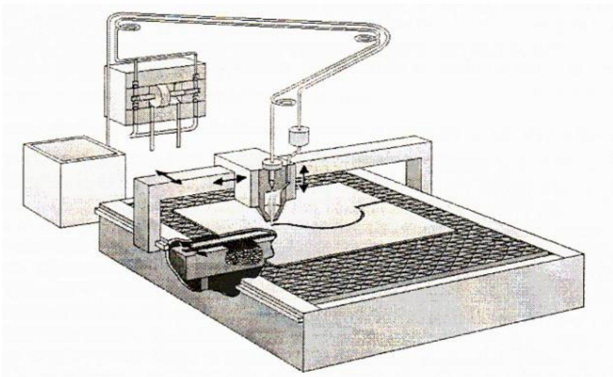


Figure 3. Machine for contour cutting of sheet metal using water jet

When te liquid hits the workpiece surface, high pressure on a small workpiece surface is generated, causing damage to the material, and side impact waves lead to fast deruction of the material on the boundaries of crystal grains and to micofissures. Because of dynamic load caused by the jet, microfissures spread very fast leading to instant local destruction of workpiece material. Destruction of material also happens due to the effects of turbulent flow of fluids in the fissures, and due to the cavitational behaviour of gas bubbles. The water jet cutting process starts with a mould formed by the high pressure fluid which gradually converts into an opening, which is widened by movement of workpiece which also produces a cutting gap. (Figure 3).

Table 4: Influence of noise o man [1]

Noise level in dB(A)	Influence of noise level on human body		Examples of noise sources
0	The quietest noise that can be heard		
20	Noise level having no negative effect on human body, people feel comfortable		quiet dormitory
30			quite work place
40-50	Learning capabilities and communication problems	Mental effect zone	quiet converation
50		Extraaural effects of noise	normal conversation
65			TV, window looking on the street
80			Vacuum-cleaner, dogs barking
82	Serious mental and neuro-vegetative problems; damage to hearing cells; temporary change of audibility threshold	Aural effect of noise	Passing car, hair dryer
85			Crowing of a cock
90			Air-cooled electromotor
103			Chainsaw
110			Disco club, overloud music device
120	Acute hearing damage even after short exposure		3 m distance from a rock-band
130			Pneumatic hammer , shot from a rifle next to two shooters
145			Near a jet plane at taking off

The process of taking off material with water jet cutting may be described as a supersonic erosive process. Not only pressure, but also the velocity of the water jet, has on the removal of microscopic parts of material. Pressure and speed are two different forms of energy. In the machining head, the pressure generated by the pump through the machine is transformed into the speed of the jet. For example, a water pressure of 4000 bar, corresponds to a water jet velocity of approximately 3 Mach (three times faster than sound).

Unfortunately, the work of the water jet cutting device with abrasive material is accompanied by a certain amount of noise, which can reach a value greater than 100 dB.

RESEARCH RESULTS

The noise on a water jet cutting machine was measured in three cases:

1. When the workpiece is placed on the work table so that its contact surface is significantly above the level of fluid gathering on the work table of the water jet cutting machine,
2. When the workpiece is placed on the work table so that its contact surface is at level with the fluid gathering on the work table of the water jet cutting machine,
3. When the workpiece is placed on the work table so that it is completely immersed in the fluid gathering on the work table of the water jet cutting machine. (Figure 5)

The noise level measurement was carried out using a digital noise meter “Metrel” Multinorm M1620 in combination with a sound sensor of type A1146. The measurement was conducted at the mentioned work places, in intervals of 20 min with a duration of 5 minutes. A total of 22 measurements per work place per shift was obtained this way. During measurement, the microphone of the noise meter was placed at the height of the worker’s ear.

Figure 4. Machine for contour water jet cutting of sheet metal

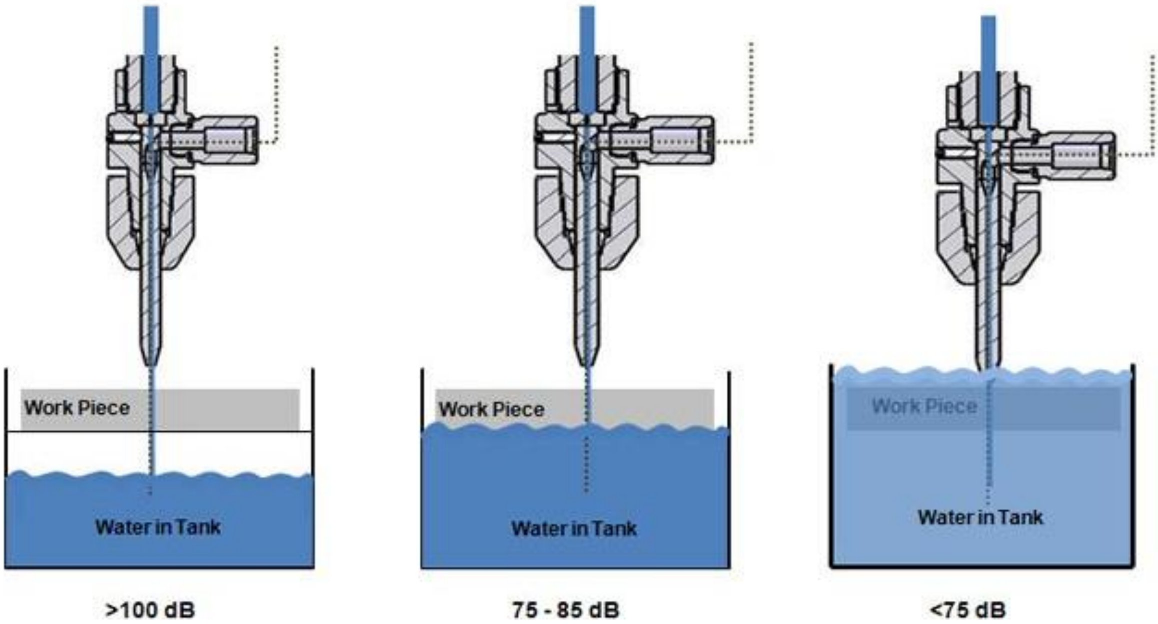


Figure 5. Diagram showing the dependence of noise level on workpiece surface position and work table water tank level

The measurement results show the following:

- in the first case, when the workpiece is placed on the work table so that its contact surface is significantly above the level of fluid gathering on the work table of the water jet cutting machine, the noise level was slightly below 100 dB,
- in the second case, when the workpiece is placed on the work table so that its contact surface is at level with the fluid gathering on the work table of the water jet cutting machine, the noise level was between 75 and 85 dB,
- in the third case, when the workpiece is placed on the work table so that it is completely immersed in the fluid gathering on the work table of the water jet cutting machine (*Figure* 4), a noise level below 75 dB was measured.

To reduce the noise level harmful to the environment, the so-called underwater cutting (workpiece and top of the nozzle are immersed in the work table tank) is used.

CONCLUSION

Speaking about hazards for the environment and the working area, besides various other harmful effects, noise is the most often mentioned hazard. Industrial noise causes loss of concentration with workers, lower productivity and, in the worst case, loss of hearing. To avoid this, appropriate standards have been established which prescribe a maximum allowed noise level of 80 dB. A worker has to use personal protection equipment to protect himself from noise.

The results of noise measurement carried out on the water jet cutting machine showed noise levels from 75 to 100 dB, depending on the position of the material to the work table water tank level. If the workpiece is immersed into the water in the work table tank during machining, the work parameters (cutting depth, speed, etc.) are a little worse than when the workpiece is above the water, but therefore the noise level is significantly lower, approx. 75 dB on average, which is within the limits given in the standard.

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NOISE AS FACTOR OF LIVING IN URBAN AREAS

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ABSTRACT

The noise in urban areas as influential factor to quality of life is considered in this paper. Basic theoretical considerations are presented, at first, to establish relevant measurement methodology for research. Brief overview of characteristics and properties of instrument that was selected for research is presented in this paper with focus to its specific characteristics in order to identify relevancies of measuring and analyses. The results of noise measurement at different zones of urban areas are analyzed and compared to related levels that are allowed by regulations. Also, the different sources of noise are identified and considered in this paper. It is implicated that, from the aspect to improve quality of life in urban areas, noise must be considered with great care. The guidelines for noise reduction procedures that are related to noise characteristics, generated by specific sources are listed altogether with its correlation to quality of life in urban areas.

Key words: *noise, urban areas, quality of life, ecology.*

INTRODUCTION

Sounds and noises are compositional elements of living environment with very significant and complex influences to quality of life, especially in urban areas. The term noise is related to high intensity sound, monotonous sound, and sound of unpleasant frequencies or related to combinations of sounds mentioned above.

From the technical aspect, sound (noise) is generated as consequence of local pressure variations from the direction of sound source. Spreading of sound from the source can be compared to spreading of spherical weaves of liquids caused by impact of rigid body into it. Acoustically, sound pressure superimposed with environmental atmospheric pressure that is about 10^5 Pa.

The analysis of noises and sounds present very important source of relevant information and data that are done for different causes, among which the most important are listed:

- noise can point out to potential problem that could cause damage and failure of technical systems,
- to evaluate the influence of noise to humans that are exposed and to estimate the risk of hearing damage,
- present standards and regulations order that during development of new product, constructional solution that generate lowest level of noise must be selected,
- to estimate if noise levels are outside define limits,
- to evaluate the influence of noise to quality of human life and
- in order to identify and insolate sources of noise.

For ordinary human, hearing diapason is between 20 μPa to 200 Pa, when pain occurs, so diapason is in range of $1{:}10^6$. As intensity of sound is proportional to square of pressure, the diapason is in range of $1{:}10^{12}$. With existing ranges, it is implicated to define amplitude of sound pressure at logarithmic scale. For measuring of noise, sound pressure level (SPL) is used and it is expressed in units called decibel (dB) and it is defined as [1]:

$$L_p = 10\log_{10}\left(\frac{p_1}{p_0}\right)^2 = 20\log_{10}\frac{p_1}{p_0}, \quad (1)$$

where are: Lp, dB – sound pressure level; p_1, Pa – amplitude of sound pressure and p_0 = 20 μPa – referent pressure.

As unit decibel (dB) is based on logarithmic scale, two levels of noises can be added arithmetically According to above mentioned, the resultant level of sound pressure L_{pr} that resulted as interaction of noses generated by different sources, L_{p1}, L_{p2}, ... can be calculated by following relation [1]:

$$L_{pr} = 10\log_{10}\left[\left(\frac{p_1}{p_0}\right)^2 + \left(\frac{p_2}{p_0}\right)^2 + \ldots\right], \quad (2)$$

while by addition of two identical noises, when is $L_{p1}= L_{p2}= L_{p,}$ it is:

$$L_{pr} = 10\log_{10}\left[2\cdot\left(\frac{p_1}{p_0}\right)^2\right] = 10\log_{10}\left(\frac{p_1}{p_0}\right)^2 + 10\log_{10}2 = L_p + 1.3 \ [\mathrm{dB}] \quad (3)$$

Duplication of sound intensity rise level of sound pressure by 3 dB. That means, for example, that to identical sounds of 90 dB act as one sound of 93 dB.

NOISE MEASURING IN URBAN AREA

Human ear, fundamentally, react on sound pressure with sensitivity that very with sound frequency, so the highest sensitivity is within frequency range of 1÷5 kHz, while the sensitivity decrease at lower and higher frequencies. This fact provoked development of filtering frequency functions that simulate sensitivity of human ear at different frequencies. Also, response of human ear to time dependent signals and impulses caused development of instruments with defined time dependent estimation functions. As result of presented characteristics of human ear the measuring device for sound pressure level phonometers were developed. Phonometers uses specific filters that correspond to characteristics of human ear and that are regulated by International standard IFC 651.

Phonometer measures the characteristics of sound that is registered by microphone. Signal is amplified and filtered before the measured value of sound level is displayed at analog or digital display. In dependence of device characteristics and properties, different filters can be used (1/1 or 1/3 octave) with different scales A, B or C for balance. Those tree balance scales simulate the response of human ear to low, middle and high frequency sounds, respectively. The dynamic of response of measuring device can be also selected as fast or slow. Phonometers must be calibrated to standardized sources of sound. Producers of phonometers usually use calibration instruments that are placed at phonometer microphone. Calibration instruments generate sound with defined intensity (usually 94 dB and/or 114 dB) with defined frequency (usually 1 kHz).

The appearance of phonometer - sound level meter - Type 2270 producer Brüel & Kjær that is used for measuring of level of communal noise in urban area is presented at Figure 1 [2].

Figure 1. Sound Level Meter – Brüel & Kjær Type 2270

The used instrument is dual-channel, hand-held analyzer and sound level meter that perform high-precision, Class 1 measurement tasks in environmental for occupational and industrial applications. It is multipurpose, modular platform with many optional application modules such as frequency analysis, FFT, advanced sound profiling and sound recording. Its two measurement channels allow it to perform sound intensity measurements according to IEC 61043, sound power measurements, and two-channel building acoustics measurements. The predicted uses of selected instrument, according to producer information are:

13. General-purpose Class 1 sound measurements to the latest international standards,
14. occupational noise assessment,
15. environmental noise assessment and logging,
16. product development and quality control,
17. FFT analysis of sound and vibration,
18. sound power determination and sound intensity,
19. two channel building acoustics measurements and
20. noise reduction

The features of selected Sound Level Meter – Type 2270 producer Brüel & Kjær are:

- Dual-channel input (microphone, sound intensity probe, accelerometer or direct signal),
- 4.2 Hz-22.4 kHz broadband linear frequency range with supplied microphone Type 4189,
- 16.6 - 140 dB A-weighted dynamic range with supplied microphone Type 4189,
- inputs: AC or CCLD, External Trigger,
- outputs: Generator and Headphone,
- communication via USB, LAN, or GPRS/3G modems,
- USB 2.0 host for connection to printer, GPS, weather station, modem,
- plug-in rechargeable Li-ion battery and
- photo observations with built-in camera.

RESULTS OF NOISE MEASURING

Measuring and analyses of communal noise level were done during March 2013 in Kragujevac at selected representative locations with determination of noise levels allowed by regulations for days and for nights. Measuring of noise in living environment was done according following regulations: Norm for indicators of noise, allowable limits, methods for estimation and evaluation of noise indicators, disturbance and damaging effects of noise in living environment (Republic Serbia, Official Periodical No. 75/10), National standard SRPS ISO 1996-2: Definition, measure and evaluation of noise in living environment and Law of protection from noise in living environment (Republic Serbia, Official Periodical No. 36/09) [3 and 4].

Measuring and evaluation of communal noise levels during day and night ware done by using of define methodology. For the measuring of noise level precise device, phonometer that is presented, sound level meter – Brüel & Kjær Type 2270 was used with 1/3 octave filter set. Calibrations ware done before and after measuring. Descriptions of measuring locations with related potential sources of noise are presented at Table 1 [5 and 6].

Table 1: Locations of measuring with potential noise sources

Location		Description	Potential noise sources
1.	Area Sušica-Restaurant „Merkur“	Measuring position is parking place in front of the restaurant. The stadium is behind of restaurant, while residential houses are across the street.	The source of noise is traffic of motor vehicles at neighboring streets and parking places.
2.	Area Aerodrom – Restaurant „La Boem“	Parking place between buildings is measuring position in direction from Atinska street. Neighborhood is mainly consisting of buildings.	Noise is generated by traffic of motor vehicles.
3.	Primary School „Sent Sava“	Measuring position is parking place at Vlada Bagata street in direction from school. The area is formed of school with yard and residential houses at other side.	Noise is generated by traffic of motor vehicles and from school yard.
4.	Area Denino Hill – Church „Sent Petka“	Measuring was done at parking place in front of church. The residential houses are around at distance of 50 to 100 m.	The source of noise is traffic of motor vehicles at neighboring streets and parking places.
5.	Area Petrovac – Pertol Station „Rade šped“	Measuring position is parking place near petrol station in direction of road Kragujevac – Topola. Surrounding is uncultivated land without of high vegetation, few houses, car washing place and shop at other side of street	Traffic of motor vehicles at streets in the area is source of noise.
6.	Area Petrovac – street „Queen Milice“	Street with residential houses at one side and small industrial zone at other side of street is measuring location	Traffic of motor vehicles at streets in the area is source of noise.

Before measuring of communal noise level, microclimate parameters, that were relevant to measuring results, were determined: air temperature, relative air humidity, air pressure, wind speed. Those microclimate parameters were adopted from data provide by Local hydrometeorological Center that is part of National hydrometeorological institute (Tab. 2) [5 and 6].

Table 2: Microclimate parameters at location of measuring

Microclimate parameter	Day			Night	
Time of measuring	09-12h	13-16h	18-21h	23-02h	03-06h
Wind speed, m/s	1,2	3,8	2,6	1,8	1,3
Temperature, ^{o}C	8	12	9	7	4
Relative air humidity, %	59	51	56	60	64
Air pressure, mbar	975	988	988	982	979

The results of communal noise measuring and its related allowed levels are presented at Table 3. Criteria of allowed noise level can be evaluated from two aspects: noise limits at interior and noise limits at exterior places. Allowable level of noise at residential rooms (bedrooms and living rooms) with closed windows are 50 dB during days and 40 dB during nights, according to Regulation for noise measuring methods and definition (Republic Serbia, Official Periodical No. 72/10), Law of protection from noise in living environment (Republic Serbia, Official Periodical No. 39/09) and National standard JUS U.J6. 205 2007, SRPS ISO 1996-1 Part: Basic values and procedures SRPS

ISO 1996-2 Acoustics: Description and measuring of noise in environment – Part 2: Information about purpose of urban zone.

Table 3: Results of noise measuring with related allowed levels

Measuring location		Noise level, dB						
		Day				Night		
		09-12h	13-16h	18-21h	Allowed level	23-02h	03-06h	Allowed level
1	Restaurant „Merkur“	56	57	60	65	53	51	55
2	Restaurant „La Boem“	52	52	55	55	51	49	45
3	School „St. Sava“	49	55	50	55	55	50	45
4	Church „St. Petka“	52	55	55	55	47	47	55
5	Petrol station „Rade šped“	65	64	68	65	58	60	55
6	Petrovac	57	58	48	55	46	38	45

Relevant level of noise was determined according to National standard SRPS ISO 1996-1 - Part 1: Basic values and procedures SRPS ISO 1996-2 Acoustics: Description and measuring of noise in environment - Part 2: Information about purpose of the area that regulate methods of acoustic zones mapping in relation to purpose. Allowed nose levels according to those regulations are presented at Table 4.

Table 4: Allowed noise levels in respect to area

Purpose of zone	Allowed levels, dB	
	Day	Night
Recreation and rest zones, hospital zones and spa zones, schools, Cultural and historical monuments, parks	50	40
Touristic zones, camps and school zones	50	45
City center, trade, shopping, administrative – official zones with apartments, zones near highways, main roads and city streets	65	55
Business – residential zones, trade – business zones, playgrounds	60	50
Residential zones	55	45
Industrial, depot and service zones, transport terminals	Noise at borders of those zones must be under limit for related neighboring zone	

Results of noise measuring with allowed levels during days and nights with allowable limits are presented at Figure 2 and 3.

Figure 2. Results of noise measuring with allowed levels during day

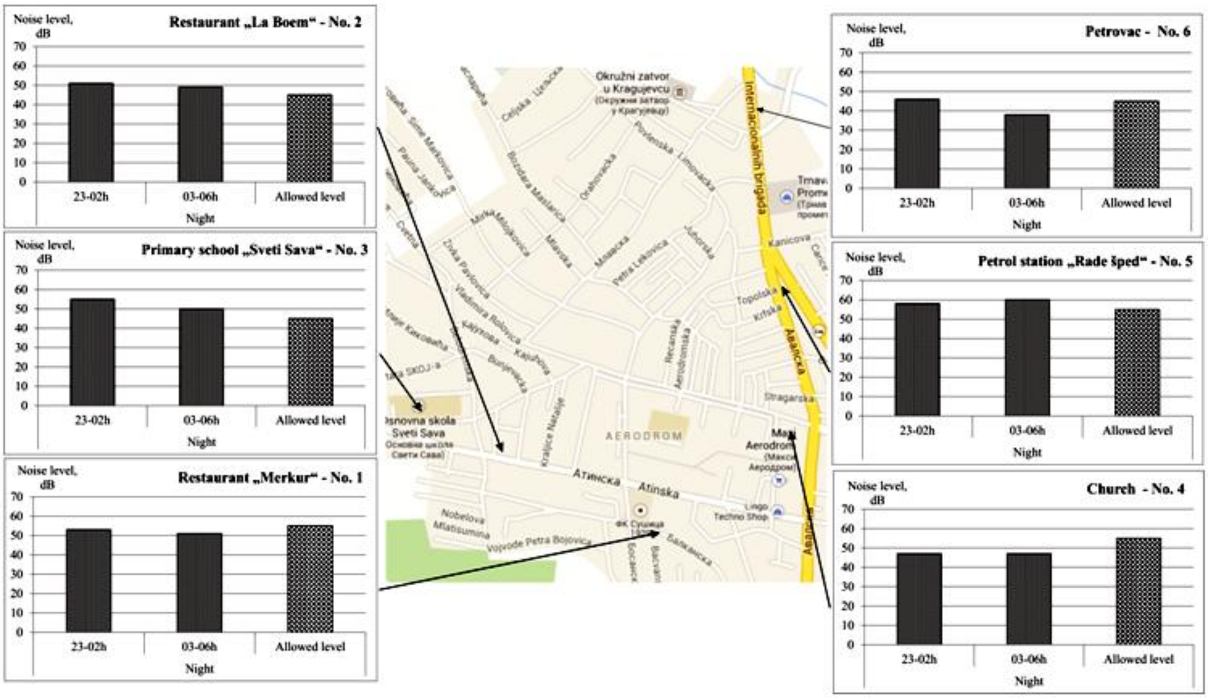

Figure 3. Results of noise measuring with allowed levels during night

CONCLUSIONS

Evaluations of obtained results implicate conclusions and identify procedures for reduction of noise level at every considered location that are presented at Table 5.

Table 5: Results analysis and noise reduction guidelines at specific measuring positions

Measuring location	Conclusion and recommendation for noise reduction
1	Measured noise is time dependent and by frequency analysis belongs to wide range by fast measuring dynamics and do not consist of major tone of frequency, so no specific procedures for noise reduction is indicated. Measured noise levels during days are from 56 to 57 dB, in the evenings 60 dB, and during nights are from 51 to 63 dB. Equivalent noise level is equal to relevant noise level. Average number of vehicles is 120/5 (car/track).
2	Measured noise is time dependent and it is generated by traffic. The noise is wide frequency range measured by fast measuring dynamics and do not consist of major tone neither sound information, so reduction procedures are not indicated. Equivalent noise level of 52 dB is measured during days, 55 dB during evenings and 49 to 51 dB during nights. Average number of vehicles is 302/10 (car/track).
3	Traffic is source of measured noise and it is time dependent, with wide frequency range by fast measuring dynamics and do not consist of major tone, neither sound information, so reduction procedure is not indicated. Measured equivalent noise levels during days are from 49 to 55 dB, in the evenings 50 dB, and during nights are from 50 to 55 dB. Average number of vehicles is 1/0 (car/track).
4	Measured noise is time dependent generated by traffic and wide frequency range by fast measuring dynamics and do not consist of major tone of frequency, so no specific procedures for noise reduction is indicated. Measured noise levels during days are from 52 to 55 dB, in the evenings 55 dB, and during nights 47 dB. Equivalent noise level is equal to relevant noise level. Average number of vehicles is 196/25 (car/track).
5	Traffic generate time dependent noise, with wide frequency range by fast measuring dynamics and do not consist of major tone neither sound information, so reduction procedures are not indicated. Measured equivalent noise levels during days are from 64 to 65 dB, in the evenings 68 dB, and during nights are from 58 to 60 dB. Average number of vehicles is 509/102 (car/track).
6	Measured noise is time dependent generate by traffic, wide frequency range by fast measuring dynamics and do not consist of major tone of frequency, so no specific procedures for noise reduction is indicated. Measured equivalent noise levels during days are from 57 to 58 dB, in the evenings 48 dB, and during nights are from 38 to 40 dB. Average number of vehicles is 54/20 (car/track).

On the basis of the obtained results at measuring position No. 1 and No. 5 it could be concluded that at places classified as main roads, main streets and big crossroads, the noise level during day do not overcome related allowable levels. Noise levels during evenings do not overcome allowable limits at measuring position No. 1, but do at measuring position at measure position No. 5.Also, noise levels during nights do not overcome allowable limits at measuring position No. 1, but do at measuring position at measure position No. 5.

On the basis of the obtained results at measuring positions classified as residential zone (measuring positions No. 2, 3, 4 and 6 it is implicated that noise level overcome allowable limits during day only at measuring position No. 6. At all measuring locations, noise levels during evenings stay within allowable limits. During nights, noise levels at measuring positions No. 2, 3 and 6 overcome allowable limits, while noise levels overcome those limits only at measuring position No. 4.

Analysis of the obtained results can provide relevant information and data for future research in the area. Those results can be used to identify effective procedures for reduction of noise level and put them into allowable limits.

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CLIMATE CHANGES AND URBAN POLLUTION

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THE SOCIAL ASPECTS AND ROLE OF GREEN INFRASTRUCTURE IN MITIGATING CLIMATIC CHANGES AT REGIONAL LEVEL

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ABSTRACT

Green urban parks and their management as well as the forest ecosystems near urban regions provide economic, social, cultural, and ecological services to the society. Biogeochemical cycles of elements in these urbanized ecosystems are the changes due to the complex of factors including both climatic and anthropogenic. Concerning climatic changes, the greenhouse gases (GHG) are of great importance, especially CO_2 cycle is of a considerable scientific interest. While the cities are perceived mainly as sources of GHG through emissions of the transport, combustion, etc., the urban green spaces contribute to carbon sequestration and mitigation of climatic changes at regional level. The present study focuses on carbon stocks in forest parks of two urban centers along an urban-rural gradient. It is underlined that green urban parks have great potential in sequestering carbon and their management improves this ecosystem service. Based on the obtained results, it could be concluded that the anthropogenic factor has a high degree of influence upon carbon accumulation in urban zones. Depending on urban-rural gradient, significant differences between carbon stocks in urban forest parks and controlled semi-natural forests was established. Different aspects of management of urban forest parks have high importance for the population in these areas. The results from the interviews and questionnaires showed that in both urban centers, despite the contrast between the two populations, level of urbanization, and climates, the urban forest parks should be preserved for future generations as a good option as regards recreation and relaxation. This is related to the improvement of living conditions in urban areas, together with highly aesthetic views of forests. Based on data obtained and the results of social investigation performed, it is recommend that new zones of green infrastructure should be created and/or enlarged.

Key words*:* *Urban forests, green infrastructure, carbon stocks, social aspects.*

INTRUDUCTION

The inventory of greenhouse gas (GHG) emissions is of a great importance for mitigating global warming and climate change. It should be underlined that at regional level **the cities are perceived mainly as sources of GHGs through the emissions of transport, combustion etc., while the urban green spaces contribute the carbon sequestration and mitigation of climatic change.** The urban green spaces are referred as elements of Green Infrastructure (GI) and serve to mitigate the negative influence of urbanization on the local climate and support the strategy for adaptation of the region to climate change (Newell et al., 2013). The concept of “Green Infrastructure” emerged in the middle of 90s of the last century in USA and is introduced in the White Paper for climate change adaptation of the European Commission in 2009. Green Infrastructure means the strategically planned network of varieties of natural, semi-natural and man-made green spaces, which have multifunctional role in ecological, social and economical aspect (DG Environ. News Alert Service, 2012). The established green and blue spaces on both existing and new urban areas are included in GI. GI connects the urbanized zone with surrounding environment in a unified system and reduces the fragmentation of green spaces in the region (Van Bohemen, 1998). The elements of GI are parks and gardens, natural and semi-natural urban green spaces and wet zones, green corridors, recreation zones, sport facilities etc. (www.rics.org/standards). All these elements of GI are **capable of delivering a wide range of environmental and quality of life benefits known as ecosystem services for local communities** (www.naturalengland.com). The benefits for environment include: improving air quality (Nowak et al.

2006, Powe and Willis, 2004); protection of biodiversity (Harrison and Davies, 2002); adaptation to climate change (La Greca, 2011), support the hydrological regime and drainage (Gill et al., 2007). As ecosystem services of GI with social focus are concerned: providing places for education, training and green jobs (Natural England, 2010), health and wellbeing (Tzoulasa et al., 2007) and common improvement of quality of life for local community (Benedict and McMahon, 2003; Younger et al., 2008). Urban Forest Parks facilitate the social contacts and integration within the society and moreover provide specific cultural services. Good quality of GI ensures also economic benefits for society such as increased investments and property prices (Schäffler and Swilling, 2013).

The components of GI in urban zones and especially tree vegetation and soils are main reservoirs of carbon and play key role in mitigating climatic changes at local level and their management is crucial element in urban climate change adaptation strategies (Hallegatte, 2009). Nowadays the scientific efforts are directed to clarify the question of carbon sequestration by different components of ecosystems under pressure and the effects of their management.

The aim of this article is to study the potential of urban forest parks as elements of green infrastructure in mitigating climatic changes through analysis of carbon accumulation in their components and to present the social aspect of their management.

LOCATION AND METHODS

The studied objects are Urban Forest Parks in Sofia and Sandanski (Bulgaria). The both cities are located in different climatic zones. The Sofia capital city is located in temperate zone with mean annual temperature of 9.9°C and mean annual precipitation of 572 mm. The town of Sandanski is located in Semi – Mediterranean zone with mean annual temperature of 13.9°C and mean annual precipitations of 533 mm.

The both regions have contrast characteristics in relation of population and level of urbanization. Sofia is characterized with maximum concentration of population in the country 1 402 627 while Sandanski has significantly lower population - 30 175 (in 2013) (http://sfoblast.government.bg). The studied urban centers have well organized green systems and clearly expressed urban gradient toward the surrounding mountains.

The Urban Forest Parks as well as Control Sites in the both urbanized centers were studied in 2010-2012. The forest parks were distinguished in the following areas: urbanized area (U) and control non-urbanized area (NU) - (Table 1).

The sampling sites are located on higher, well drained places, on soil types *Luvisols*, *Vertisols* and *Anthrosols* (WRB, 2006). The soils from high urbanized areas characterized with strongly altered characteristics in the upper soil layers and could be referred to *Urbic Anthrosols*, which are formed on natural soil types for the region. The tree forest vegetation is dominated by oak species (40-80% participation), with ages of the plantation at least 60 years. In addition, the forest stands formed by other tree species were also included. In each site (U and NU) the experimental plots with area 50 m x 50 m were outlined on the field. Five experimental plots per site were sampled and analyzed for carbon stock in soil, forest floor and aboveground tree biomass according to the methodology of IPCC GPGLULUCF (2003).

The accumulation of carbon in studied areas is presented by implementing the network approach and using GIS in Google EarthPro environment.

In social aspects of park management was studied by the method of direct inquiry. In processing of empirical information and visualization of the results the program products SPSS and Excel were applied.

RESULTS AND DISCUSSIONS

The results for carbon stock in different components of studied ecosystems – soils and aboveground tree biomass is presented on Figures 1, 2, 3 and 4. Visualization of the results obtained for urban forest parks in both studied cities gave clear picture of the high potential of these GI elements to accumulate and sequester carbon.

Table 1: Features of sampling plots from Sofia and Sandanski

Sampling Plots	Geographical coordinates	Altitude m	Exposure	Slope °	Distance from urban center km	Building spaces of the site %	Dominant tree species	Soil type
Sofia								
U1 – Borisova garden	N 42°41'22.89" E 23°19'45.34"	553	E-SE	4	3.3	71	*Quercus cerris* L. + *Q. robur* L.	*Anthropogenic Vertisols (Urbic Anthrosols)*
U2 – Loven Park	N 42°40'15.56" E 23°20'10.56"	606	S-SE	4	3.7	56	*Quercus rubra* L.	*Anthropogenic Chromic Luvisols (Urbic Anthrosols)*
U3 – Western Park	N 42°42'49.47" E 23°16'54.51"	564	W-SW	4	3.8	64	*Quercus rubra* L.	*Anthropogenic Vertisols (Urbic Anthrosols)*
U4 – Northern Park	N 42°44'31.61" E 23°18'06.09"	536	N-NE	4	5.6	35	*Quercus robur* L.	*Technogenic Anthrosols*
NU1 – German Monastery	N 42°35'51.61" E 23°26'19.86"	884	NE	24	15	0.2	*Quercus petraea* Liebl.	*Chromic Luvisols*
NU2 – Tihia Kat	N 42°38'15.74" E 23°13'09.00"	1054	W	20	11	0.3	*Quercus cerris* L.	*Chromic Luvisols*
NU3 – Bonsovi meadows	N 42°38'57.32" E 23°11'20.47"	1028	NE	15	13	0.2	*Quercus polycarpa* Schur.	*Chromic Luvisols*
NU4 – Beledie Khan	N 42°53'14.13" E 23°10'20.57"	700	N	7	25	0.2	*Quercus cerris* L.	*Chromic Luvisols*
Sandanski								
US1 – Sandanski Park St. Vratch	N 41°34'08.66" E 23°16'53.25"	247	NW	2	4	35	*Quercus petraea* L. + *Platanus orientalis* L.	*Anthropogenic Chromic Luvisols (Urbic Anthrosols)*
US2 – Sandanski Park St. Vratch	N 41°33'56.46" E 23°16'56.46"	232	NW	3	1	55	*Quercus pubescens* L. + *Pinus nigra* L.	*Anthropogenic Chromic Luvisols (Urbic Anthrosols)*
NUS1 – road to Lilianovo	N 41°35'35.73" E 23°17'35.73"	385	W	7	15	0.1	*Pinus nigra* L.	*Chromic Luvisols*
NUS2 – Experimental station FRI BAS	N 41°34'17.67" E 23°17'11.65"	272	N	12	6	1	*Quercus petraea* L. + *Q. pubescens* L.	*Chromic Luvisols*

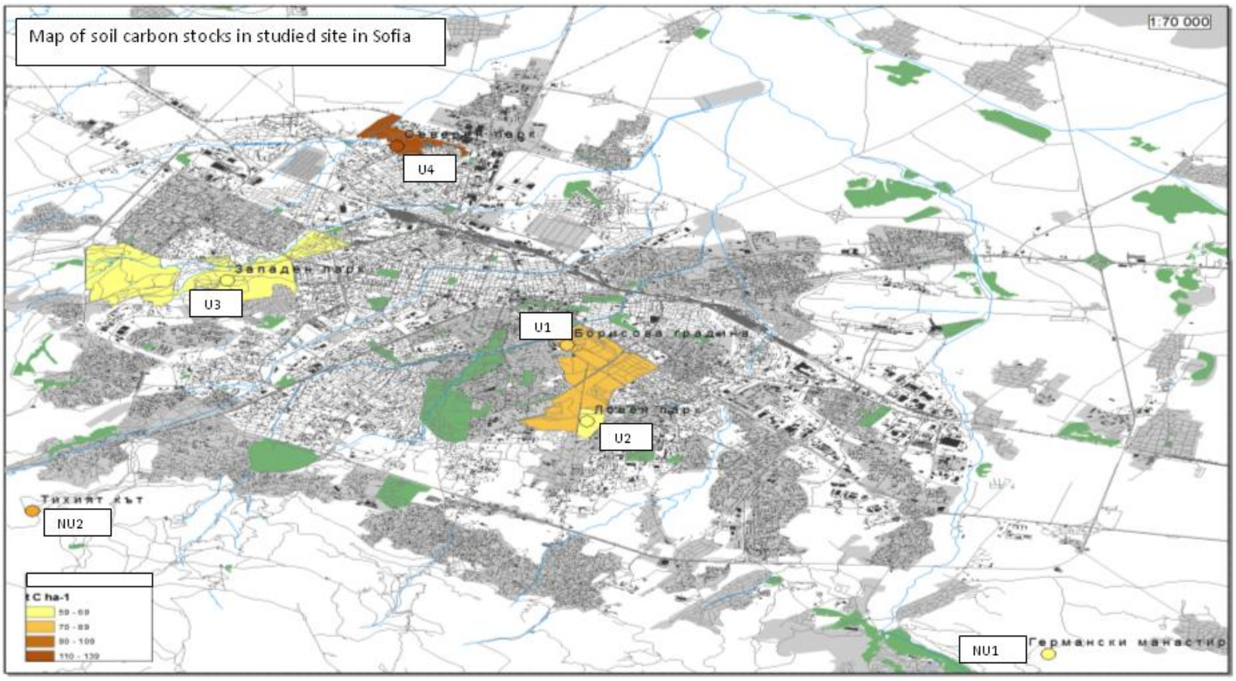

Figure 1. Soil Carbon Stock in Urban Forest Parks from the region of Sofia

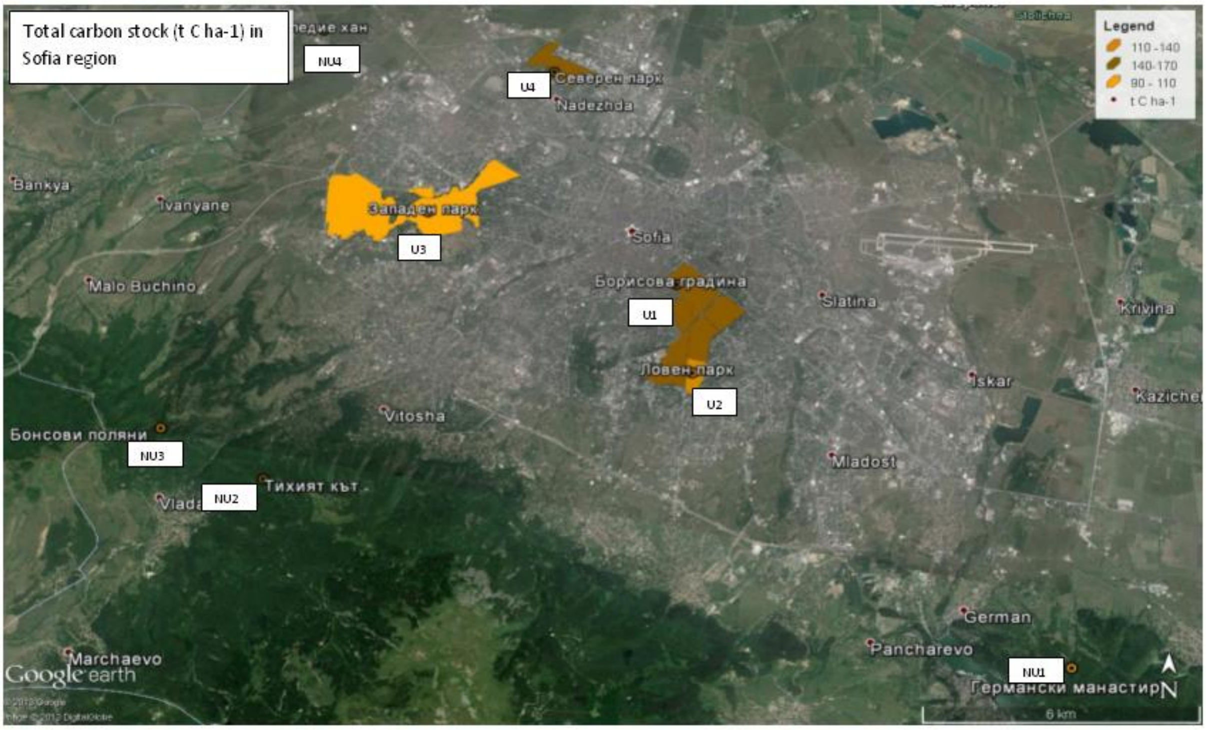

Figure 2. Total amount of carbon in Urban Forest Parks from the region of Sofia in Google format

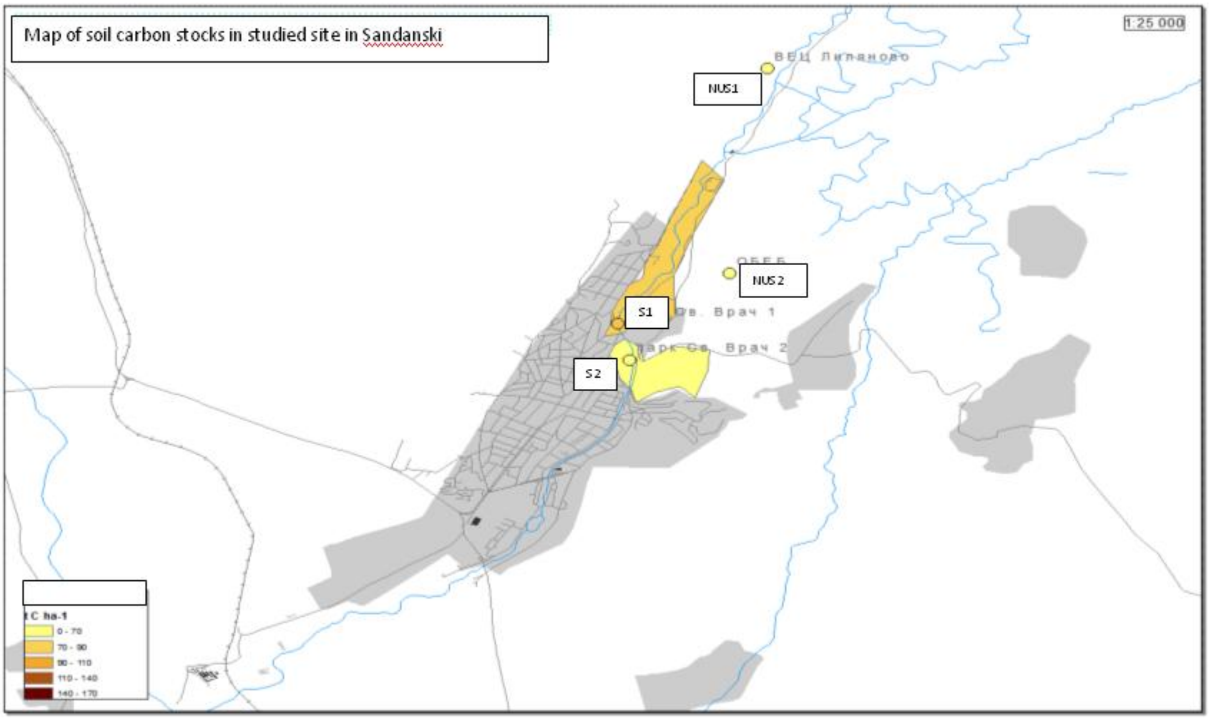

Figure 3. Soil Carbon Stock in Urban Forest Parks from the region of Sandanski

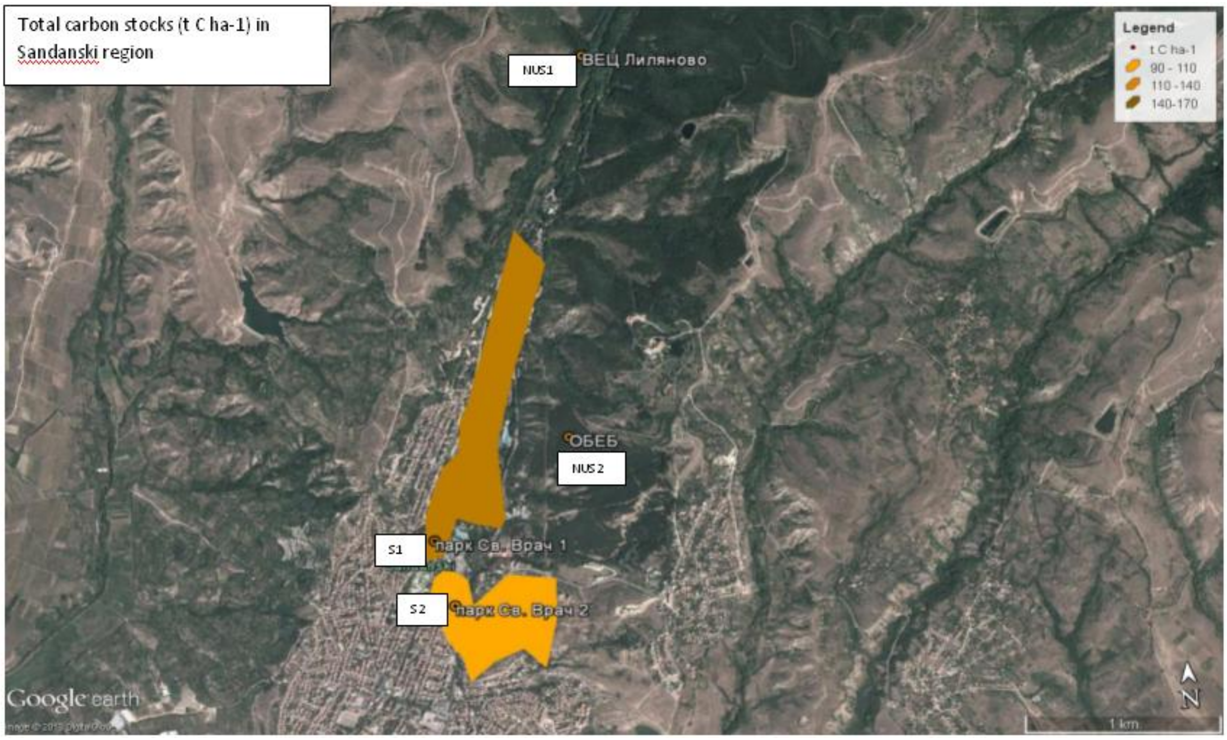

Figure 4. Total amount of carbon in Urban Forest Parks from the region of Sandanski in Google format

The region of Sofia is characterized with higher carbon stocks both in urban parks and in control sites in comparison with the region of Sandanski due to differences in climatic and soil conditions.

The biggest reservoir of carbon in studied forest ecosystems are soils – mean value ~ 80 t C ha^{-1} in comparison with aboveground biomass (mean value ~ 46 t C ha^{-1} and forest floor (mean value ~ 5-6 t C ha-1). From Fig.1 could be outlined a decrease of soil carbon stocks in Sofia Parks as follows: U4 > U1 > U3 > U2. In U4 site the soil is *Technogenic Anthrosols* (in bulk) with buried humus layers in depth, while the site U1 presents the largest park in the city - Borisova garden, where the melioration activities are regularly performed – mowing of grass and remaining of plant residues at the same place, artificial irrigation and other management activities.

For the Sofia region, the highest amount of carbon is accumulated (0-50 cm) in the anthropogenic soil from U4 (ranging between 110 and 130 t Cha-^{1}), followed by the soil of NU4 (the remotest point) ≈ NU2 - (with highest altitude) both ranging between 90 and 109 t C ha^{-1} > U1 ≈ NU3 (both ranging between 70 and 89 t C ha^{-1}) and at the end – soils in U3 ≈ U2 ≈ NU1 (ranging between 59 and 69 t C ha^{-1}).

Total carbon stock – Fig. 2 (including aboveground tree biomass and forest floor) for the region of Sofia followed the order: U4 ≈ U1 ≈ NU2 ≈ NU4 (ranging between140 and 170 t C ha^{-1}) > U2 ≈ NU3 (ranging between 110 and 140 t C ha^{-1}) > U3 ≈ NU1 (ranging between 90 and 110 t C ha^{-1}).

Generally, the urban forest parks in Sofia have high potential to sequester carbon, as the total carbon stock (530 t C ha^{-1}) is similar to the values obtained for control non-urbanized forest ecosystems (548 t C ha^{-1}). It could be confirmed that urban forest parks defined as “amount of tree and other vegetation, located around densely populated zones” (Konijnendijk et al., 2006), could captured and sequestered a large amount of carbon in the towns (Brack, 2002). However degree of urbanization pressure influences these processes and distinguishes them from those occurring in the natural environments (Pouyat et al., 2002).

For the region of Sandanski (Fig. 3), soil in S1 (under mixed deciduous plantation with intensive management) the higher carbon stock was determined (ranging between 70 and 90 t C ha^{-1}) in comparison with the soils from sites S2, NUS2 и NUS1 (ranging between 10 and 70 t C ha^{-1}).

The total amount of carbon in forest ecosystems from the region of Sandanski (Fig. 4) was highest in S1 (ranging between 110 and 140 t C ha^{-1}), followed by the carbon stock in the forest of pure black pine in NUS1 (ranging between 90 and 110 t C ha-^{1}) and the lowest carbon stock defined in S2 and NUS2 (undeveloped oak plantation) both within the range from 70 to 90 t C ha^{-1}.

Generally, for Sandanski region more carbon was stored in urban forest parks compared with values obtained for non-urbanized controls, due to higher sequestration in the soil component. Only in NUS1 more carbon was accumulated in the aboveground biomass of black pine tree vegetation, which is related with specifics of the stands formed by coniferous trees and could not be used as reference.

The different aspects of management in urban forest parks with great importance for the society are presented in table 2. The closed empty circles in the table show that the corresponding aspect is of great importance for the individuals or society. The black small and dense circles show that in inquiry the indicated aspect/causes is important but doesn’t achieve the set targets and needs of society. The circles, marked with sign „X“ indicate that the relevant aspect is assessed as high priority from more that 50% of the interviewed persons. The index N / A indicates that the corresponding variant is not applicable for the region.

Table 2: Social aspects of the role of Forest in Urbanized regions of Sofia and Sandanski

Under theme	**Aspect and/or case, connected with Forests in urban zones**	**Sofia**	**Sandanski**
Incomes	Individual revenue for population	●	○
	Collective income population / of municipal projects and more. /	●	○
Employment	Increase the employment of people in the community	○	○
	Increased opportunities for young people to remain in the settlement	○	●
Improving the quality of life and related infrastructure	Improved living conditions	⊗	⊗
	Benefits of investments in Urban Forest Parks and related infrastructure	○	●
Supply of timber and non-timber products	Supplying the timber	n/a	n/a
	Providing of non-timber products	○	○
Relating knowledge and skills	Improved business management, marketing and market evaluations	●	○
	Developed agro-forestry systems	n/a	●
	Well-managed plantations	●	⊗
Preservation of cultural and natural heritage	Maintenance of plantation aesthetic appearance	⊗	⊗
	Protected cultural values	⊗	○

	Protected species /plants, animals/	●	⊗
Recreation and relax	Exist the good conditions of recreation and relax	⊗	⊗
Preservation for future generations	Forests must remain for future generations	⊗	⊗

Summarizing the results of the survey it could be underlined that in both regions the management of urban forest parks is of a great importance for the community. Moreover most of the inquired person confirmed the highest importance of maintenance of forest parks and their preservation for the next generation which is involved in their perceptions for good quality of life, good conditions for recreation and relaxation.

CONCLUSION

The urban forest parks in Sofia and Sandanski play a role as a reservoir of carbon and have a high potential for carbon sequestration in their components. The maintenance and management of forest parks contribute for betterment of carbon storage.

The anthropogenic factor influences the carbon accumulation in ecosystems. The carbon content in urban forest ecosystems in studied cities Sofia and Sandanski is similar to the content in control plots which indicates their high potential to sequester carbon and to play and important role in mitigating climatic changes at local and/or regional level. The total amount of carbon is mainly determined the soil type and the tree species. The management activities in parks contribute to the improvement of carbon storage in different components of these ecosystems. The analysis of carbon stocks in components of urban forest parks along an urban-rural gradient is a valuable approach in calculation of long-term effect of green zones on reduction of greenhouse gas emissions.

The results from the interviews and questionnaires showed that in both urban centers, despite the contrast between the two populations, level of urbanization, and climates, the urban forest parks should be preserved for future generations as a good option as regards recreation and relaxation. This is related to the improvement of living conditions in urban areas, together with highly aesthetic views of forests. Based on data obtained and the results of social investigation performed, it is recommend that new zones of green infrastructure should be created and/or enlarged.

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SATELLITE OBSERVATION OF THE EARTH – A TOOL FOR CLIMATE CHANGES MITIGATION AND URBAN POLLUTION MANAGEMENT

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ABSTRACT

By launching a series of satellites, equipped with instruments for data acquisition for Earth observation, EOS (Earth Observing System) has been established. In this way, the Planet is scanned, different components of soil, water and rocks are measured, but also data processing and interpretation are performed in computing centers. Method of data acquisition is known as remote sensing. Various methods of remote sensing are used for observation of the Earth's systems (geosphere, pedosfere, hydrosphere, cryosphere, atmosphere, biosphere and anthroposphere), as well as system interactions and changes in the environment. Satellite observations of urban environment exist as special field of investigations and that is why various applications within protection of urban environment against pollution and climate changes mitigation are presented in the paper.

Key words: *Remote sensing, satellite observation, climate changes, urban pollution*.

INTRODUCTION

Modern remote sensing began with invention of the *camera obscura* in early 1800s. Shortly thereafter, the first aerial photograph was taken in Paris in 1858 with a camera mounted on a balloon. During the World War I, cameras mounted on planes were used in military reconnaissance. The greatest expansion of the use of aerial photography occurred during World War II, primarily for military reconnaissance. The military also pioneered the development of remote sensing outside the eye's visible range, such as near infrared imagery for discriminating camouflage from real vegetation. After the war, several civilian applications were developed including hazard mapping, vegetation mapping and planning. Until the early 1960s, the aerial photograph remained the only tool for depicting the earth's surface from a vertical (or nadir) perspective.

Space remote sensing began with the launch of the first military intelligence satellite in 1958. In 1960, the first U.S. meteorological satellite, *TIROS-1,* was launched by an Atlas rocket into orbit. This satellite was devoted mainly to looking at clouds. Onboard this satellite, were the first nonphotographic sensors. TIROS, for *Television Infrared Observation Satellite*, used vidicon cameras to scan wide areas at a time to produce generalized weather maps. The 1972 launch of the *Earth Resource Technology Satellite (ERTS)*, later renamed *Landsat*, initiated the era of land remote sensing. These satellites were equipped with multi-spectral sensors dedicated to continuous imaging of the earth's surface.

Fundamentals of remote sensing

The process of remote sensing is based on the detection and measurement of radiation of different wavelengths reflected or emitted from distant objects or materials, by which they may be identified and categorized by class/type, substance, and spatial distribution. The background required for use of remote sensing tools may seem overwhelming at first. The decisive factor in the successful application of remote sensing data, however, need not be the technical sophistication of the user, but rather the suitability and precise use of the tool to obtain accurate and relevant data. A general grasp of the technical process that transforms electromagnetic energy into useful information can improve and expand the appropriate use of these tools. Nevertheless, depending on the application, social scientists wishing to work with remote sensing imagery would do well to partner with physical scientists with a deeper understanding of how the imagery represents physical processes on the ground.

In the broadest sense, remote sensing refers to information gathered by measuring and interpreting signals. To use perhaps the simplest analogy, the human body is constantly involved in a variety of remote sensing tasks. Hearing and vision are two obvious examples, involving the gathering and interpretation of sound and light waves, both in limited ranges of the entire sound and light spectra.

Active and *passive* remote sensing are used to describe the way sensors gather data. To illustrate the two types of sensors, consider a snapshot camera, a sensor that captures electromagnetic radiation in the visible spectrum. Outdoors in full daylight, a camera is ordinarily used as a passive sensor in that it receives reflected visible light from its surroundings and uses optics, a shutter, and film to create a lasting image. At night, on the other hand, when there is inadequate light for most cameras to capture a useable image, the camera may employ a flash. The flash is emitted from the camera and bounces off the object to illuminate it, just as an active (or radar) sensor sends a burst of energy towards its target and then receives the reflected radiation.

A key factor in the choice between passive and active sensor is the relative strength of the potential signal each system must measure. For a passive system, the source of the signal is ultimately the sun, which emits electromagnetic radiation at its highest intensity between the ultraviolet and infrared. In the radar wavelength ranges, however, sensors must provide a signal of sufficient intensity to travel to the earth, and return with enough strength to be distinguishable from the background “noise” from other sources.

All remote sensing systems – active and passive – generally have the following seven elements (Fig. 1).

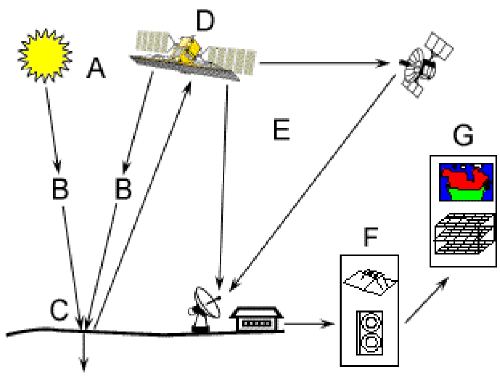

Figure 1. Diagram of elements of a remote sensing system (Committee on the Earth System Science for Decisions About Human Welfare, 2007)

Applications of satellite observations

Broad Area Mapping Applications (Fig. 2):

- Transportation - roads, railroads, utility features, and pipelines;
- Hydrography - rivers, lakes, reservoirs, dams, wells, and springs;
- Hypsography - elevations, contours, and spot heights;
- Boundaries - counties, cities, and municipalities; national parks, national forests, and reservations;
- Vegetation - forests, shrub land, wetlands, and agriculture;

- Manmade features - buildings, airports, and stadiums;
- Natural features - sand dunes, coastlines, volcanoes and glaciers;
- Survey control - horizontal and vertical control for geodetic networks;
- Coordinate grids - latitude/longitude, public-land survey system, projections, and international grids.

Figure 2. GEOSS – Global Earth Observation System of Systems (Komatina Petrović S., 2011)

Infrastructure & Asset Management Applications:

- Pavement management systems;
- Maintenance management systems;
- Asset management systems;
- Traffic incident management planning;
- Location based services;
- Fleet management systems;
- Intelligent transportation systems.

Planning Applications:

- Urban;
- Mining;
- Exploration;
- Surveying;
- Land use / land cover;
- Subdivision;
- Property line adjustments;
- Zoning;
- Water, waste-water, and storm-water management;
- Utilities planning and usage;
- Parks and recreation;
- Forestry;
- Economic development.

Disaster Response Applications:
- Prediction mapping - storm tracking, damage prediction, flooding, population density, routing;
- Post disaster mapping - affected road systems and transportation routes, including federally declared counties;
- Census demographics;
- Emergency response development - temporary housing, debris removal, emergency power and water, emergency services, and evacuation route clearance;
- Mitigation assessment, measures, and programs;
- Recovery recovery action planning, long-term economic recovery planning, post-disaster building-inspection capability, housing-recovery strategy.

Situational Awareness – Applications:
- Providing up to date information to First Responders;
- Bio Surveillance programs;
- War fighter applications;
- Anti-terrorism surveillance and monitoring;
- Monitoring public water supplies and utilities.

Visualization & Simulation Modeling – Applications (Nicklin S. et al, 2007):
- Insurance: risk assessment, catastrophic-loss reduction, response planning for natural catastrophes;
- Military: mission planning and rehearsal, aerial reconnaissance;
- Environmental monitoring, planning, and management: flooding, forest damage, and water pollution;
- Emergency facilities planning;
- Utility planning and management: energy transmission, telecommunications;
- Entertainment / media: scenery development for computer games, movies, documentaries, news programs, and Web media;
- Marine applications: seafloor exploration for geological applications, navigational hazards, shipwrecks;
- Flight-simulation: military and commercial aviation training, flight simulator development;
- Archaeology: virtual exploration for locating viable sites.

REMOTE SENSING AS A TOOL FOR CLIMATE CHANGES MITIGATION AND URBAN POLLUTION MANAGEMENT

Cities are places of light, action and complex social interactions, multi-faceted cultures, and fast-paced living. It’s no wonder cities are growing faster than rural areas. More than 50 percent of the world’s human population now lives in areas of contiguous urban development. People are driving landscape-scale changes on our Planet: the land surface, vegetation, water cycle, radiant heat and other aspects of the landscape. Using remote sensing data, people can monitor urban change and also forecast patterns of change in future urban landscapes. Satellite sensors employ a spatial resolution of 30 m, which is an ideal scale for observing human impacts on the land. They detect urban growth with visible and infrared reflectivity consistently, objectively, and dependably over time.

Identification and Delineation of Urban Areas

Identification, delineation and classification of urban areas have typically been the realm of the technical remote sensing community. Much of the social and demographic information social scientists require can be more easily obtained from traditional government and private sector sources. Satellite imagery may be used to define urban areas in a more consistent way and to produce spatially georeferenced urban extents. A relatively new approach is one that looks at data fusion for urban analysis, which is based on the integration of data from different satellites, and with different spatial and spectral resolutions, to identify urban features, building types and building density.

Classification of Urban Areas

If delineating urban areas is a difficult task, classifying different types of urban land use is even more so. The urban environment is characterized by a mixture of diverse material and land use classes, such as buildings, commercial infrastructures, transportation networks, and parks. Because they are combinations of spectrally distinct land cover types, mixed pixels in urban areas are frequently misclassified as other land-cover classes. Similarly, the definition of an “urban” spectral class will usually incorporate pixels of other non-urban classes. Such spectral heterogeneity severely limits the applicability of standard classification techniques, where it is assumed that the study area is comprised by a number of unique and internally homogeneous classes. Urban classifications are often improved by integrating satellite-derived classifications with ancillary data in a GIS environment. Ancillary data might include a range of socioeconomic variables, such as population or housing density, derived from the census or similar data sources or variables like land use and digital elevation models.

More recent techniques in urban classification rely on hyperspectral data. A hyperspectral image is one in which the radiance from each pixel is measured at many narrow, contiguous wavelength intervals. This enables identification of surface features, making hyperspectral sensors good candidates for mapping complex urban systems, particularly for classifications based on material composition. However, there are some limitations in their applicability for the social sciences.

Measuring and Monitoring Physical Properties of Urban Areas

Urban areas exert an influence on local weather and climate, but they also affect wider regional and global atmospheric systems. Changes induced by urbanization include changes in solar radiation absorption, surface temperature, evapotranspiration, water vapor and pollutants concentration, which in turn link to human health problems.

Urban construction materials such as metal, concrete and asphalt absorb, reflect, emit, and store heat differently than tree or grass-covered land. During the day, urban materials absorb heat and hold it long after the sun sets, creating a warm bubble *(heat island)* over a city that can be as much as 6 degrees Celsius higher than temperatures in surrounding rural areas. Landsat’s thermal imaging capacity clearly indicates where temperatures are heightened by urban landscapes. Landsat observations of urban land cover together with weather and other data have helped to show that urban heat islands can influence where and how much it rains. The heating of the surface and the overlying air creates instability in the atmosphere that encourages air to rise. As it rises, it cools, and water vapor condenses into rain that falls downwind of the city. Rainfall downwind of major urban areas can be as much as 20 percent greater than in areas upwind (Fig. 3).

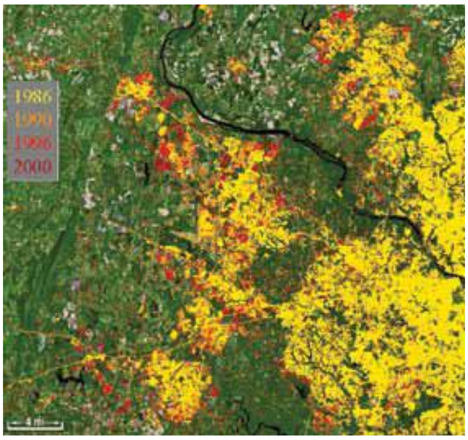

Figure 3. Maps derived primarily from Landsat data were analyzed to produce this image of change over time in Northern Virginia between 1986 and 2000. Oranges and reds indicate increases in impervious surfaces such as asphalt, concrete, and rooftops, of more than 20 percent between eras GMES (TERRAFIRMA, ESAQ, 2011).

Other physical parameters measured include *vegetation, ozone, dust and overall air quality in urban areas* (Fig. 4). Vegetation can substantially affect the wind, temperature, moisture, and precipitation regime of urban areas and is believed to have very important practical applications in urban planning, such as heating and cooling requirements of buildings, dispersion and concentration of pollutants, and urban weather. Using Landsat, researchers create land-use maps that distinguish urban surfaces from vegetation. They use computer models to quantify land use efficiency; assess the impact of urbanized land on energy, water, and carbon balances; and project growth. Landsat brings a major advance in monitoring capability because aerial photo mapping can’t keep up with the pace of change. Maps of counties and cities capture new development and can be repeated much more quickly than the tedious and expensive traditional photo interpretation work.

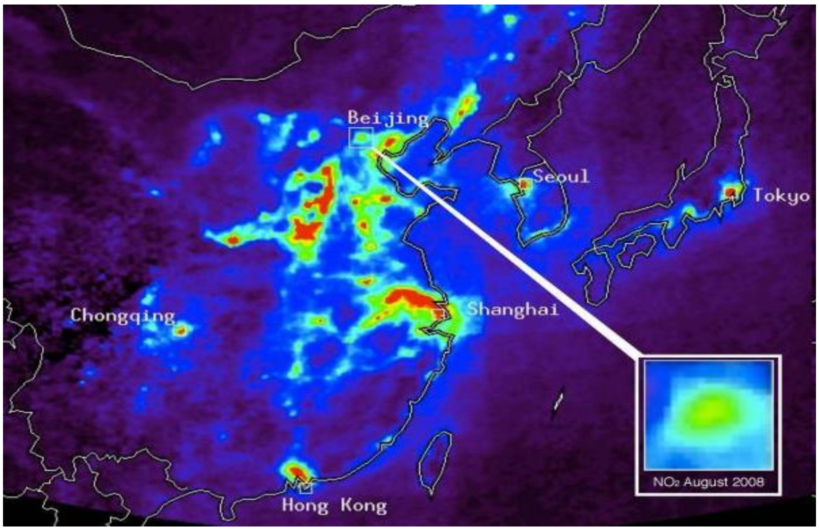

Figure 4. Air quality monitoring during Olympic Games in Beijing, summer 2008. During two months of traffic restriction, NO_2 level decreased up to 50%, and CO_2 level – for 20%

Analysis of Physical Characteristics and Demographic/Socioeconomic Patterns

Both social and physical scientists deal with the issue of integration of physical variables derived from remote sensing and traditionally collected socioeconomic and demographic data. Such integration might eventually lead to a better understanding of urban impacts and urban drivers of environmental and social changes, bringing benefits to both communities. Remote sensing provides repeat coverage of a given area, allowing great data availability, but often at moderate spatial resolutions, while some ancillary data may provide levels of detail that are not available through the satellite data. Combining the two proves to be an effective way to reduce misclassification errors and improve the specificity of the final classification.

Other studies reflect the growing need of the social science community to use remotely sensed data in conjunction with demographic and socioeconomic data to study urban change dynamics or to better understand the spatial distribution of population and socioeconomic phenomena.

Monitoring Urban Growth

Monitoring urban growth is one of the questions social scientists, urban planners and decision-makers deal with most frequently. The direct impacts of urban expansion on physical, ecological and social resources have made research on urban sprawl of increased interest. Traditional census sources are extremely useful in that they capture changes in the socioeconomic and demographic structure of cities, but they lack spatial details and are not frequently updated. Remote sensing, on the other hand, makes available a vast amount of data with continuous temporal and spatial coverage and can therefore provide a successful means for monitoring urban growth and changes (Fig. 5).

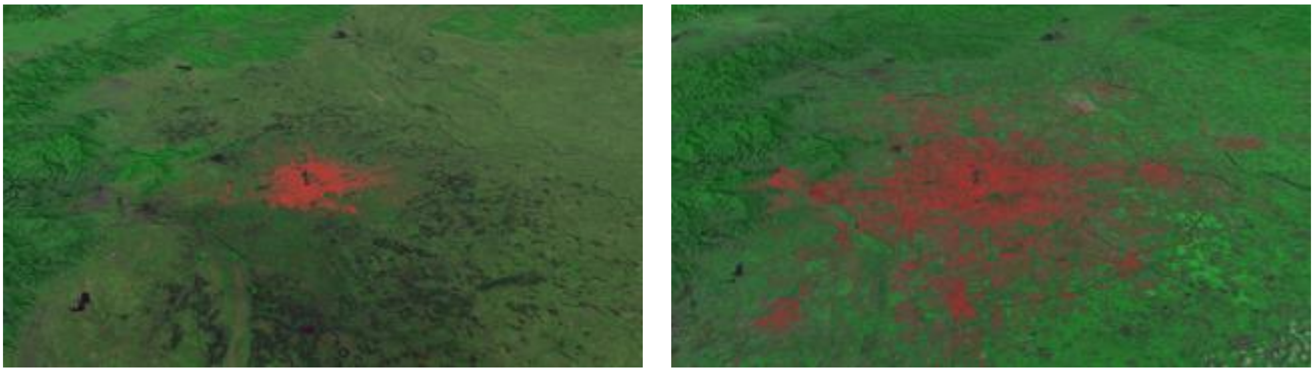

Figure 5. Landsat data of Beijing in 1978 and 2010

Recent Applications and New Developments

Measuring impervious surface area. Highly impervious surfaces, such as concrete, asphalt and rooftops, prevent precipitation from infiltrating soils. Impervious surfaces concentrate pollutants into streams and ultimately into rivers, lakes, bays, and oceans. They alter the hydrological regime and cause soil erosion by inducing faster runoff from land. Landsat observations of visible and infrared reflectivity are highly effective at quantifying changes in land use from pervious to impervious surfaces (Fig. 6).

Municipal planning and development

- Local as well as regional type municipalities can accurately plan for and maintain areas earmarked for housing as well as the development thereof;
- Implementation of subsurface and above surface pipe lines and electrical cables,
- Plan and develop of new roads as well as maintaining existing roads, etc.

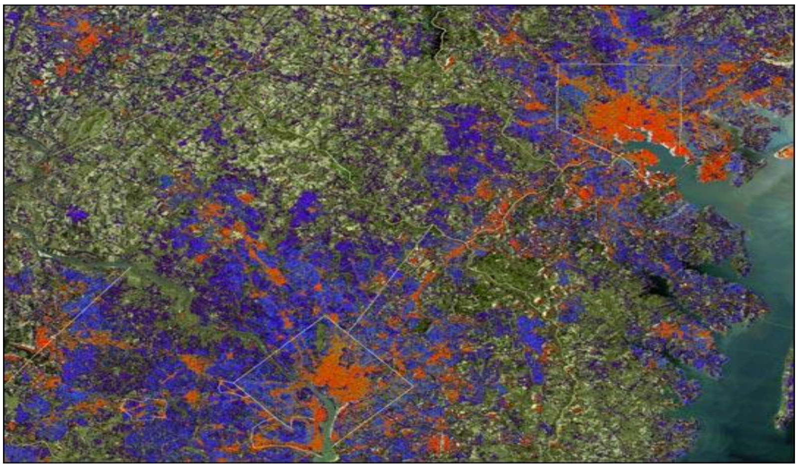

*Figure 6. Plan of impervous surfaces***.** *NASA Landsat (Committee to Review Near-Earth Object Surveys and Hazard Mitigation Strategies, 2010)*

Applications to human health

Remotely sensed data provide a spatial perspective on human health issues not typically incorporated into human health research and applications. Remotely sensed data, as applied to human health and welfare, can assist in taking into account multiple factors affecting health, such as food production, availability, and distribution; environmental health hazards; contagious and infectious diseases; chronic health issues; and health delivery. All of these factors have traditionally been considered separately by a variety of organizations. Health professionals do not typically observe the human land uses and ecological conditions affecting human health from the viewpoint of the remote sensing satellite. For health professionals, who often view issues in terms of point estimates or community averages, the visual and spatial perspective from remote sensing fosters a more integrated approach.

Remotely sensed data, in combination with other data, can provide spatial information on environmental conditions for understanding distributions of water-borne disease, air quality, soil, and vegetation as they influence community health and livestock. Remotely sensed data also provide spatial information on land use and infrastructure, which aids in determining where people live, where vulnerable populations live, the distribution of urban populations, and the quality of roads and other infrastructure for health care delivery. Interdisciplinary and international collaboration are needed between remote sensing scientists, ecologists, and human health scientists to realize the full potential of remote sensing applications.

Tourism

- Various tour operators, hotel owners, resort owners, municipalities as well as governments can use our satellite Images in presentations to show tourists the various attractions in a particular country,
- Development of existing resources to build new resorts as well as maintaining existing ones (Fig. 7),
- Mapping and planning of river adventures like rafting,
- Compilation of tourist maps to sell as souvenirs, etc.

Figure 7. Belgrade. Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR), Space Shuttle Endeavour. Area: 36 x 32 km. October 2, 1994

CONCLUSIONS

In all parts of the world, effective communication between land remote sensing community (technical experts) and decision makers is inadequate. To be most useful in decision making, technicians and policy analysts trained in remote sensing and geographic information analysis could become part of interdisciplinary teams. Information from such teams could provide useful information that feeds into appropriate decisions. Policy makers could become better informed about the utility of remote sensing data, to ensure both that resources are available to utilize these data and that data are fed into all appropriate stages of the decision-making process. Minimum data needs and levels of accuracy would be communicated. In addition, public and private sector data users would understand and implement integrated communications and knowledge management strategies. When remote sensing data and information are disseminated, activities such as culturally specific outreach and data presentation could occur to make the data meaningful to recipients.

In the paper, the following topics, providing examples of uses of remote sensing in urban analysis are presented:

1. Identification and delineation of the urban environment
2. Classification of urban areas
3. Measuring and monitoring physical properties of urban areas (vegetation, air quality, etc)
4. Analysis of physical characteristics and demographic/socioeconomic patterns of the urban environment
5. Monitoring changes and urban growth over time.

The first three topics intrinsically address relatively technical issues of physical characterization of the urban environment and do not directly relate to social science applications. This background is important, however, for social scientists to be aware of, because it informs both the advantages and the limitations of remote sensing in the urban environment. The last two topics, on the other hand, report on studies that are clear social science applications.

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SPATIAL PLANNING AND GREENING IN URBAN AREAS

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TOWARDS SUSTAINABLE URBAN MODEL – A FRAMEWORK FOR DEVELOPING INDICATORS FOR PLANNING AND DESIGNING NETWORKS OF GREEN SPACES IN URBAN CENTERS IN SERBIA

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ABSTRACT

The paper aims to highlight the need for introduction of additional indicators for designing and planning of green space networks (GSN) in urban centers in Serbia. An important element of urban sustainability and quality of life in urban areas is the percentage and distribution of green space. The urban planning practice in Serbia lacks systemic approach to spatial development of GSN. In order to improve the quantity and quality of urban green spaces we have firstly to define particular urban models. In order to monitor progress towards the defined models, we have to have clearly defined guidelines supported by system of indicators. In this regard, definition of required indicators plays a key role in development of GSN. Thus, the objective of this paper is to develop a framework for defining qualitative and quantitative indicators for planning and designing GSN in Serbian cities, based on available data. In that way, paper also suggests tools for measuring the existing density of urban green spaces. Firstly, paper analyzes existing indicators for planning and designing of green spaces in urban centers in Serbia. And secondly, based on comparison with indicators from European cities, it discuses possible improvements of existing and introduction of new indicators for development of GSN.

Key words: *green space networks, sustainable urban model, urban planning, Serbia.*

INTRODUCTION

Despite the common question among decision makers, as Heidt and Neef (2008) point out, how we can quantify the benefits of urban greenery, there are numbers of studies that prove the contribution of urban green spaces to the quality of life and ecosystem services in cities. Increasingly profit-driven urbanization results in many instances in a disappearance of green structures within the cities. The replacement of green areas, including natural soil and water, with artificial surfaces such as asphalt or concrete have negative effects on the ambient environment, at first place with the reduction of evapotranspiration, and increased heat accumulation (Carlson et al., 1981; Goward, 1981; Owen et al., 1998; Wilson et al., 2003). Land cover changes influence not only a heat balance, but also have a negative effects on the landscape aesthetics, energy efficiency, human health and quality of life (McPherson et al., 1997; Yue et al., 2007).

The greater share of artificial impervious surfaces over the natural land cover in urbanized environment is considered as the main cause of urban heat island (UHI) effect (Onishia et. al. 2010). Among others, as Oke (1987) comments, UHI is the best documented example of human climate modification. The UHI has been commonly defined as higher surface and air temperature in urban areas then in the corresponding temperatures of surrounding rural areas. Studies shows that temperature in the city is usually 1° to 5°C higher than in the surrounding environment (Ackerman, 1985; Taha, 1997), which portray cities as a 'heat islands' (Oke, 1973). Even though average difference is approximately 3°C, local condition can reach critical temperature level.

Increased ambient temperature have multiply negative consequences on local environment and human health. Investigating relation between 'heat islands' and 'death islands' Buechley et al. (1972) found that mortality rate increases with rise of temperature, an effect that is enhanced by the UHI. Maximal local ambient air temperature is the major source for summer heat stress. During the extreme heat waves often all causes of mortality increase (mostly circulatory system failure from heart attack or stroke), and it is usually much higher in the inner city areas (Tan, 2010), where often built up structure is prioritized over the green areas. In some extreme cases mortality can increase up to eight time caused by heat wave (Chen et al. 2013).

Furthermore, the increased local ambient temperature is closely related to the peak electricity usage, due to increased demand for electricity for air-conditioning. With rise in temperature, electricity generation rises, therefore, greater economic costs occur. The extensive use of air-conditioning during the peak hours and UHI extremes may lead to power blackouts. The overloading of electricity system have indirect consequences on environment. Increased electricity generation by power plants leads to the emission of various gases such as nitro oxides, carbon monoxide, sulfur dioxide and carbon dioxide, a greenhouse gas known to contribute to global warming and climate change (Heidt and Neef, 2008). Also, asuspended particles add to air pollution.

Urban vegetation has substantial effect on temperature in urban settings. Many studies refers to what Luber and McGeehin (2008) call ”cool cities” concept or urban greening as a strategy to mitigate the consequences of higher temperatures due to the heat island effect and thus reduce greenhouse gas emissions (Bowler et al., 2010; Givoni et al, 1991). By providing shade and by transpiration of water through leaves, vegetation cool the ambient air. While documented air temperature differences between between areas of tree cover and nearby urban surroundings is about 2–4 °C (Jauregui, 1990; Spronken-Smith and Oke, 1998), surface temperature difference in the same area can go over 15° (Chen et al. 2013). Furthermore, solar radiation in the trees' shade can be lower for 10% (Givoni et al. 2003). Also vegetation and trees can lower annual cooling and heating expenses. Study shows that energy savings in heating and cooling ranges from 20-30% (Ting, 2012, Gago et al. 2013, McPherson et al., 1999). Up to 227 kWh can be saved by each tree through cooling by evapotranspiration and 61 kWh through the direct shading of a home (McPherson et al., 1999).

On the other side, urban greenery have profound effect on human health and well being in cities. Even though proximity to green space does not directly imply physical activity, it does promotes healthy lifestyle and might lead to the reduction of obesity and the improvement of cardiovascular health (Branas et al. 2011). Studies indicates that greening can be indirect remedy for psychological disorders. The exposure to green view or access to green space may help in promoting emotional recovery, reducing cognitive fatigue, anxiety and buffering the impact of stress on urban residents (Agyemang et. al. 2007, Maller et. al. 2006, Stigsdotter 2010, Wells, 2010). Also, some researches suggest that different level of green vegetation may play a role in reduction in inter-family violence and possibly crime (Kuo and Sullivan 2001).

Moreover, the urban vegetation ameliorates the climate, filtering the air, water, and soil of many pollutants, serving in same time as dispersion corridors for flora and fauna and contributing to higher biodiversity in cities (Heidt and Neef 2008). But this is a case even in the case of small urban green spaces. Because of the high particulate dust-binding capacity of leaves, as Meyer (1997) suggests, small neighborhood park of 50 to 100 m depth can improve air quality up to 300 m in radius.

In economic terms studies indicates that both the quality and the quantity of green space affect positively property values and financial return to developers. McMahon (1996) comments that proximity to green space may increase financial returns from 5% to 15%. Furthermore, studies shows that 70% to 80% consumers put urban green spaces and access to nature on the top of priorities when choosing a new home (McMahon, 1996).

Considering above mentioned, if we want to make a step forward towards sustainable urban models, we can agree that the planning of urban green space has to be on the top of planning agenda. And as Heidt and Neef (2008) point out, systemic approach has to consider both urban and the suburban green areas and to develop them synchronously. In this regard, the definition of planning framework plays a key role in the development of green space networks (GSN).

METHODS

A comparative analysis approach was chosen for this research. It is based on the comparison of indicators for designing and planning of GSN in Serbia and two clusters of European cities with focus on quantitative indicators. Focus has been on understanding planning methodologies and related indicators. In case of Serbia, the paper analyses the consistence of qualitative and quantitative indicators between the cities, based on terminology and values, considering methodologies upon which indicators are defined. It considers following Master Plans (MP) and General Urban Plans (GUP): Master plan of Belgrade 20211, Master plan of Novi Sad 20212, GUP Niš 2010-20253, Master Plan of Subotica-Palić 20204, and GUP Kragujevac 20155. In total, research comprises seventeen quantitative and six qualitative indicators. Afterwards, based on available data, we calculated common indicators and compared them with indicators from the reference cities.

As benchmarks cases, research has used two clusters of EU cities:

1) The cluster of cites from the Mediterranean region, under CAT-MED project (Cots et al, 2012). CAT-MED is transnational initiative with objective to set the platform for defining the Mediterranean sustainable city model, identifying the sources of climate change and advocating the solutions. Institutional frame comprise the municipalities of 11 Mediterranean cities, with project objective to favor synergies between two levels: the local level and the transnational level. Urban sustainable policies are valued in line with five axes and 23 indicators, where the performance of green areas (GA) is evaluated within the axes of territorial management and urban design; and

2) The cluster of European Green Capitals (www.ec.europa.eu/environment/europeangreencapital) – here, we have also considered some of the applicant cities. As a cross European initiative, European Green Capital Award (ECGA) is one of the policy tool that European Commission is using to address environmental challenges, recognizing local effort in improving quality of life in cities, and it is underpinned by 7th Environmental Action Program (EAP). The objective of EGCA is to establish environmental role models among EU cities, which will inspire other cities to boost their efforts towards a greener urban environment by sharing experiences and promoting best practice. The evaluation is based on the city's state of the environment as defined by the performance levels of the twelve proposed indicators. The state of GA is evaluated under the theme of Green urban areas and Sustainable land use, considering existing situation and planed measures for improvement.

DISCUSSION

Methodology and policy frame for planning and designing of GSN

Treatment of GA is present at all levels of spatial and urban planning in Serbia, and the level of refinement increases with the level of planning (from national, to regional and local level). Spatial Plan of Republic of Serbia (SPRS)6 recognizes the problems of GA in terms of prominent loss of green and open spaces in urban centers and the degradation of public space, and its use for new developments, which further leads to decrease in the ecological quality of the built environment and the imbalance in sustainability of the city (Law on Spatial Planning of Republic of Serbia, 2010)7. Furthermore, it also recommends the creation of GSN links between urban and sub-urban areas, but it doesn't suggest methodological frame (for instance the creation of GSN in line with environmental sustainability agenda). The legal basis for the GUP development is The Law on Planning and

1 Generalni plan Beograda 2021, "Sl. list grada Beograda" br. 27/03.
2 Generalni plan Novog Sada do 2021. Godine, "Sl. list grada Novog Sada" br. 39/06.
3 Generalni urbanisticki plan Nisa od 2010-2015, "Sl. list grada Nisa" br. 43/11.
4 Generalni Plan Subotica-Palic 2020, "Sl. list opštine Subotica, br. 16/2006, 17/2006 ispr. i 28/2006"
5 Generalni Urbanisticki Plan Kragujevca do 2015, Sl. list Grada Kragujevca, br. 3/02.
6 Prostorni plan republike Srbije 2010-2014-2021, Ministarstvo Zivotne Sredine i Prostornog Planiranja, Republicka agencija za prostorno planiranje, Beograd, 2010
7 Zakon o prostornom planu Republike Srbije ("Sl. glasnik RS", br. 88/10)

Construction from 20098 (LPC) and The Ordinance on the content, method and procedure of planning documents from 20109. The GUP is a strategic development plan, with the general elements of spatial development where the part of GA is worked out within the general requirements for the development and spatial organization of urban areas and public areas and facilities. However, SPRS and act and rules within mentioned documents do not define a specific methodology for the planning of GSN, neither provide overarching frame or guidelines. The MP of Belgrade, Novi Sad and Subotica-Palic rely upon the methodology of The Law on Planning and Construction 200310, while GUP of Niš and Kragujevac use the methodology of The Law on Planning and Construction 2009[7].

At the regional level, the definition of GA is partially present through clause in a certain sections of the regional spatial plans in terms of suggestions such as: raising the protective vegetation along roads and around industrial plants, increasing the share of green space with proper spatial distribution, create a network of green and public spaces which connect to natural and cultural values of the settlements,, improving the ecological corridors within the built up area by establishing the continuity of green spaces, the structure and purpose of the support functions of corridors, etc. At the local planning level General Zoning Plans and Plans of the General Regulation consider the definition of GA more in details. But, as planning legislation at the higher spatial level recognize problem of GSN just in terms of recommendations, as the analysis of MPs and GUPs of the cities of Belgrade, Novi Sad, Nis, Kragujevac and Subotica point out, difference in applied methodology in the planning of GSN expectably implies different set of quantitative and qualitative indicators in planning documents.

However, in addition to formal instruments defined by legislation, cities in Serbia are involved in various projects in the analysis and improvement of GA. City of Belgrade is involved in projects “The Green Regulation” (Projekat “Zelena Regulativa Beograda”-IV faza) initiated by the Secretariat of Environment of Belgrade and with institutional support by the city of Belgrade. The project aims to improve the regulation and management of GSN in Belgrade, its planning, development, maintenance and protection. The project is divided into four phases; the last phase of the project is development of the general regulation of GSN of Belgrade. Similar project is conducted by the Planning Institute of Subotica (Projekat „zelena regulativa Subotice“- prva faza projekta) with objective to create inventory GSN data base, define the challenges and suggest solutions for the improvement of existing situation.

In case of the selected benchmark clusters of CAT-MED and European Green Capital (EGC) cities, the environmental and spatial characteristics of GA have been treated within the methodological frame built upon the overarching theme of environmental sustainability and the climate change. However, in both cases in general, GA has been just evaluated based on recommended indicators, and not treated within the specific methodological frame for GSN. There are instances within the CAT-MED pilot projects Green Apple, as it is a case with Attica region, where GA is considered within more systemic approach such as green network model combined with traffic regulations. In case of EGC cities, the represented results are often selected information that is underpinned with different studies at the local level. The main characteristic, in both cases, is joint effort at transnational level to improve the environmental performance of the city, and thus, the performance of GSN.

Methodology for the measurement of GSN performance

As it was mentioned, the planning legislation does not provide nor require precisely defined methodology and the related system of indicators for the planning of GA while making MPs and GUPs. Thus, developed indicators are rather the result of individual approaches adopted by each city. Therefore, cities have applied different methodologies, and their own set of qualitative and quantitative indicators (Table 1), which in some cases overlap between the cities but not as the result of joint planning among them. In terms of use of qualitative indicators, despite different methodology,

8 Zakon o planiranju i izgradnji ("Službeni glasnik RS", br. 72/09, 81/09-ispravka, 64/10-US, 24/11, 121/12, 42/13 – odluka US i 50/13 – odluka US)
9 Pravilnik o sadržini, načinu i postupku izrade planskih dokumenata ("Službeni glasnik RS", br. 31/10, 69/10 i 16/11).
10 Zakon o planiranju i izgradnji ("Sl. glasnik RS", br. 47/2003 i 34/2006)

analyzed cities use a similar system of indicators such as vegetation types / categories, and the requirements for the organization of area by categories (and in some places by location), treated with the greater or lesser degree of detail. But when it comes to quantitative indicators, the number of indicators used while planning of GA differs noticeably from case to case. For instance Novi Sad relies on four GA indicators while Subotica and Belgrade relies on nine indicators for the planning of GA. In total, analysis recognizes seventeen quantitative indicators. Furthermore, definition of indicators both terminology wise and in terms of what indicator actually indicate is different for different cities. For example, total percentage of GA in case of Belgrade and Nis is defined in comparison to MP / GUP area, while in case of Novi Sad and Kragujevac is defined in comparison to total built up area. Moreover, agreement on what is considered as GA in calculating total percentage is also different for each case.

Nevertheless, we can identify a few common indicators, which are in use in all cases: 1) the planned green area, 2) the percentage of the planned area under vegetation in relation to the planned area for the construction i.e. GUP, and 3) the min percentage of green area within the lot for specific purpose. Also all five cases recognize planned green area under defined GA categories. Some cities such as Belgrade and Subotica-Palic developed this indicator further according to the planned green areas by location within each category. Other indicators vary from plan to plan.

As it was stated in previous section, both EGC and CAT-MED methodologies favor integral approach at local and transnational level. Thus, they measure green urban areas as an element within the group 12 (20) city sustainability (environmental) indicators. In both cases the definition of a common system of urban sustainability indicators enables tracking of the evolution of entire urban system in time. This approach helps cities to monitor progress towards the defined sustainable models as indicators are consistent between each other and allow comparison between the cites.

Table 1: Quantitative indicators for GA planning in Serbian cities

<table>
<tr><th colspan="2">Belgrade (BG), Nis (NI), Novi Sad (NS), Subotica-Palic (SU), Kragujevac (KG)</th></tr>
<tr><td>• The total planned green area (ha) (BG, NS, NI, KG)
• Incrcrease of green area surface (ha) (BG)
• The total planed green area / urban area (Master Plan Area) (%)(BG, NI)
• The planned green area by categories (ha) (BG, NI, SU, KG)
• The planned green areas by location within the category (ha) (BG, SU, KG)
• Green area / Building block surface area (%) (BG)
• Green area / lot surface area according to zones (%)(BG)
• Green area / building complex with specific function (%)(BG)
• Green area / Number of Inhabitance (m^2/per capita) (BG, SU, KG)</td><td>• Planned green area / Planned construction area (%) (NS, KG)
• The minimum width of the external protective green belt along the edge of the construction area (m) (NS)
• Green area / Building lot (%) (NS, KG)
• Planed green area by category / GUP area (%) (NI)
• Planed green areas of specific category / Planned green area (%)
• Planned green areas according to category within urban zone (ha) (SU)
• Depth of green buffer layer (m) (SU)
• Min green area within the block (m^2/per capita) (SU)</td></tr>
</table>

Both methodologies recognize the importance of planning of urban green areas in terms of sustainable land use and territorial management. They measure green areas using the common system of quantitative indicators: 1) the green zones and recreation areas per inhabitance, 2) the green zone density - percentage of green zones and recreation areas in comparison to total urban area (green zone density) and 3) the green zone proximity- inhabitants that live next to a green zone per total number of inhabitance. Both methodologies highlight the importance of distribution of GA, as proximity and accessibility in fact play more important role then the total amount of green areas. This indicator describes / measures also the real exposure of the inhabitance to GA and the pattern of growth of green area within built up area. Even though the qualitative features of GA provide finer definition of its capacity to ameliorate local climate, it is interesting that both methodologies lack qualitative indicators.

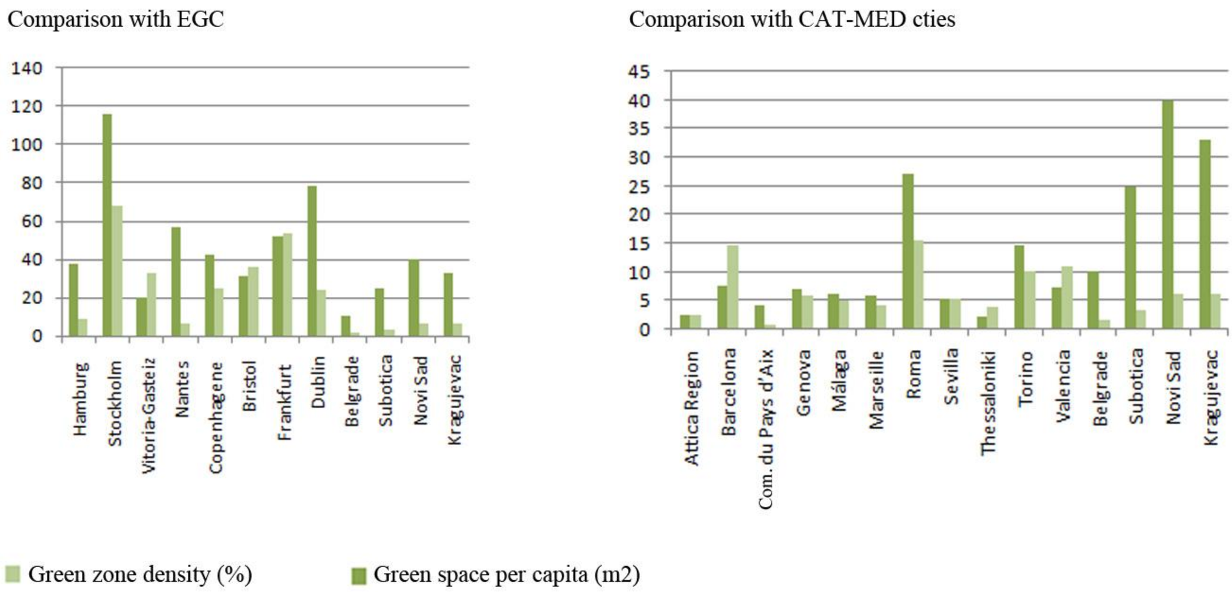
Comparison of GSN indicators' values

According to green zone density, Serbian cities are expectably more similar to Mediterranean cities, where the most of cites has value of approximately 5% of green area density or below, except in case of Rome, Turin, Barcelona and Valencia. On the other side, in comparison with EGC, Serbian cities have almost the marginal amount of total green area in relation to urban area, except in case of Nantes and Hamburg. For instance, despite the scale of the city, Stockholm and Frankfurt have 68% and 52%, while Kragujevac and Subotica are hardly close to 5% of green area density. It is highly probable that one of the main arguments of such values of this indicator, apart from other management issues, has to do with the climate issues. Serbia is a country in the background of Mediterranean region, and the average annual temperature in Serbia and Mediterranean is higher in comparison to central and northern Europe, where the most of EGC are located, which affect maintenance, and consequently planning of GA.

When it comes to green space per capita, analysis shows very high values for Serbian cites. Namely, the amount of green space per capita in Kragujevac, Subotica and Novi Sad together with Rome are among the highest in this comparison group and close to average in EGC group together with Bristol and Victoria-Gasteiz. But here is not the high values itself that draw attention, but rather the disproportion between the green space per capita and the green space density in case of Serbian cities. In most of cases the amount of green space per capita is respectively high / low to green space density, and obviously depends of the population density in particular city. But prominent discrepancy between those two indicators, in case of Serbian cities, suggests that different methodologies might have been used while calculating two mentioned indicators, with most likely overestimated amount of green space. Even Stockholm, which has the highest share of green space and green space per capita among European cities, does not have such noticeable disproportion of those two indictors.

This discrepancy points to a possible presence of administrative overestimation of the given values of GA in plans, in terms of what types and GA coverage within the municipal borders has been considered in the evaluation process, in relation to the actual percentage of municipal GA. It can be assumed that such projections occurs because current practice in Serbian cities lacks the green area proximity indicator that reflects the distribution of presented GA and that might works as corrective indicator for GA other indicators. For instance if the proximity indicator value is very high, it means that total green area is well distributed across the city in respect to inhabitances. In contrary low level suggest whether the insufficient amount, bad distribution of GA or that wide green ring around cities has been taken into account in the calculation process. Thus, it can prevent to a certain degree overestimation of GA. Cities considered as role models have very high values of this indicator. For example, all EGC have between 90 and 100% of inhabitance who lives in proximity of less than 300m to closest green space. The same intervals are set as a goal for analyzed Mediterranean ciites.

Table 2: Comparison of green space per captia and green zone density in Serbian cites with ECG and CAT-MED cites



Source: EGC www.ec.europa.eu/environment/europeangreencapital, CAT-MED www.catmed.eu,
MP Belgrade 2021 (Sl. list grada Beograda br. 27/03),
MP Subotica Palic 2020 (Sl. list opštine Subotica, br. 16/2006, 17/2006 ispr. i 28/2006)
GUP Kragujevac (Sl. list Grada Kragujevca, br. 3/02), Study of Green and Recreational areas for Novi Sad
(www.atisma.home.xs4all.nl/Studija%20zelenih%20i%20rekreativnih%20povrsina_print.pdf)

CONCLUSION AND RECCOMENDATIONS

The study provides an insight in the planning and design frame for GSN in five Serbian cites and its comparison to the GSN indicators ‘benchmark’ in European cities. It provides basis for further research, as well as information for the policy improvement.

The methodology of evaluation and related set of indicators in the ECG and CAT-MED cities highlight critical points in the methodology and indicators for planning and designing GSN in five Serbian cities. Firstly there is an evident difference between the Serbian cities’ regarding approaches and the lack of methodological frame, structured guidelines or requirements in the plans and legislation on the national level for planning and designing of GSN at the local level. While in the same time, in the frame of international researches and development projects, with objective to embark on a visioning sustainability process, we can see a tendency of integrated methodologies at the transnational level under the umbrella of environmental excellence in case of EGC and CAT-MED cities. Secondly, differences in methodologies, in case of Serbian cities, have produced different number of indicators in each city. On one side, at the city level, this can be beneficial, since it can reflect/address the local specificity of GA. On the other side, at the national level (between cites), this may support the possible divergent developmental trends in planning of GSN and serve as constant drawback in establishing common methodological platform for monitoring and planning of GSN. The defined common GA indicators, as it is a case across the EGC and CAT-MED cities, allow the monitoring of the progress towards defined environmental objectives, both in case of the city itself and inter-cities comparison.

In line with the international discourse, the involvement of city government in issues about their local environment, and consequently the role of GSN play in it, city of Belgrade, Subotica and Novi Sad, which have undertook additional research on GSN within their municipalities, show high awareness and can serve as role model to other Serbian cities. Even though they are instances of a good practice, yet, they are isolated examples, and still additional step has to be made towards more strategic and comprehensive approach to GSN. Certainly the first step towards the systemic treatment of GSN is the formation of institutional and professional consensus in relation to it, which involves the improvement of the existing legal and planning framework especially at local level. The strength in case of existing state is that the treatment of GA in spatial and urban planning in Serbian is present at all levels of planning. Additional strength is the strong institutional support of some cities to this problem, which prove the increasing awareness and understanding of GSN importance in city development among city officials. Furthermore, this is opportunity for increase of the financial support for development of GSN at the local level. On the other side, the weakness is the unequal treatment of GSN in urban planning practice in different cities, considering the mainstream practice, and the lack of interest of local governments in this topic, which may lead to the failure of implementation of GSN plans.

Improving the planning treatment of GSN should bring measures that have at first place methodological character. In that sense we suggest the following:

1) The definition of overarching methodological framework for the treatment of GSN in the legislation (SPRS and LPC) such as environmental sustainability or climate sensitive planning, both at the national and local level. This methodology will help the treatment of GSN as a part of the wider system of environmental policies. It goes in line with current SPRS that point out the necessity of updating the instruments and policies for integration of climate change issues in spatial and urban development. The introduction of common methodology for GSN will provide legal framework for city planning institutions to: a) harmonize current methodologies for the planning and designing of GSN, and b) improve coordination between the cities regarding the GSN issue, raising awareness about the need of GSN in ameliorating the effects climate change, and the other social benefits of GSN. Furthermore, it would create an opportunity for adequate definition of the common system of indicators and consequently the better physical and functional treatment of GSN, avoiding a multiply interpretation of indicators and related problems in implementation;

2) The alignment of the system of indicators with the practice of planning of GSN in EU cities. This will give a possibility to Serbian cities to compare their progress with role models in EU and beyond, and in that way constantly improve practice at the local and national level. But firstly, we have to define clearly what categories of green space will be considered in the calculation of Green area density and Percentage of green area per inhabitance indicators? The current practice recognizes both indicators but calculate them taking into account different categories case-by-case. The synchronization of categories for those indicators will allow creation of the similar inventory of GSN and the better understanding of it at the local and national level. Secondly, we suggest the introduction of green area proximity indicator as indicator that reflects the distribution of presented GA and, as we explained, works as corrective indicator for GA and it is priority indicator for the evaluation of GSN organization; and

3) The establishment of common GIS platform at the national and local level. GIS platform will create opportunity for: a) the integration of local and regional climate change effects in the improvement of existing and definition of new indicators for planning and designing of GSN such as green space proximity indicator, and b) allow the monitoring progress towards defined objectives and GSN models in relation to other environmental indicators within and between the cities.

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MODERN ACQUISITION TECHNOLOGY OF SPATIAL DATA AS A BASIS OF URBAN PLANNING

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ABSTRACT

This work present summary of possibility advanced geodetic technologies for creating 3D digital topography maps for using in spatial and urban planning and for all other spatial related activities. Paper also give detailed review of: 1) creating orthophoto maps and digital elevation models from high resolution satellite images; 2) advanced methods for data acquisition using mobile LIDAR system and mobile mapper DynaScan.

Key words: *orthophoto map, remote sensing, digital elevation model (DEM), digital terrain model (DTM), laser scanning.*

INTRODUCTION

The satellite high-resolution frames have demonstrated a high potential in forming the frames to national maps (charts) of all kinds and purposes. In addition to geometric data offered by the digital terrain model for the necessities of determining spatial form of urban planning, a very important role belongs to the orthophoto map as a geocoded digital raster photograph, on the basis of which different space forms can be identified. The satellite high-resolution frames have demonstrated a high potential in forming the frames to planning and designing of various kinds and purposes. What is attractive to many potential users is just the meter resolution which, practically, makes it possible to extract the objects appearing in the majority of digital cartographic products. Laser scanning technology is often used in urban design and space planning project.

Updated and high quality geodetic layouts, which comply with needs of modern design, are requested for the projects with high level of detail. In the process of preparation of zoning and other spatial plans, as well as in all other phases of works in civil engineering, architecture and town planning, surveying and cartographic activity have application, starting from the Project concept, surveying and Project execution in the field as well as control of it in the exploitation. Conventional method of preparation of geodetic and topographic layouts referred mostly to cadastral and cadastral-topographic layouts, which in its updated version do not fully suit the specific needs of users. With highly intensive development of geo – information technologies, the conditions for the preparation of geodetic layouts are fulfilled which would suit more and more complex design requests. The technology of preparation of digital topographic layouts in vector and raster format is in expansion, great number of satellites with sensors for remote sensing provides the resolution better than 1 meter, which means that one pixel of digital image represents the square of earth area of 1 x 1 meter size.

Obviously, there are significant events in the area of spatial information technologies. Systems are more powerful than ever, but still easier and cheaper for use. Now it is possible to use different sources of information and extract from them wide range of information. All this, of course, is done with significant increase of the system performances. All in all, it is reasonable to expect that future development in the field of geo – information technologies is going to be as much as exciting as it has been in the last couple of years. And this is the reason which point out to the breaking point from transfer from conventional method to introduction of new technologies of preparation of digital topographic layouts.

According to a better presentation of spatial data, GPS has a special application in efficient gathering of data (positioning with the use of satellite), especially in the sense of generating spatial data by methods of continual kinematics, as well as robotized total station, i.e. integral system of surveying which provide spatial data of very high density. Relatively new technology which is more and more in use is terrestrial and kinematics laser scanning of the terrain, whose result represents very dense display of measured points, whereas the result processing takes more time than measuring itself. At terrestrial (stationary) terrain and building scanning, density of measured points amounts to 1 dot/0,5 cm^2, while at scanning from air (kinematics) density amounts up to 150 dots / m^2. The accuracy of determining the spatial coordinates of points ranges from 2 to 3 mm at stationary measuring, while at kinematics measuring from the air, the accuracy can be achieved up to 5 cm. Density and achieved accuracy of determining the spatial coordinates of points of the terrain and buildings provide complete justification of the use of the mentioned technology in all designs of procuring layouts for zone planning and all other designs and plans. Having in mind that density of the survey provides identification of even the smallest structural lines of the terrain and buildings, the conditions for generating 3D models of building and terrain have been secured by the combination of these geometrical data with raster (photographs) which were obtained from professional terrestrial digital cameras of high resolution. In such way obtained 3D models, which in a picturesque way enable the real display of the terrain and building represent ideal bases for digital archiving of spatial information for all types of design, as well as all possible repairs and rebuilding. In this way the conditions for leaving the conventional method of data archiving have been met, and the assumptions for the application of contemporary geo-information technologies where manipulating with, in this way, generated spatial data becomes significantly easier with obtaining much more information than with what recent techniques have been providing.

TECHNOLOGY OF LASER SCANNING OF TERRAIN AND BUILDINGS

For the purpose of solving practical problems in many branches of engineering industry, there is a need for measuring and modeling of measured data as much as possible real display of spatial surroundings. By development of laser scanning technology the conditions for application of 3D measuring of points of very high density have been met in a way that modeling of subject survey can be carried out by using this data. The necessity for highly detailed 3D terrain and building coordinates occurs in different engineering disciplines, such as:

- Quality control, supervision and comparison of construction with plans, especially on complex construction sites
- Virtual planning, analysis of spatial relations between buildings themselves, but also between a building and surroundings (complex buildings)
- Digital archiving of infrastructure (tunnels, bridges and road network) in order to provide the basis for efficient management
- Control of different deformations on construction sites (landslides, strains, faults on facilities), surveying of entire construction sites, not only the previously determined selected points.

Detailed survey of culturally significant buildings, monuments, churches, towers with very accurate documentation of their condition (interior and exterior) in order to repair them in case of collapse or destruction of any kind.

Kinematics laser scanning

Laser scanning of the terrain from the air (LIDAR) today represents one of the most contemporary technologies which is used in surveying and preparation of topographic plans and maps for different purposes. The technology is based on gathering three different sets of data. The position of a sensor is determined by the use of Global Positioning System (GPS) using a phase measuring in the regime of relative kinematics, and the orientation is determined by use of Inertial Measurement Unit (IMU). A laser scanner is the last component. The laser sends an infra red beam to the earth and it reflects to the sensor. Time lapsed from emission to reception of signal with knowledge of sensor and orientation position, enables for the three dimensional coordinates on the Earth to be calculated.

During flight speed of approximately 250 km/h and altitude of approximately 1000 meters with standard characteristics of a sensor (130000 emissions / second), the data on position of points on the ground with density of up to 100 dots/m² have been gathered. Usual relative accuracy of a model with calculated omission of GPS and inertial system amounts to 5-7 cm. Absolute error is always better than 15 cm and it can be significantly reduced by use of control points on the ground.

Almost all modern LIDAR systems, next to GPS, IMU and laser scanner also integrate RGB/NIR (Red – Green-Blue, Near Infra Red) cameras of high resolution which enable the making of quality ortho-photo plans of resolution of up to 2 cm (depending on the height of over flight).

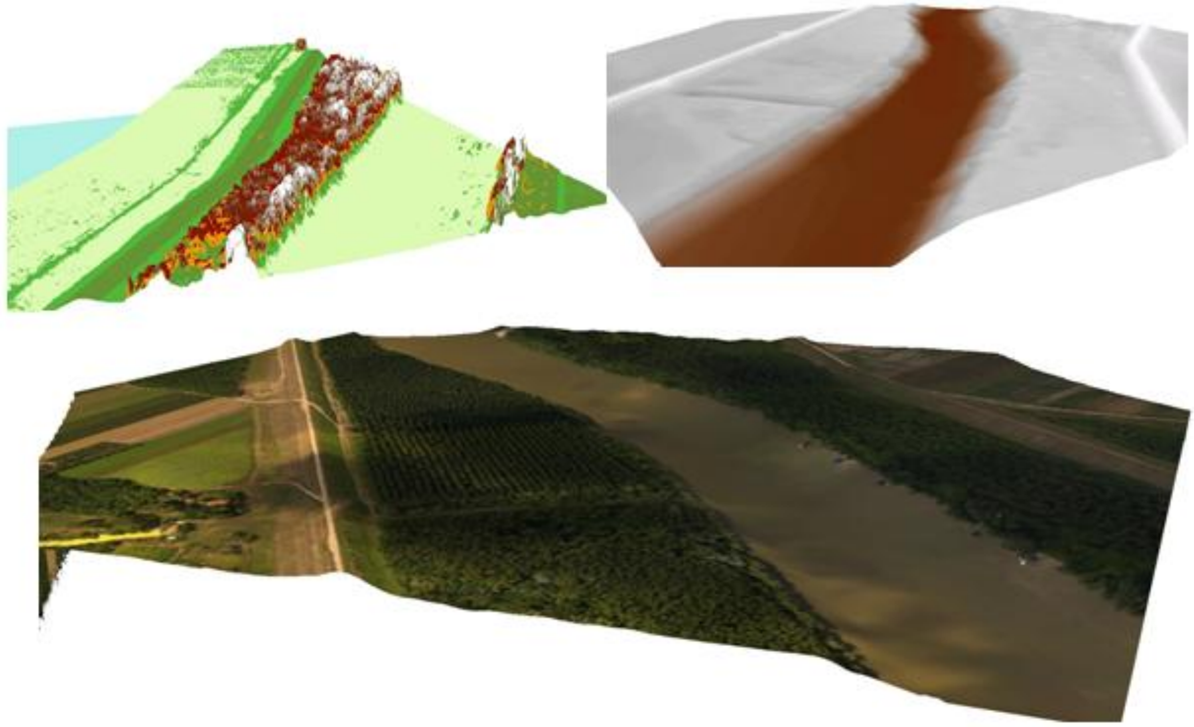

Figure 1. Products of laser scanning of Tisa river (Digital Surface Model - top left, Digital Terrain Model - op right, Orto-foto map on DTM - down), GeoGIS Consultants, 2011

Survey with LIDAR is carried out while moving and the system can be mounted to a vehicle in the aim of scanning corridor such as roads or similar line facilities or to an aircraft for scanning the corridor from the air . LIDAR has a very simple principle of measuring. The scanner emits the high frequency impulses and it reflects from the surface to the instrument. The mirror inside laser transmitter moves by rotating perpendicular to the flight direction which enables the measuring in wide belt. Time elapsed from the emission to the return of each impulse and angle of divergence from the vertical axes of the instrument are used for determining relative position of each measured point. Data from laser scanning are combined with scanner position and orientation in order to obtain three dimensional coordinate of laser print on the surface of the terrain.

After the processing of GPS vector from base stations to each measured sensor position, orientation and determining relative position on the ground in regard to the sensor, the following data are obtained:

- The cloud of points of first and last echo
- DSM first and last echo
- RGB and NIR recording

Based on RGB and NIR recordings and DSM of the first echo, orthorectification and georeferencing is carried out and as a final result orthophoto plans in color and in specter close to IR are obtained. DTM is obtained by classification of points of LIDAR data and by creating models from points which belong to the terrain Digital Surface Model (DSM) from the first and last echo in the shape of raster of

1m resolution with altitude resolution of 2 cm has been obtained from the survey and processing. Final Digital Terrain Model (DTM) has been obtained by further processing, and orthophoto recording for the entire area of the surveying has been obtained with the help of RGB/NIR recordings and DSM of the first echo. The resolution of the orthophoto recordings amounts to 20 cm by which the preparation of orthophoto plans of up to 1:1000 scale has been enabled. Isolines for the entire area with equidistance of 2 meters have been generated based on DTM. Transversal and longitudinal sections have been generated at the request of the Designer. DTM and DSM of the first echo have been used for generating the sections, in such way that height of the buildings, forest and similar through which the section passes can be seen on the sections besides the terrain. Three basic classes have been obtained based on the classification of points obtained with LIDAR: terrain points, building points and points representing the higher part of the vegetation. Polygons of cultures and classes, lines of smaller roads and springs and points of lonely trees have been obtained by digitalization of orthophoto plans and GIS results processing. Quality control of the spatial data has been carried out in 10 locations, directly by terrestrial survey on the terrain by use of GPS receivers and comparison of recording data with LIDAR (Ninkov et al., 2010).

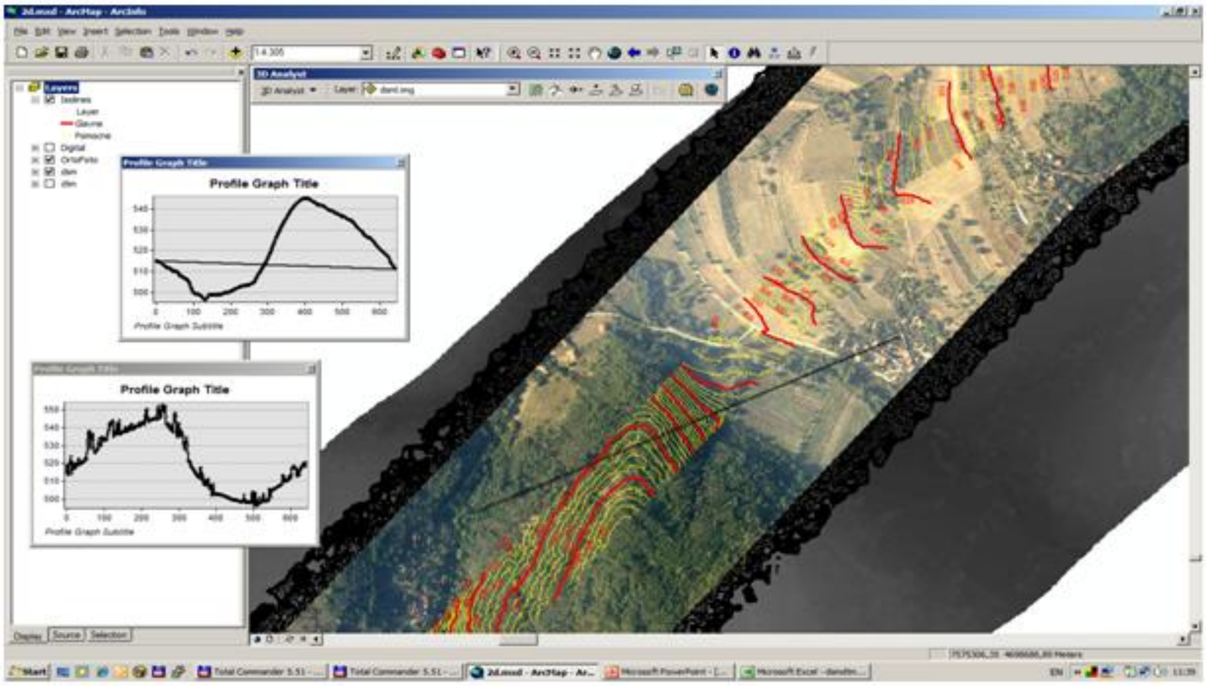

Figure 2. Ortho-photo plan of the part of the corridor and cross section of the terrain with and without vegetation (3D models of corridor of powerline from the Town of Leskoavac up to the border of the FRY Macedonia in the length of 100 km and 400 m, GeoGIS Consultants, 2007)

The control results for the Project of 3D modeles of corridor of powerline from the Town of Leskoavac up to the border of the FRY Macedonia are the following:

- Position accuracy is better than 10 cm
- Altitude accuracy is better than 15 cm
- Altitude accuracy is better than 5 cm for 80% of the results
- GIS of the corridor Town of Leskovac – State border with the following contents has been implemented after the all data processing from LIDAR surveys and cadastral plan in 1:2500 scale:
- Geo referenced cadastral plans
- Orthophoto plans
- DTM
- Isohypse with equidistance of two meters
- Digital topographic plan
- All recording points with accompanying attributes (point and the class affiliation)

Technique of mobile laser scanning

The implementation of the most recent laser scanning technique combined with the high-precision navigation system, yields a system for 3D scanning of roads, buildings and trees from moving vehicles.

The device utilises several laser scanners where each of them performs up to 10.000 measurements per second with a scanning speed of at most 100 acts of scanning per second. In the case of this system different scanners, located at different places of the car platform, can be utilised. In Fig. 3 the technique of mobile laser scanning by using the ”MDL Dynascan” system, model 250, is presented.

Figure 3. Mobile mapper system MDL DynaScan model 250

The system is specially designed for a rapid 3D mapping of motorways, roads, runways, railways, infrastructure objects etc. The data can be registered in a normal drive speed, the survey of urban environments over a relatively short time is also possible. Such a system makes it possible to register every detail along the scanning corridor, including road verges, traffic signs, surface lines, object facades and everything entering the view field of the scanner. Combining the data scanned with laser with the video and the photographs makes it possible to produce a very precise 3D model. Such a system makes it possible to scan the corredor very quickly (even 60km/h – recommended not higher than 30 km/h) with high precision satisfying various necessities. One of them would also be the canal scanning for the purposes of reconstructing and designing (Damaturu, The State of Yobe, Nigeria).
LIDAR scanning, even 350,000 points per second, a large number of points are obtained with georeference coordinates. Such a set of points is not suitable to any application in the process of designing, consequently, a data treatment is unavoidable. To generate 3D models with all technical characteristics necessary to all kinds of space analyses and new designing is possible by means of a numerico-graphical data treatment, by using a specialised software. One day of scanning requires about 7 days for data treatment in order to obtain the corresponding formats of graphical presentations suitable to standard designing in space planning, urbanism and other engineering branches (Vasić et al., 2011).

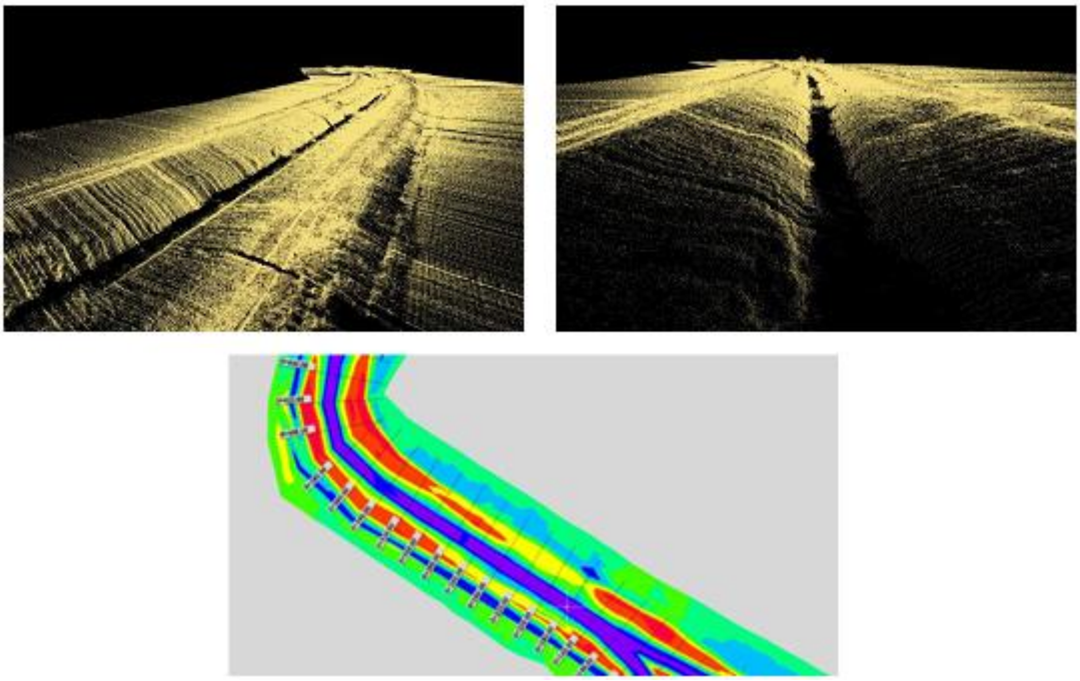

Figure 4. Cloud of points for scanned canal with 3D model

By a computer treatment of the collected cloud of points, it is possible to generate a 3D model and from it the characteristic profiles (Figs. 4). By comparing them to the profiles generated from the existing topographic documentation or to the profiles from the same measurement after a time interval it is possible to quantify the changes and determine the degree of terrain degradation.

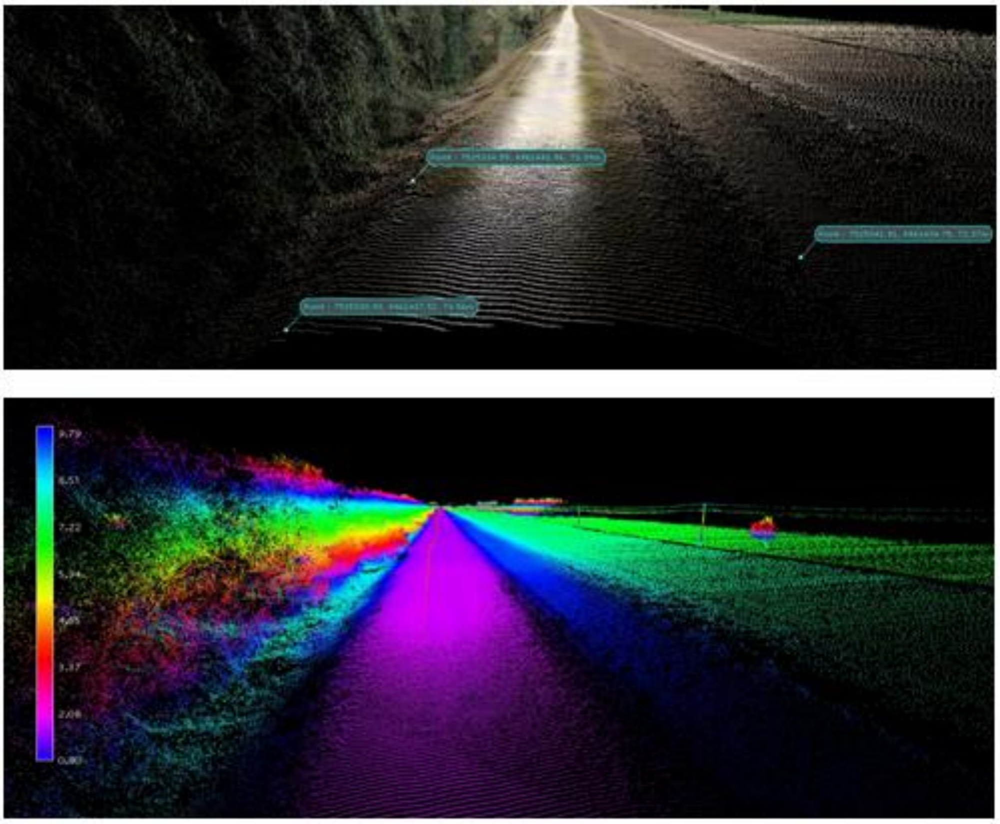

Figure 5. Surveying the river embankment by using mobile laser scanning technology(GeoGIS Consultants, 2012)

CONCLUSION

Modern data-collecting methods can to a high extent quicken and improve the formation quality for 3D topographic frames which are necessary, because the quality of the urban planning carried out depends on the quality of geodetic maps. Modern technological procedures of gathering and processing of spatial data enable 3D display of spatial forms (terrains and buildings) in full-color regime. Practically all most recent geo-information systems have an integrated module for 3D visualization which enables a 3D positioning of the buildings in relative and absolute model, i.e. coordinate system. Many of them have some additional possibilities such as the extraction of the building height, flight simulation over the digital terrain model etc.

Observing the surface of the Earth in spatial mode, users can visualize, interpret, measure and extract the buildings in 3D surrounding. As we have seen in this paper, an excellent effect of a display and simulation of spatial surrounding can be achieved by integration of geometrical data of centimeter density and digital photographs of high resolution, based on which spatial data of any kind can be generated. Civil engineers, spatial planners, town planners, communal services, they will all be able to watch cities in 3D forms, and to present to the public the form of the building, the structure of the settlement, bridges, roads and other buildings of infrastructure in the effective way. Engineers of different professions connected with spatial planning shall consider this 3D analysis as extremely useful for planning the transport and telecommunications, environment protection etc (Sušić et al., 2011).

The conventional manner of the presentation of spatial data in 2D form enriched with information on the sea level of certain points (isohypses) is slowly abandoned and it is replaced by modern concept of 3D presentation of altitude display of the terrain and buildings, where in regard to recent experiences more geometrical and visual information on terrain configuration and artificial buildings on it is obtained by manipulating 3D model in suitable software surroundings. For that purpose, the technology of laser scanning of the terrain and buildings is becoming more and more dominant technique of mass gathering of spatial information in regard to recent techniques, with great saving in time and money.

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AN APPROACH FOR RESEARCHING URBAN AND METROPOLITAN AREAS UNDER THE CONDITIONS OF DYNAMIC CHANGES

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ABSTRACT

Big cities, or their metropolitan areas, represent an important arena for research of spatial and socio-economic changes, with implications in a wider (national) framework. Urban dynamics, mainly from the aspect of land-use and distribution of population, is theoretically analysed following the sustainable development paradigm. Recently, with the growing influence of factors of uncertainty and vulnerability, that are exhibited also in the network of settlements, ideas such as "renewal","transformation" and "reorganisation" gain a new significance. This paper makes an overview of the short period in which the transformations of land-use as well as some demographic and socio-economic changes of population took place and have been observed on the metropolitan areas of Belgrade and Novi Sad. Some potential directions of future changes in the selected metropolitan areas have been determined, with the goal of achieving a more successful urban areas' steering through constant cycles of transformation and adaptation.

Key words: *metropolitan areas, land use, population distribution, dynamics of change.*

INTRODUCTION - ECOLOGICAL ASPECTS OF URBAN/METROPOLITAN AREAS

Urban areas presently encompass already more than half of the world's population. According to the UN projections, the number and share of urban population will continue to rise to 5 billion people by 2030, i.e. to more than 60% of the total population, thus inducing profound impacts on the environment, society and global and local economies (Forman, 2008). Even though the total area covered by the urban areas is seemingly small (1-6% of the total Earth surface), a dominant urban population relies on a wide range of products and services which derive from outside the geographical boundaries of urban areas and it alters virtually all of the Earth's ecosystems (Meyer and Turner, 1992; McIntyre et al., 2000).

In order to understand what constitutes an "urban" ecosystem as well as to understand its nature in parallel with "human dominated" area, it is necessary to employ knowledge from both natural and social sciences. Human settlements are social-ecological systems, i.e. both physical and social in their construct. With that in view, disciplines which research urban settlements from the aspect of natural or social sciences should include those variables that are usually attributed to the other branch of science, i.e. to use the interdisciplinary approach for comprehending what "urban" means when applying the demographic, economic, cultural, psychological, etc. criteria in conjunction with geospatial and ecological criteria (McIntyre et al., 2000). Various disciplines of the natural and social science domain demonstrate tacit assumptions what the term 'urban' means. Still, when reviewing how 'urban' is understood by ecologists and social scientists, one cannot discern a single overarching or precise definition, mainly because 'urban' may be understood as 'entity' as well as 'quality' (Pacione, 2001). Social sciences generally offer more consistent, quantitative definitions of 'urban'. Sociology, for example, often employs the population size as a criterion for identifying urban places. Yet, in practice urban population size thresholds vary over time and space. The United Nations defines "urban" as: 'an area with more than 20,000 people' (United Nations, 1968:38). However, in countries with sparse distribution of settlements, e.g. Sweden, any settlement with more than 200 inhabitants is classified as 'urban'. On the other hand, in densely settled countries, e.g. Japan, population threshold for considering a settlement urban is 30,000 inhabitants. In addition to this, many countries apply administrative definition of urban places, which however has a very little correspondence with the actual physical extent of the urban area. In the science of ecology, the definition of ‘urban’ often omits the density or any parameter which could be accurately measured (e.g. ‘urban area consists of houses and lawns’ (Emlen, 1974), or as Erskine (2002) puts it: “urban” is a “built-up area”). Subjective, or cognitive structure of ‘urban’ relates to the urban as a ‘quality’, and this mental categorisation is equally pertinent in the sphere of urban ecology as in social disciplines such as environmental psychology. According to McIntyre et al. (2000), in comparative urban studies, integrative definitions of ‘urban’ should endorse both quantitative and qualitative attributes: population density; economic characteristics; governance type; growth pattern; relation to other urban areas; historical, current, and adjacent land-use types; land-cover type; housing type and density; road type and density; traffic frequency, etc. The same authors conclude that each study of urban environment is recommended to have at least a working definition on what makes the ‘urban’ construct, ‘explicitly including baseline information on demography, physical geography, socioeconomic, and cultural factors that can potentially explain existing urban structure and predict trajectories of urban growth’ (ibid:18).

As Stearns and Montag (1974) point out, urban ecosystems are created by humans specifically for dwelling and are dominated by “built environment”. Urban ecosystems certainly bear the effects of human influence since humans occupy (live in) them, whereas human-dominated ecosystems, which cover much broader territory, may or may not be actually inhabited by people. This notion is clearly linked to the point that cities have always been dependent on their hinterlands for the resources supply and waste disposal. Depletion of resources is driven by the ‘humankind’s insatiable desire to produce and consume’ (Walker and Salt, 2006:4). This is almost an evolutionary drive, which was not a problem when human population and its activities were small and limited and when there was no overshoot of the Earth’s carrying capacity. However, ‘business as usual’ of increasing efficiency and optimizing the performance of an urban system and its integral parts, but failing to acknowledge negative impacts on the bigger system may jeopardise sustainability of all. In line with ecological economics, when addressing the resource flows in terms of inputs and outputs of and urban ecosystem, several models may be used for accounting for them, including the well-known “ecological footprint”. This tool uses ‘area’ measured in hectares or acres as the ‘universal currency’ to calculate population or person’s impose or ‘load’ on the biosphere (Forman, 2008). As calculated more than a decade ago, average ecological footprint was already 2.2 global hectares per person, whereas only 1.7 global hectares have been available per person as a ‘fair earthshare’, which means that we require 1.2 planets in average to sustain the current population with its production and consumption patterns. There should be stressed that there is also the intra-generation inequality meaning that the average ecological footprint does not equally apply to the whole World. While the ecological footprint of average African or Asian consumer (with smaller GDP per capita) is less than 1.4 global hectares per person, the average Western European’s ecological footprint is 5.6 global hectares per person, and the average North American consumes 9.6 global hectares per person. To put it in our perspective, Serbian ecological footprint is currently 2.6 global hectares per person, which is above the World’s average but still much below the average for more developed countries (Happy Planet Index, 2003). A strong point of ‘ecological footprint’ as a measurement tool is that it takes in account the effects of humans on both their immediate surroundings and areas of influence which are on much wider distance (McIntyre et al., 2000). Also, ecological footprint as a biophysical measure, rather than monetary, is better in expressing the interrelationship between humans (their constructs) and biosphere. However, ecological footprint analysis also shows the lacks, particularly when large urban regions are in concern having that their boundaries are not always consistently defined, what may prevent the comparability of data (ibid.: 9).

The idea of city as an ecosystem is applied in urban ecology, where city is regarded as a part of a much larger system, i.e. urban region. Considering the city itself as a system was especially emphasized over the second half of the 20th century, which was possibly related to the increasing popularity of the idea of urban metabolism (Marcotullio and Boyle, 2003). Urban metabolism of modern cities is of linear nature as ‘resources flow through the urban system with little concern about their origin or about the destination of wastes’ (Pacione, 2001:582). In contrast to that, nature has a cyclical metabolism, where ‘every output by an organism is also an input that sustains the whole environment' (ibid.:583). Urban metabolism approach, based on modeling material and energy flows between human societies and their environment, was largely popular in the 1970s being synchronised with the discourse presented in the famous book 'Limits to Growth' and the Club of Rome. In the 1980s, the popularity of urban metabolism concept declined, only to re-emerge in the late 1990s with a critical question whether cities can move towards sustainability and adaptation, i.e. to evolve in different trajectories (non-linearly) within multi equilibrium states and with short, medium and long-term perspectives, integrating the dynamics of social and ecological systems as paired/coupled ones (Chelleri, 2012).

With increase of the process of population concentration in towns and cities, which was sequelled by outward distribution of people and built areas, the regional city (city-region, or metropolitan region) as a form of decentralised concentration has been proposed in relation to sustainable urban development. Being inspired by Ebenezer Howard's 'Garden City', the 'Regional City' concept (coined by the American planner and architect Clarence Stein in the 1920s) addressed the issue of suburbanization and sprawl as unsatisfactory spread out (rather than compact) pattern of distributing built structures. Spatial organisation of a 'Regional City' is aimed to retrieve people's sense of belonging to the local environment, and more broadly, this model should achieve a balance between urbanisation and environmental requirements. It should comprise 'a series of separate medium-sized communities surrounded by large areas of open space and connected by major roads' (Pacione, 2001:591). The 'Regional City' concept envisages further development of polycentric city cluster. Instead of a monocentric city of an equivalent size, the network of close polycentric cities should therefore develop with complementary urban functions which also achieve certain 'urbanisation economies' (Vujošević et al., 2012:97). Present emphasised importance of polycentric urban development doesn't relate only to big metropolitan cluster-regions but also to smaller, remote and even rural regions aiming to achieve 'territorial cohesion' being promoted by all European spatial planning documents. Planning support to selective dispersal and complementarity of functions within certain urban nodes of urban region may be challenged by the change of their relative growth in time, where the current complementarity of functions represents an outcome of particular dynamics, i.e. of "natural" historical-geographical competitiveness between cities (ibid.:247).

TRANSFORMATION IN THE NETWORK OF SETTLEMENTS – CHALLENGES UPON THE RESILIENCE THEORY

On the basis of the explorations of urban agglomerations development, as well as spatial and functional relations and connections in them, general model of the urban development level has been formed. Urbanisation is, according to this view, considered as a transitional process, complex and continuous, which manifests itself through: 1) concentration of economic and social activities and population in the city; 2) spatial and functional integration of the city and surrounding settlements achieved due to the economic interactions and social mobility of population; 3) development of communication systems and infrastructure, which leads to the deconcetration of socioeconomic activities and the increase in the radius of the daily migration of population; 4) development of suburbs with various functional purposes and roles; 5) reduction of disparities between the quality of life of the population living in the centre and the one living on the peripheries of urban regions; and 6) achievement of spatial and functional and socioeconomic equilibrium (Ravbar, 1997; Tošić, 2012.)

Development of cities and their role in the organisation of space in Serbia has three key features: a) demographic growth of cities; b) increase in the number of urban settlements; and c) transformation of rural into urban/urbanized settlements and areas due to the spreading of urbanization from urban centres/nucleuses over regional surroundings-periphery. Social division of labour, mobility of capital, development of industry as well as local and regional trade have turned rural areas into influential spheres of cities which due to this acquire regional centrality and become places of concentration of complex functions (Tošić, 2012).

From the historical perspective, the network of settlements in Serbia has been largely influenced by parallel processes of politically initiated de-agrarisation and emphasised industrialization after the

Second World War. In the period until the 1980s, unlike planned industrialisation, the course of urbanisation was not systematically steered by the former country (SFRY), and the consequence was concentration of population and work places in towns and cities, accompanied by general exodus of rural population. Similar processes took place at the local (municipal) level with intensified growth of municipal seats on the account of depopulation and decay of a traditional village. The concentration of people in urban centres, however did not result in enhanced policentricity of the network of settlements in Serbia. In contrast, Serbian network of settlements has been featured by functional and other dominance of Belgrade as the capital city. When observed at the macro-regional level, the development of networks of settlements in Central Serbia and Vojvodina had different paths until the end of 1980s. As Veljković et al. (1995) put it, polarisation effects and development stimuli in Central Serbia were pronounced to a greater extent only around a small number of cities, i.e. around Belgrade, Niš, Kragujevac, Kruševac, Kraljevo and Loznica. At the same period of time, i.e. until the 1980s, Vojvodina (northern province of Serbia) had a polycentric polarisation, which related not only to two of its biggest cities (Novi Sad and Subotica) but also to a number of towns of more or less similar size (Zrenjanin, Pančevo, Sombor, Kikinda, and Vršac) (Krunić, 2012). Domination and respectively stronger position of Belgrade has increased in Serbia in the period after the 1990s, but simultaneously the network of settlements in Vojvodina has been transformed due to strong monocentric polarisation with Novi Sad attaining a dominant position (ibid.). Some previously developed urban centres started lagging back, which is particularly the case for a group of small and medium-sized towns. In the latest inter-census period (2002-2011) these towns faced depopulation and economic decline largely as the consequence of loss of employment and one of the greatest de-industrialisation processes that happened in the former communist world.
Although it is inevitable that the biggest cities of the country demonstrate a stronger respective position in terms of competitiveness and agglomeration advantages, moreover if they are physically close one to another as the case is with Belgrade and Novi Sad, the main challenge from the aspect of ‘resilience of cities’ is to achieve balanced development of the network of settlements. This presumes targeted, i.e. concentrated decentralisation, based on selection of priority projects (including much needed reindustrialisation) in order to advance the position of macro-regional and regional centres in the country and their polarization effects. Consequently, such scenario should bring to enhancement of the quality of living not only for the parts of the country that are now lagging back, but also the quality of living would improve within Belgrade-Novi Sad urban agglomeration due to its better position on the international scene based on competitiveness and urban twinning process.

From the aspect of ‘resilience in cities’ which is closely linked to ‘urban form’ and ‘land-use patterns’, one needs to consider the mechanisms by which built environment (urban form) affects ecosystem functions including the change of land cover (Alberti, 2005). With that in view, Serbian cities have been affected by sprawl, i.e. scattered development of built up area into rural land in the city periphery, qualified by lower density, single housing, inadequate infrastructure and social facilities supply, etc. Although sprawl is not a unique phenomenon for Serbian cities alone, it is largely emphasised here through spontaneously and illegally developed city outskirts, without adequate provision of quality of living standards. When big cities of Serbia are in concern, their urban form and land-use pattern have not been influenced only by the conditions of sprawl towards periphery, but also by the so-called ‘implosive sprawl’ (Graovac and Đokić, 2008). The latter involves development towards the inside of the city area, where large zones of open spaces, such as: green areas, forests, riverbanks, and land occupied for infrastructural objects, have been transformed into built-up developed land, and converted to single-use districts, typically for housing, but also for commercial or industrial use. This process brings to much higher densities within the city (and perceived compactness) but it deteriorates the quality of living standards, hence reducing the desirability of inner-city areas. Analysis of the change in relation between demographic strength of urban centre and inner urban area of Belgrade (defined by Živanović and Gatarić, 2013), indicates the larger growth of the inner urban area of Belgrade than the rest of the city (measured by index of population development). Additionally, the demographic aspect, i.e. the in-migrations especially to the periphery of Belgrade and Novi Sad that were intensified in the late 20th century due to war conflicts in the former Yugoslav republics, led to intensification of uncontrolled urban expansion. This was not just an outcome of the weakness of planning policy to protect public goods from this type of development but also an issue of incomplete and prolonged post-socialist transition of the country.

SPATIAL AND FUNCTIONAL DEVELOPMENT OF URBAN/ METROPOLITAN AREAS IN SERBIA

Recent explorations of urban regions in Serbia are teoretically and methodologically based on paradigms of spatial organisation. That is functional and process approach, based on the priniciples of the nodal regionalism whose instrument is urban region (nodal/functional region, or functional-urban region). The chosen process-functionalism approach has given to the spatial and functional structure of the network of settlements evolutionary character, viewing the relations between the elements of the settlements system as changeable categories dependent on the force, intensity, quality, duration and territorial reach of the relations constituted in the mentioned networks. Every functional relation is the outcome of processes whose synergistic or individual effects cause the changes of the structures of settlement network systems. On the other hand, the concept of nodal region has been chosen due to the empirically established fact that urban settlements, through their functioning, have an impact on regional integration and differentiation of complex and heterogeneous space.

Urban regions are the product of complex interactions between urban settlements and their surroundings. The extent of their influence on the functional integration and regional differentiation of the territory is directly reliant on the transitional phase of urbanisation. Regions are developed in the conditions of dynamic processes of concentration and decentralisation of functions, population, working places and public utilities and services. Evolutionary development stages of urbanisation are synchronized with the attained economic development, that is, with the level of socioeconomic transformation of population. This is the reason why urban regions are regarded as core elements of spatial and functional organisation of the territory. Urban region is, therefore, the space of functional integration of the city and the settlements in its zone of influence and represents an open and dynamic system.

Morphological structure of Serbian urban systems

One of the latest models of urban systems in Serbia distinguishes 4 types of cities according to their functions (Tošić and Krunić, 2004; Tošić and Maksin-Mićić, 2007): 1) cities of great importance for the international integration of Serbia; 2) cities of great importance for the integration of Serbian geospace; 3) cities at the internal development axes; and 4) cities of local integrations. Primary axes of development are those of the Danube, the Morava (the Velika Morava and the Južna Morava) and the Zapadna Morava. Secondary axes of development are not sufficiently differentiated, or lack adequate infrastructure. In addition, the model distinguishes geospaces with demographic and economic depression, which are out of reach of the axes’ influences and include peripheral, border and mountain parts of Serbia. In most parts of the country the hierarchy of urban centres has been established, with the formation of zones of influence around these centres based on spatial and functional complementarity. It is worth emphasizing that the mentioned hierarchical relations are the consequence of the position of the centres in territorial and administrative organization of Serbia.

Morphologically and structurally, several forms of nodal centres and areas have been formed (Tošić, 1999; Derić et al., 2003; Krunić et al., 2009). Belgrade-Novi Sad metropolitan areas distinguished by its complex and dynamic system of urban settlements with high level of functional and morphological connections, specific hierarchy, large zone of influence which surpasses the borders of Serbia, and which possesses the potential to become the centre of the future European metropolitan region.

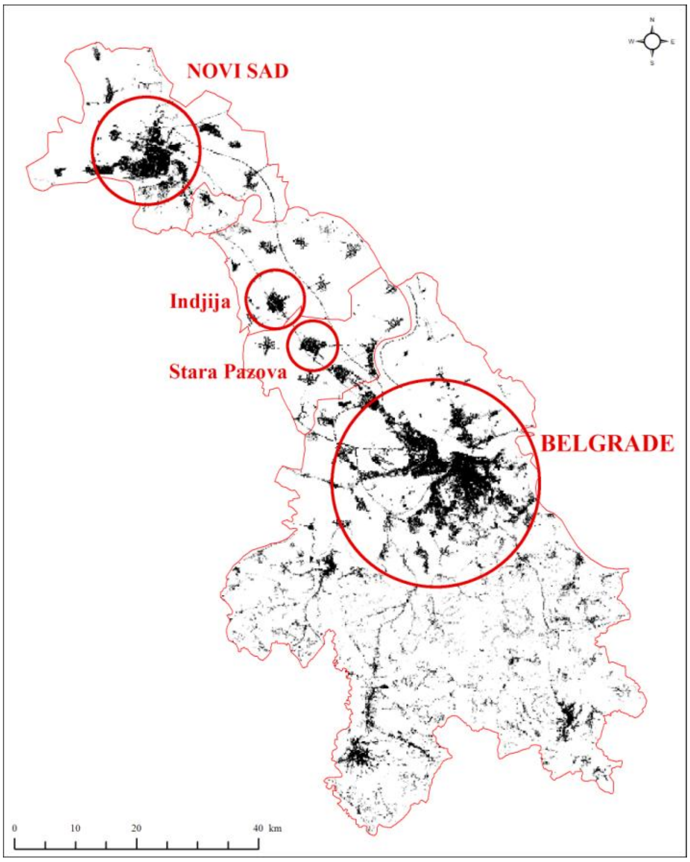

Figure 1. Urban areas of the analyzed Belgrade - Novi Sad metropolitan area

Analysed metropolitan area (Figure 1) includes 5 administrative units (City of Belgrade, City of Novi Sad, and municipalities of Inđija, Stara Pazova and Sremski Karlovci) and covers about 4718 km2 (about 5,3% of the Republic of Serbia), with total population of about 2096250 (around 29,4% of the total population of the Republic of Serbia). This metropolitan area is the most attractive for commuting and its daily urban system is the most developed in the country.

A brief analysis of spatial changes was conducted and it is aimed to track the recent land use changes and its dynamics within Belgrade-Novi Sad metropolitan area in the period between 1990 and 2006. Dataset1 are obtained from publically available dataset from European Environmental Agency (EEA) (Table 1, Figure 2).

In Table 1 changes of the spatial structures (i.e. land cover) are shown. It is indicated that in the observed period artificial areas (mainly urban areas) grew by the rate of over 115%, dominantly on the account of the agricultural areas (which slightly declined).

[1] For this preliminary analysis following datasets are acquired: Corine Land Cover 1990 - 2000 changes (dataset consists of raster data, spatial resolution 100x100 m, about changes between the CLC1990 inventory and the CLC2000 inventory; and Corine Land Cover 2000 - 2006 changes (dataset consists of raster data, spatial resolution 100x100 m, about changes between the CLC2000 inventory and the CLC2006 inventory) and administrative borders of study areas.

Table 1: CLC Structure and changes in the land cover between 1990 and 2006 (ha, %)

CLC	1990	%	2000	%	2006	%	Change 2006-1990	Change, %
Artificial surfaces	49738,9	10,5	53296,1	11,3	57257,5	12,1	7518,7	115,12
Agricultural areas	342215,7	72,5	344957,8	73,1	341595,0	72,4	-620,8	99,82
Forests and semi-natural areas	55324,9	11,7	59322,8	12,6	58626,8	12,4	3301,9	105,97
Wetlands	2040,3	0,4	2040,3	0,4	2268,0	0,5	227,7	111,16
Water bodies	12099,0	2,6	12168,9	2,6	12038,6	2,6	-60,4	99,50
Unknown	10367,1	2,2	-	-		-	-	-
Total	471785,9	100,0	471785,9	100,0	471785,9	100,0	10367,1	100,0

Table 2: Demographic development of the Belgrade-Novi Sad metropolitan area (1991 – 2011)

	Pop, 1991	Pop. 2011	Change 1991-2011	Change ratio
City of Belgrade	1552151	1639121	86970	105,6
City of Novi Sad	261121	335701	74580	128,6
Sremski Karlovci	7403	8722	1319	117,8
Stara Pazova	55871	65508	9637	117,2
Inđija	42849	47204	4355	110,2
Total - Metropolitan area	1919395	2096256	176861	109,2

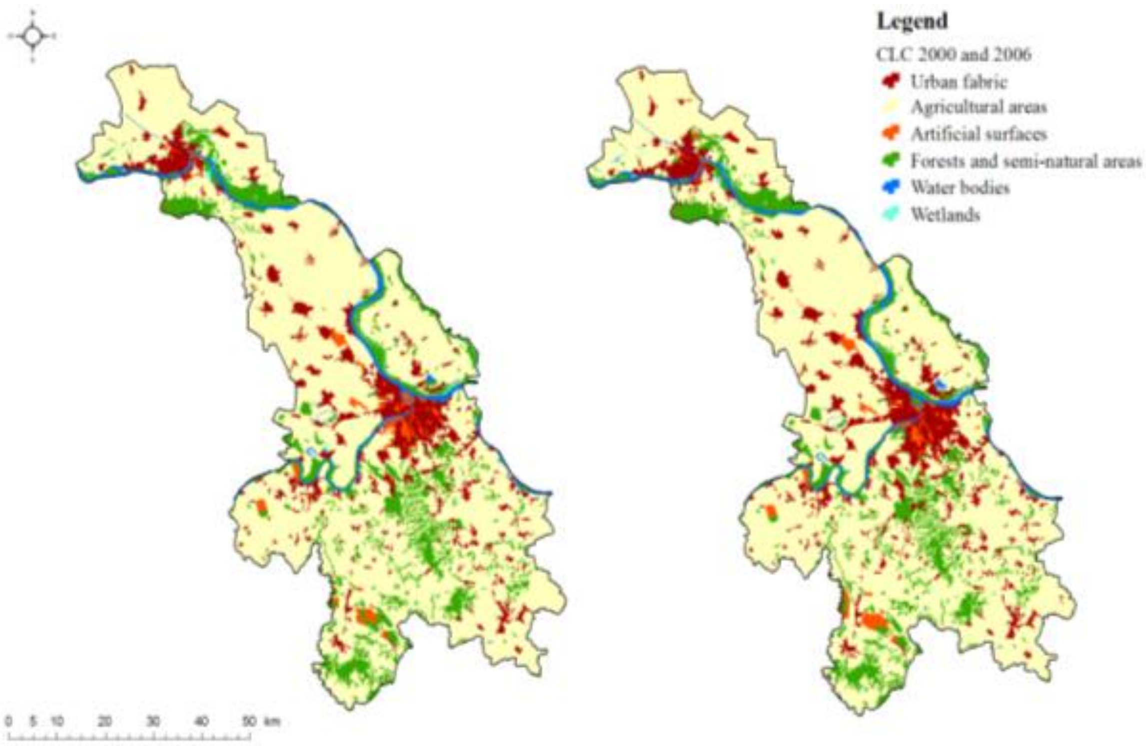

Figure 2. CLC for year 2000 (left) and 2006 (right)

During the analysed peiod, over the last 25 years, total population of the Belgrade-Novi Sad metropolitan area grew from about 1919400 to about 2096250 (by ratio of almost 10%), caused by the positive natural growth and positive migration trends (Table 2). For the same period, demographic development was followed by the relatively intensive spatial changes in the land use. Agricultural areas and forests have been transformed in the artificial surfaces – urban areas.

In contrast to the development of the infrastructural systems and industrial areas, newly urbanized areas that consist of residental and commercial buildings are developed during the spontaneous process regardless the implementation of the spatial and urban plans and regulations.

More details about spatial dynamics in analysed metropolitan area, and differences between planned and actual development can be found in research conducted by Samardžić-Petrović et al. (2013), who applied advanced GIS and statistics modelling to analyse the similarity between the Master plan and the actual land use map for the City of Belgrade. The results suggest that largest discrepancies between these maps can be observed in the following land uses: green areas, industrial and agricultural categories. Observed discrepancies within the green areas and agriculture areas wich are classified as unbuilt land, are caused by the illegal construction. Interesting for the analysis of economical development of the City is that only of 47% of the total area anticipated by the Master plan for industrial development was used for this purpose by 2010. Similary to this, only 54% of traffic areas have been realised at the moment although they are located according to the plan. It is obvious that planned spatial developement of the City was overestimated by the Master plan. The peripheral municipalities (Surčin) have very slow spatial development in the contrast to the central ones (Novi Beograd). During the analysed period the construction of residential and commercial structures dominated all development projects. It is very interesting that there is almost no match between planned commercial areas and build ones in the peripheral municipalities (Samardžić-Petrović et al., 2013).

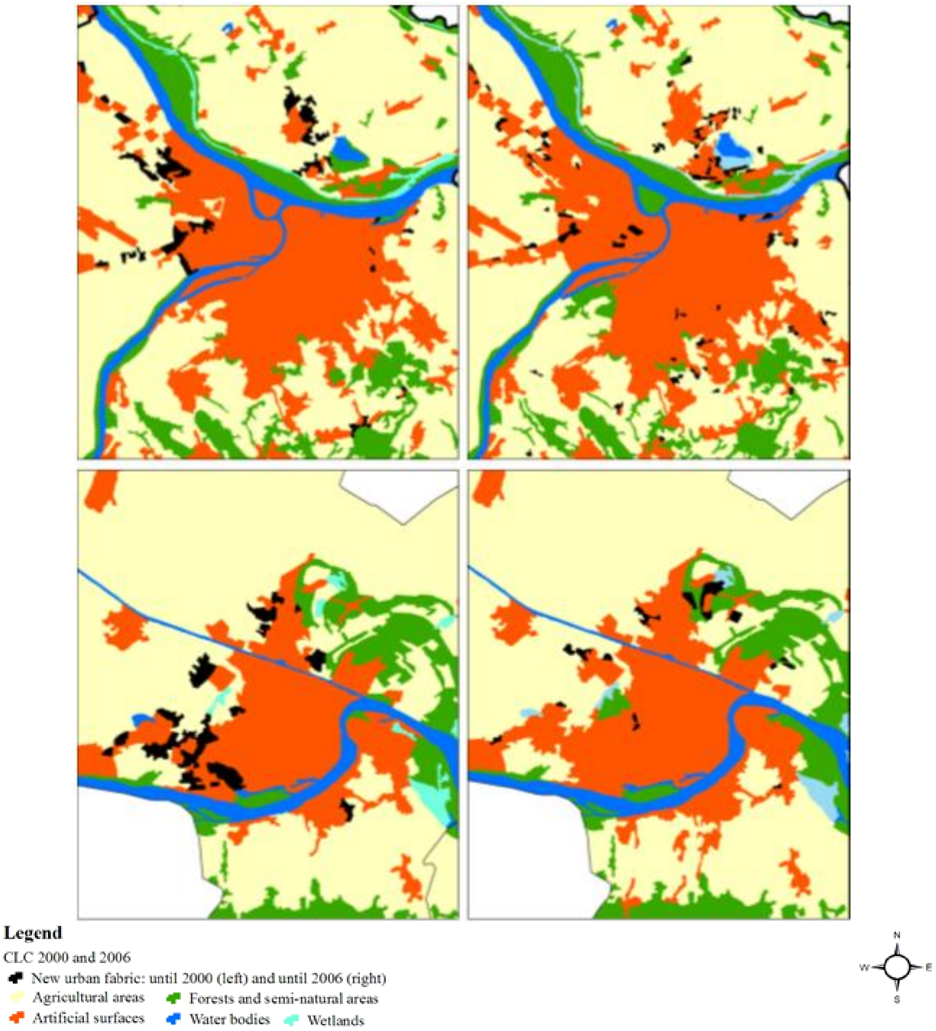

Figure 3. New urban areas in Belgrade (top) and Novi Sad (bottom)

Figure 3 illustrates that intensive urban development and changes in the land cover during the observed period occured in the peripheral areas of both cities. New urban areas are characterised by residental and mixed residental-commercial uses, with often poor infrastructure facilites, both social and technical, with potentially negative ecological impacts.

CONCLUDING DISCUSSION – TOWARDS A SUSTAINABLE AND RESILIENT SPATIAL DEVELOPMENT OF URBAN/METROPOLITAN AREAS

Urban society and cities reflect now more than ever accelerated changes, driven by place-specific contextual conditions on the one hand and the effects of globalisation, on the other. In order to respond to challenges of sustainable spatial development and urban resilience, the existing socio-economic, ecological and other perspectives on cities need to engage the alternative paths (solutions).

Urban/metropolitan areas, which are understood as social-ecological systems, experience continual evolution that happens non-linearly, has multi equilibrium states, with short, medium and long-term perspectives. Such notion requires a shift from planning for a ‘predictable future’ to transitions in urban planning and governance, that would help navigating human settlements through continual transformation and adaptation cycles.

During the analysed period, over the last 25 years, population growth of the Belgrade-Novi Sad metropolitan area was followed by the general transformation of the land cover and land-use, in favour to new artificial surfaces, i.e urban areas. These new urban areas are developed in the city outskirts during mainly spontaneous process regardless spatial and urban plans and regulations, and that resulted in their poor infrastructure equipment and overall lower quality of living.

The research presented in this paper shows a preliminary analyses that identify changes in the land cover and population dynamics of the Belgrade-Novi Sad metropolitan area in the period after the 1990s. Future directions of research should be concentrated on the driving factors and implications for the parts of urban areas that are more likely to experience changes and consequent particularities of demographic structures in such areas.

ACKNOWLEDGEMENTS

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DEVELOPMENT OF URBAN ECOLOGY THROUGH EDUCATIVE AND INFORMATION ACTIVITIES

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ECOLOGICAL ASPECTS OF ENGINEERING DESIGN

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ABSTRACT

Design is a complex activity that is performed in order to obtain a new or improved product. This paper analyzes the environmental aspects of engineering design in the cryptographic protection of the environment. Protection and enhancement of environment is a significant global problem of modern society.

Key words: engineering design, product, ecology, recycling.

INTRODUCTION

When discussing about the design of a product, subject or object, under the word design it is usually considered an arrangement or configuration of the individual components that make up the whole of the product, subject or object. The word design has its roots in the Latin words de and signare. (Ljevar and Nikolić, 2004). Market products are the leaders of economic, scientific-technical and general social development. Product development, through economic parameters, directly or indirectly, is based on the development of key areas of human activity. For the realization of the process, production technology and production itself are required. In product development, as previously mentioned, a big part is given to art, and the inclusion of their specific industry focus on product development - industrial design. However, the holder of the product development is an engineering design that involves the direct transformation of the achieved level of knowledge in the technical solution. Depending on the language they come from, the alternative terms are construction and / or projecting. Constructing involves the construction, creation, realization. (Ognjanović, 2007)

Recently, high-quality design can prevent environmental pollution. Existing technology and methods of construction are exposed to thorough scrutiny to protect man and his environment. It is therefore necessary to design such products, which will be the creation of a concept particularly consistent with the principles of environmental protection.

ENGINEERING DESIGN

The development of computer technology has enabled the efficient solution of problems of design and other engineering activities. Design is a complex activity that is performed in order to obtain a new or improved product. Objects of design can be produced (e.g. mechanical transmissions, gears, shafts) or processes (technological process). The design work includes all theoretical and experimental researches, calculations, based on which a detailed elaboration of approaches may occur during the design phase. Design is always performed after prior study before engineering and presents reasonable engineering solutions, which can be technically accomplished and is economically profitable. (Kuzmanović, 2001) and (Adamović and Desnica, 2006).

Industrial design is oriented towards the aesthetic presentation of products and companies and developing products with a lower degree of desirability and simple functions. In technical systems with complex structures that must satisfy the conditions of minimum weight and dimensions, the minimum cost, optimum performance and convenience in handling, optimum reliability, vibration, noise, etc., a solution can only be reached by the methods of engineering design. In the set of system properties aesthetic properties are included. They need to be composed during the conduction of all phases of engineering design (construction). The team oriented on industrial design in this sense, can achieve significant effects.

ENVIRONMENTAL ENGINEERING AND DESIGN

Ecology is the study of the environment (from the Greek word oikos - home, household, and logos - science). Ecology is a multidisciplinary scientific discipline that studies the scheduling and distribution of living organisms and biological interactions between organisms and their environment. Environmental protection is one of the areas dealing with ecology. Today, all over the world great efforts is made in preserving the human environment, preventing further spread of ozone holes, cuts of the Amazon forests, melting glaciers, elimination of using fossil fuel. Protection and improvement of human environment is a significant global problem of modern society.

Recycling products

Protecting the environment is one of the fundamental demands of functioning in modern economies. An important step in this direction is recycling. Recycling is the processing of those waste materials that can be used as secondary raw materials in production. Recycling is used for material reuse which saves natural resources and protects the environment. Recycling reduces spending and rationalize the use of natural resources and reduces the amount of waste that must be disposed of sanitary and extending the service life of sanitary landfills.

Recycling includes several groups of activities:

- Primary recycling: separation of components of solid waste at the source (sorting),
- Secondary Recycling: centralized separation of recyclable components from brought integrated waste in a facility,
- Preparing these materials for reuse, reprocessing or remanufacturing
- Reuse, reprocessing or re-producing products, materials and their placement on the market.

Recycling, as a single or multiple uses of waste materials or their individual components as substitutes for commercial products or raw materials in industrial processes, its main goal is achieved in two ways: by giving useful, usable components of an integrated municipal solid waste and it's processing, or removing pollutants from waste and facilitating its re-use.

There are several strategies of product management at the end of their life (Kuzmanović,2010) and (Srdić and Ćosić,2003)

- Reuse of used product is suitable for the protection of the environment (e.g. returnable packaging)
- Reuse of used products for spare parts, suitable for the protection of the environment (e.g., old cars)
- Reconstruction of used products is suitable for the protection of the environment (e.g., certain types of old cars)
- Recycling with disassembly, it is suitable for the protection of the environment (e.g., old cars)
- Recycling without disassembly suitable for the protection of the environment (e.g., irreversible packaging) and
- Dumping of used products is the most unfavorable from the point of environment protection (e.g., nuclear waste).

When designing a product, the recycling instructions must be made or the elimination of waste products. Table 1 shows the recycling labels: (www.ekostarpak.rs)

A student Gary Anderson at the University of Southern California in Los Angeles was the first who designed a symbol for recycling in 1970. He won on a competition that was held on the first Earth

Day, which is celebrated since. It is necessary to distinguish two words of different meaning. "Recycled" – means that the object has been already developed by the process of recycling. "Recyclable" – means that the subject needs to be separated in the recycling bin.

Table 1: Recycling labels (www.ekostarpak.rs)

"Recycled" 	Package or box that is marked with white arrows in a black circle contains a product that is at least partially made from recycled materials. Often standing a text "Printed on recycled paper." If the product has a symbol of black arrows in a white circle, it means that at least some of the material is recycled. Often the arrows are colored.
"Recyclable" 	Both symbols mean the same thing, but the first left with the white arrow is the original symbol, and the other is a modification of the previous one. Both symbols indicate a product that can and should be - recycled.
	Typical symbol solutions to indicate that the packaging is suitable for recycling.

The fact is that scientists and experts around the world are working on developing new technologies based on efficiency and rationality of the recycling process. The following example supports this: Automobile recycling industry - anywhere in the world, there is no place where you can recycle a whole car. The composition of the car reveals the complexity of the recycling process. Glass makes up about three percent of the mass of the car and due to the complex chemical composition is not processed in factories for glass manufacturing, but is often chipped used in construction as a concrete additive. Various types of fluids (fuel, oil, coolant) make about 6% of the weight of vehicles. They complicate the recycling process because of their chemical composition and toxicity, so it is necessary to take account their unloading and storage. Upon discharge these fluids are sorted and transported to the chemical plant where they can be recycled. Tire makes about 4% of weight, and plastic 8%. In developed countries, rubber is used in processing industry for various types of floor coverings. The rest, more than 70% are metals-steel, aluminum and copper. This waste is sent to the cutting and as an end product obtained metals are used as a secondary raw material in the steel mills. Currently, two technologies are applied in the process of recycling cars. First, based on the so-called optical separation, involves manually separating component parts car, such as glass, rubber, plastic, and metal parts that are sent to the press. Another technique uses multiple methods where the entire car is cut in small pieces in special crushers and then the contents are separated. These two methods are often combined.

Investing industry has a legal obligation to take care of their packaging waste in the process of setting up the system, the collection and recycling of packaging waste collected will contribute large amounts to the processing and preparation of the recycling process. Processing facilities in Serbia will therefore increase, as well as new production capacity from recycled materials.

For products that cannot be recycled/re-used as raw materials separate guidelines should be developed for the management of waste. Also infrastructure should be prepared for the collection and treatment of waste. For environmentally harmful products special containers must exist for collecting and transporting them.

Ecological packaging

Today it is given great attention for environmental packaging products. Thus, in use are: cotton eco-bags (made from organic natural cotton), Jute Bags (made of jute material, biodegradable in the country), and eco bags for packaging (Fig. 1).

Plastic bags are the mostly used form of waste and therefore represent a major environmental problem. The regulation that bans the sale and distribution of polluting bags in Serbia is in force from 1 January. Serbian citizen per year, on average, uses 500 plastic bags, but to decompose plastic bags take up to 400 years. In Italy and Luxembourg plastic bags are banned in Belgium and Germany people pay tax on them, while the Irish had a campaign which reduced the use of plastic bags by 95 percent.

Figure 1. Eco promotional bags (www.pro-bag.net, www.virtualnigrad.com, www.biobaganz.com)

CONCLUSION

Design is a scientific discipline because it researches phenomena, methods and processes in the creation and development of products. Design is an interdisciplinary scientific discipline which includes: technique, technology, mathematics, physics, art and crafts, organization, management, marketing, etc. Protecting the environment includes a set of different actions and measures that prevent risks to the environment in order to preserve the biological balance. Environmental Defense is multidisciplinary and should be a continuing obligation of all members of society. Its multidisciplinary approach stems from the fact that health, environment and social conditions are a complex area and problems are in constant interaction. Therefore, any disturbance of the environment leading to environmental disorders and social relations, are inter-related and conditioned (www.lawdem.org)

Pollution and environmental protection are very important problem of humanity for decades, regardless of the current stage of development of the productive forces of society in some parts of our planet. Despite the significant regional differences in the vulnerability of the environment, especially its natural components, plans, programs and actions for its protection and improvement are a global problem.

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ENGLISH VOCABULARY PRACTICE FOR STUDENTS OF ECOLOGY

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ABSTRACT

English has become one of the most spoken languages in the World. It is used in almost any areas of the human being. Speakers of the English Language are either native speakers or speakers who have learnt it. One should make a clear distinction between teaching and studying English for general purposes and for special purposes. Selected vocabulary to be taught and learnt greatly depends on the goals of teaching and studying. Students of Ecology beside general English need to know the registry of their study field; in this case, it is Ecology. In order to reach the aims of teaching and studying successfully the language material, that is the vocabulary, has to be practiced correctly and thoroughly, The aim of this paper is not to give a list of words related to Ecology but to present some examples how to practice the vocabulary of Ecology.

Key words: *English, specific purposes, vocabulary, practice.*

INTRODUCTION

English has become one of the most popular languages in the World. People all around the World learn the English language for any purposes. It is a compulsory subject in most schools. There are non-native English speaking countries where university level education is offered in English. In general, people are considered illiterate if they do not speak the English language. Everybody tries to accomplish his or her goals in learning English. Students at universities, especially students who do not study the English Language study the language for specific purposes. English for Specific is "an approach to language teaching in which all decisions as to content and method are based on the learner's reason for learning" (Hutchinson and Waters 1996).

TEACHING THE ENGLISH LANGUAGE

Learning the English language students bring face to face with very demanding tasks in order to be able to speak the language and write in it correctly. They have to develop their ability of listening and comprehension, speaking, reading, and writing. They should also learn elements of phonetics (pronunciation, rhythm, stress, and intonation), grammar and vocabulary.

Teaching the English Language is a very complex and demanding task. There are many factors that influence not only the teaching processes but also the content itself. The factors that affect the teaching can be divided into two major groups: common (such as psychological, pedagogical, teaching methods, environmental) and personal. It is very hard to make a clear distinction among the importance of these factors and the ways they influence the teaching and learning English for Specific Purposes. The personal factors encompass students' reasons for learning the language. Among the aims of teaching and learning English for Specific Purposes are undoubtedly achieving skills and competencies in using the language in the interested scientific area. Students of Ecology should acquire beside the knowledge of general English the specialties of their scientific field as well. One of the major differences between general English and ESP, concerning teaching English ESP to students of Ecology, refers to the special vocabulary that is used in the given scientific field.

TEACHING ENGLISH VOCABULARY TO STUDENTS OF ECOLOGY

Students studying Ecology "need to learn the lexis of the language" (Harmer 1997). According to (Harmer 1997) students need to know not only the basic meaning of the word, but other meanings as well especially in context. Students should be familiar with the antonyms and synonyms of the words, collocations, how words are derived, spelt, and of course with the grammar of words.

One of the most important duties for educators before designing a course for teaching English for Specific Purposes is to determine the appropriate vocabulary for the given scientific field. ESP teachers also have to make distinction between the so-called "active" and "passive" vocabulary. "Active" vocabulary refers to vocabulary that students have been taught, practiced, acquired, and they are able to use them in any situations without any problems. The term productive is often used instead of active. On the other hand, "passive" vocabulary includes words that students have already met but they are not able to use them in appropriate ways; they are able only to recognize them without producing. The term receptive is often used instead of passive.

Presenting new vocabulary

One of the basic principles in teaching foreign language is to avoid using students' mother tongue. Thus, the presentation of the new language material, in this case vocabulary, represents a creative task since anything can be used to present the meaning, use, and other features of the words. Some examples of presenting new vocabulary encompasses include: bringing real object into the classroom, using pictures showing the meaning or usage of the unknown word, acting out, using mime and gesture, enumerating, explaining, drawing on the board, reading out the dictionary definition, using synonyms and antonyms, translating, etc.

SAMPLE VOCABULARY EXERCISES FOR STUDENTS OF ECOLOGY

According to the web site, http://www.wikipedia.org Ecology is the scientific study of interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic environment. Topics of interest to ecologists include the diversity, distribution, amount (biomass), number (population) of organisms, as well as competition between them within and among ecosystems.

The vocabulary chosen to illustrate some exercises is of arbitrary nature but tied to the concerned scientific field. The lexical items used in the proposed exercises are as follows ***acid rain, biodegradable, carbon dioxide, climate changes, compost, deforestation, ecology, ecosystem, global warming, greenhouse gas, pollution, wetlands.*** As the scope of teaching vocabulary is very broad, the exercises that follow are only examples of the possible wide range of practice. Designing any kind of exercise sequence is a very responsible task for the teacher has to bare in mind the pedagogical and methodological aspects of teaching and learning. On of the basic concept in composing a sequence of exercises is to start with the easiest one and to end with the hardest one. In other words, exercises have to reflect the principle of progressiveness from the beginning to the end. After students have been introduced with the new lexical items for the first time, they need to solve the offered tasks not omitting any of them.

Receptive vocabulary exercises

Engineers very often need to have receptive vocabulary in English for Special Purposes due to the wide range of the scientific fields they are familiar with.

Matching the lexical item

The lexical items, the words, and the meaning of their descriptions are given in a table. Students have to match the lexical item with the correct description. This is shown in Table 1.

Table 1: Matching exercise

a)	ecosystem	1)	It is a form of precipitation that can have harmful effects on living beings and infrastructure.
b)	deforestation	2)	It is absorbed by plants and exhaled by humans and animal.
c)	carbon dioxide	3)	The term is used to refer to 'environmentally friendly' products.
d)	wetlands	4)	They can be caused both by natural forces and by human activities.
e)	climate changes	5)	It is a mixture of decaying organic matter such as leaves, wood and manure.
f)	pollution	6)	It is destruction of animal habitats and forests to make land for agriculture.
g)	global warming	7)	It is an interdisciplinary scientific field.
h)	acid rain	8)	It can be as small as a tiny pool or as large as a huge desert.
i)	greenhouse gas	9)	It refers to the rise in the average temperature of Earth's atmosphere and oceans.
j)	compost	10)	It is a gas in an atmosphere that absorbs and emits within the thermal infrared range.
k)	ecology	11)	Contamination of the air, water or soil with substances that can cause harm to human health or the environment.
l)	biodegradable	12)	Areas of marshy or swampy ground, or any land area that tends to be regularly wet and flooded.

True or false statements

The students are given twelve sentences containing the given vocabulary and referring to the subject matter. Their task is to read the sentences carefully and decide if the sentences are true or not. The sentences are given in Table 2.

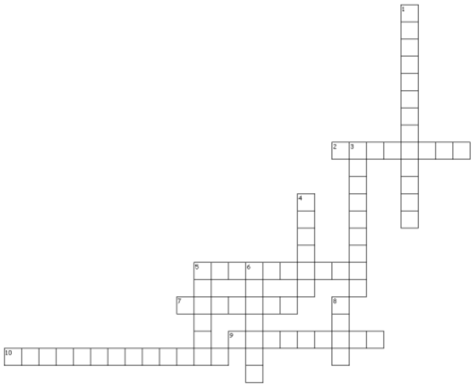
Table 2: True or False exercise

	True **(T)** False **(F)**
Acid rain is a form of precipitation not containing acidic.	
Today many products are biodegradable.	
Carbon dioxide is a colourless, odourless, non-poisonous gas that is part of the air.	
Scientists are not concerned with climate changes.	
Compost is a key ingredient of non-organic farming.	
Deforestation is a global contributor to clean air.	
Oil pollution can damage the ecology of the coasts.	
Ecosystem is a community pf animals and human being living in an area.	
Climate changes are believed to be linked to global warming.	
Greenhouse gas decreases the temperature of the earth's surface.	
Pollution is a problem only for the scientists and researchers.	
Wetlands occur naturally on every continent except Antarctica.	

Crossword

The students usually like to solve crossword puzzles probably because they represent a kind of relaxations to them Crossword puzzles are very useful in practicing not only general English vocabulary but English for Special Purposes vocabulary as well. Table 3 shows a type of crossword puzzle.

Table 3: Crossword puzzle



Across
2. one of the most fertile, natural ecosystems
5. gas, the result of it is in increasing earth's surface temperature
7. organic matter
9. any kind of environment contamination
10. capable of decomposed by natural biological processes

Down
1. cutting down trees
3. a community of living organisms
4. dioxide naturally occurring chemical compound
5. warming gradual rise of temperature
6. multidisciplinary scientific field
8. rain a form of precipitation

Productive vocabulary exercises

In the era of information technology and computer application in almost every field of living it is necessary not only to be acquainted with professional terms, idioms and lexical items, but to be able to use them appropriately. Students need to practice their vocabulary to obtain productive skills in using the correct items.

Missing words

The aim of this exercise is to choose the correct word and to fill in the gaps with the appropriate word as it is shown in the Table:

Table 4: Find the missing word

Complete the gaps in the sentences below with one the following words: ***acid rain, biodegradable, carbon dioxide, climate changes, compost, deforestation, ecology, ecosystem, global warming, greenhouse gases, pollution, wetlands.***
1. .... researches include the diversity, distribution, biomass, population of organisms, as well as competition between them within and among ecosystems. 2. .... is a naturally occurring chemical compound composed of two oxygen atoms each bonded to a single carbon atom. 3. Every year it is hotter and hotter. Scientists started a campaign to slow down the process of global warming .... 4. .... include water vapour, carbon, dioxide, methane, nitrous oxide and ozone. 5. ...., which is often called 'global warming' refers to changes in weather pattern. 6. .... is considered responsible for damaging forests and crops, and is particularly harmful to fish and other aquatic life in rivers and lakes. 7. .... refers to cutting down trees which provide oxygen and absorb carbon dioxide. 8. .... is a community of living organisms in conjunctions with the non living components of the environment. 9. .... is the capacity of being broken down or decomposed by natural biological processes. 10. .... play a number of roles in the environment principally water purification, flood control and shoreline stability. 11. .... became a popular issue after World War II, due to radioactive fallout from atomic warfare and testing. 12. .... is organic matter that has been decomposed and recycled as a fertilizer and soil amendment.

Scrambled words

In the following exercise, the students are required to unscramble the sentences. They have to write out each sentence putting the words and phrases into their correct order as it is shown in the Table 5 Unscramble the sentences.

Table 5: Unscramble the Sentences

Put the words and phrases into the appropriate order to get a correct sentence
1. possesses – levels - of hydrogen ions – elevated - It
2. materials – Biodegradable – many chemicals – are – food scraps – paper – cotton – and
3. to global warming – Carbon dioxide – contributes
4. Climate changes – changes – include – rainfall patterns – in – result – which – in – flooding
5. is used – compost – in gardening – and – and – to fertilize – agriculture – the soil - enrich
6. Deforestation – one of – is – the major – greenhouse effect – of the enhanced – causes
7. a scientific field – is – that – and – includes – Ecology – Biology – Earth Science
8. of the Dead Sea – for – the ecosystem – saving – appeal – Scientists
9. affects – and – their environment – humans – plants – animals – Global warming
10. trap – of the sun – Greenhouse gases – the heat – atmosphere – in the earth's
11. air – radioactive – water – different – there are – kind – of pollution – such as
12. wetlands – flooding – is – producing – the most – factor – important

CONCLUSION

Teaching vocabulary in English for Special Purposes is a very responsible and complex task for the teacher. Although there are textbooks for students studying different scientific fields, the teacher is the person who has to adopt the given textbook to the Curriculum of the taught subject. Lack of vocabulary awareness leads to incorrect communication. Students have to improve their vocabulary day after day in order to be able to use the language for their needs. There are many types of exercises to practice receptive and productive vocabulary.

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GENERAL CHARACTERISTICS OF ANIMAL PROTECTION FROM KILLING AND ABUSE IN SERBIAN LEGAL SYSTEM

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ABSTRACT

Modern society is going from antrpocetntrism towards biocentric principles whose acceptance radicaly changes the relationship of individuals and the society towards the environment in general, and especially towards animal protection. If we take into account animal rights, this protection can be achieved by sanctioning the conduct that represents torture and abuse. It schould be emhersired that omere introductia of a new criminal offence in Criminal legal system and more severe sentence as well as adoption on of the Law on Animal Welfare represent a significant step forward although not a sufficient one. The authors of this paper analyze general characteristics of animal protection from killing and abuse of Serbian legal systems. They are analyze criminal offense killing and torture of animals in Criminal Code of Republic of Serbia and abuse of animals according to the Law on Animal Welfare. Firstly, Anglo-Saxon legal system is described, but since in the last several decades European countries lead in protecting animal rights and welfare, authors in the paper paid special attention to continental system, with reference to good examples from German and Swiss laws.

Key words: *protection of animal rights, killing and abuse of animals, Serbian legal system.*

INTRODUCTION

The researches confirm the statement that in the countries in which changes in moral attitude of people in relation to animals exist, and that these changes of attitude are moving from exceptional anthropocentrism towards bio-centric ethics, first of all, when it is about animal rights to life, this creates the necessity for animal rights protection. In many contries, including ours, where the attitude towards extreme bio-centric ethics hasn't been changed yet, legal protection of animals and their wellbeing is very delayed. Such delayed legal protection of animal wellbeing, which has small results in practice, is followed by unequal protection for different animal species. If this trend continues, there won't be any significant progress in animal rights protection, and specistic attitude to this issue will still be present. However, certain countries have made great progress in processes of building their legal systems for animal protection. In these legal systems it can be even spoken about animal rights.

The impact of international law is also significant, because of its great influence on the field of legal protection and wellbeing of animals. Declaration on Animal Rights (Paris, 1978 Geneva, 1990) in fourteen points declared that animals are equal by birth and that they have equal rights to life, to be respected, that they must not be subjected to harassment, abandonment, experiments that cause suffering, etc., that they have the right to live in natural environment, as well as normal conditions in that environment, etc. In developed societies, acts on animal protection were passed. The first act on animal protection in Europe was adopted in England in 1822. Equal legal protection of all animal species from violence and killing as well as moral obligation of their respect was promoted in two documents adopted at international level, which, although they lack formal legal significance, have moral significance. They are: Universal Declaration on Animal Welfare from 1978 adopted by International League for Animal Rights with UNESCO support and Universal Declaration on Animal Welfare adopted by Word Society for the Protection of Animals - WSPA in 2000. According to definitions of animals adopted by these documents, protection should be provided to every mammal beside humans, as well to birds, reptiles, amphibians, fish or invertebrate able to feel pain, suffering or stress.[1] We cannot even notice progressive movements in this field in legal systems of European countries. This legal position of animals, in most European countries, has been influenced by regional European conventions as well as recommendations, or resolutions, adopted within European Committee, but also different resolutions of EU bodies. Legal standardization of legislature in European countries, represents international, or regional character.

In the countries from our region, laws on protection of animal welfare were firstly adopted by Croatia and Slovenia in 1999, Montenegro and Republic of Srpska in 2008 and Bosnia and Herzegovina and Serbia in 2009. Unlike developed countries belonging to Ango-Saxon and Continental law system which set standards related to protection, welfare and rights of animals, our legislation criminally and legally incriminated killing and violence of animals in 2006 for the first time. For criminal offense Killing and abuse our legislator has foreseen a fine and imprisonment alternatively and later its special maximum was severed. By adoption of Law on Animal Welfare from 2009 basic standards in this field were set and infringement liability established for acts against provisions of law considering killing and abuse of animals as well. Provisions of Law on Animal Welfare in Republic of Serbia should contribute to raising standards in this field although different associationa for animal protection in our country are struggling for its consistent application in practice.

PROTECTION OF ANIMAL RIGHTS IN ANGLO-SAXON AND CONTINENTAL LEGAL SYSTEMS

Modern movement for animal rights protection has been developed since 80s, first in EU countries and in the USA. The activities of this movement are based on critical relation which represents dominant pattern of behaviour towards animals (specism). Only with nonanthropocentric extention of traditional ethics and recognition of moral dignity to creatures who are different from humans, bases for developing moral obligations, empathy and feeling of duty and responsibility is created in order to correct the injustice made to animals (Zarden, 2006).

British and American laws in the field of animal protection were, until the middle of 20th century, among leaders in some aspects of animal species protection. It can be concluded that continental systems by abandoning anthropocentrism take over a primate in animal protection and use of modern solutions in this field.

Back in the nineteenth century, in Great Britain and the USA, organized efforts in order to confirm that human behavior towards animals had begun. The first organized attempts to protect rights and wellbeing of animals can be traced back at the beginning of the nineteenth century in England. The Act that prevents abuse of animals was passed in 1822, and two years later The Society for the prevention of cruelty to animals (which, from 1840, carries the name Royal Society for Prevention of Cruelty to Animals, RSPCA) was founded. Not long after, similar initiatives came to life in America, when American Society for the Prevention of Cruelty to Animals (1866) was founded. Afterwards, a few hundreds of similar societies began their work across the country. Nowadays, in these countries legal systems which protect animals have high level of standards. The question is in what extent are these standards respected in practice. However, apart from previously mentioned legal activity and various activities of referent organizations and movements, animals in Great Britain and the USA are still not recognized as legal subjects or beings who are recognized by the law. In these countries animals are still only legal objects with a tendency that certain animals (pets and endangered wild animals) in certain legal relations " these beings start being treated as valuable and sensitive beings which impose to people not only economic interests but also certain obligations and duties“ (Paunovic, 2004).
Continental legal system is slowly, at least normatively, leaving anthropocentrism. In European countries, in the last few decades, there has been significant legislative progress concerning protection of animals and their welfare.. It resulted in new regulations which anticipated completely new position of animals in legal relations. That is why it is generally accepted attitude that legal systems of

[1] Art. 1. Universal Decleracion of Animal Rights.

European countries came closer to the concept of protection of “animal rights”, so in this context, we can speak, with great caution, about animals as passive subjects of law. However, legal systems of these countries still treat animals as objects of law. If we speak about animals as passive subjects of law, we speak about certain animal species. A good example, which can explain these attitudes in developed European countries represents protection of domestic animals, especially pets. Under strong influence of European Convention on Protection of Pets, from 1987 which was recently rectified by our Parliament, the protection of cats and dogs, as most wide-spread pets, has been especially distinguished. Other animals, which are also kept in houses are not left without protection, even of criminal law. It is especially referred to different endangered wild animals, which are the subject of universal protection. In criminal legal codes of these countries new chapters related to delicts against, are being introduced.[2] The one who abandons and throws out on the street dogs, cats or any other pet will be criminally liable. Prison sentences are predicted for those who abuse or kill animals.[3] Unlike previous legislation and practice when the laws protected only animal owners – so when someone tortured or killed pets they could sue and demand a sentence, that is an indemnification, for personal suffering – according to new laws, the animal itself as “a sensitive being” becomes the holder of rights and when these rights are affected the torturer has responsibility to animals. We can say that dog, at last, in most European countries, have gained appropriate legal protection. The owner no longer can throw his dog out on the street, nor torture him, and especially he cannot use dogs for dog fights. Although in European countries these new regulations are generally approved by altruistic publicity,[4] there is awareness that their implementation in practice is difficult. Unfortunately, implementation of law, concerning the animal protection, is different in real life. Verdicts that punish violators of these laws are still rare. This condition is burdened by deeply rooted man-animal relations. Great problem lies in process failures. Although animals are treated as alive and sensitive being, animals as victims cannot by themselves participate in the process or to report a crime. A man should point on those problems and, in the same time, provide undeniable proofs to the court, which is very difficult in the practice.

As for the animal protection, in legislation activities, Germany leads in Europe. Namely, the example of Germany is very important because it became the first European country which decided to guarantee by its Constitution protection and right of animals. The main law in Germany,[5] the Constitution, by its separate provision, adopted during the latest changes of this act, obliges the state on this protection. From the stand point of legal technique in Germany is norming of animal protection has been performed which much more details and more completely than in other European countries. It has been done, first of all, by general regulations which are related to protection of the environment[6] which protects endangered wild animals, and by general regulations which are related to prohibition of cruelty against domestic animals, in other words only all vertabrates, or by a great number of

[2] For example, in the Criminal Act of Austria, a chapter is introduced with only one member that refers to torturing of animals. It is chapter 11 under the title “Torturing of animals”: Those who treat animals with cruelty or cause unnecessary suffering to them will be sent to prison for a year or will pay fee of 360 daily fines. Even those who act negligently will be punished too, because they avoided to feed or to water animals, or to torture them in longer period of time. Forrger - Sereni, StGB - Strafgesetzbuch, 6. Auflage, Manc-tezxtauslagen, 1982. From 23 May 1949. (BGB1.S.1), with last changes from 26 June 2002. (BGB1.1S.2863).

[3] Criminal provisions of Act on animal protection Tierschutzgesets from 1986. are especially important, and they determine great financial as well as prison sentences for everybody who violates the provisions of this act. For example, in the member 17 of this act it is anticipated that criminal act which is punished with two years of prison to those: “ Who: 1. Kill vertebrates without reasonable reason or 2. To vertabrate a. Causes significant pain and suffering or b. Inflicts longer or serial pain or suffering”.

[4] The following example shows how new regulations in European countries get general approval of publicity. In Switzerland, Federal Court of Switzerland in 1989 recognized animals as “alive and sensitive beings, as close creatures (beings) (…) that should be respected and which serve as moral precondition for humans who are only thanks to their intellect superior”. (Ruling of Federal Court BGE 115 IV 254). This opinion on „dignity of creatures (beings)“ was broadly accepted in public in the struggle agains genetic engineering. Referendum was held so that this opinion can find its way to Federal Constitution of Switzerland. At the referendum held on 17 may 1992 in the member 120, paragraph 2 of the new Federal Constitution this opinion was adopted through special provision.

[5] General Act of Germany from 23 May 1949 (BGB1.S.1), with the latest changes from 26 June 2002. (BGB1.IS 2863).

[6] The Act on Nature Protection from 1976 with changes from 1986, That Orderth Bundesa Tenschtzverordnung from 1986, with a list of permanently protected species including those protected by The Order of European Community Commission no. *3626*/82 which adopted CITES Convention (Guinter, 1998)

regulations in different legal branches in which some animals are protected in different legal relations (civil law, criminal law, sanitary law, administrative law, customs law, etc.). There is a great number of regulations in Germany related to protection and welfare of animals but the most significant one is The Act on Animal Protection (*Tierschutzgesets)* from 1986, which according to many solutions leads in european countries and many other countries, for example Switzerland, Sweden, Netherlands have taken it over. Member 1 of the *Tierschutzgesets* from 1986, shows that in Germany we can speak about modern regulations which leave anthropocentrism and follow the newest moral beliefs related to animals because they treat them in greatest extent as beings with their own interests and values.[7] In this member of the act we see that there is responsibility of man towards animals as co-beings, by protecting their health and life and that nobody must, without any reasonable reason cause pain, suffering or injuries to animals. This provision indicates several new things that will direct modern legislation. All animals[8] are no longer observed as objects which are completely at man’s disposal, but as man’s co-beings to whom humans mustn’t cause pain or suffering. In German law the institution of Trustee for animals which is a step forward to recognition of passive subjectivity of animals. A significant feature of this act is pretty broad legal protection of different kinds of domestic and wild animals found in all severe conditions in which they can be found due to modern industrial society. In addition, the act protects vertabrates as beings which are scientifically proved to endure different feelings, including pain and suffering.

In continental legal system, Switzerland is a country which in terms of animal protection and welfare stands out because it has broad constitutional provisions, that give a basis for animal protection (Federal constitution of Swiss Confederation from 18. April 1999- state 3. March 2002). However, we consider that the institution of a lawyer for welfare of animals is of great importance. He is nominated by Canton Government to initiate law-suits based on criminal responsibility of those who broke this law from 1991, and he receives reports of organizations for animal welfare, if there were any animal rights and their interests violation. The lawyer for welfare of animals has the right to be present at investigations of certain cases, when the act is violated, he has the right to question the accused persons, witnesses or experts as well as the right to complain at first instance decisions to federal bodies. The fact that animals are much more than objects with certain interests was first established in Federal court in Switzerland when in 1989 the animals were recognized as „alive and sensitive beings“ that should be respected and which represent moral precondition for men who is only thanks to his intellect superior. This opinion about animals as “dignified beings” is widely accepted in public and after referendum it was introduced in new Federal Constitution as constitutional provision 28. This provision in a certain way overcomes animal protection in the field of genetic engineering and experiments on animals. It has also came into the very essence of man-animal relations because the use of the term referred to “dignity of beings” has certainly changed the relations of man to animal welfare (and probably to animal right) in different fields, for example in breeding animals, relations towards pets, etc.

Very important example is Sweden which has appropriately, with its legal system, protected animals in accordance with European and universal standards. By the Act on Animal Protection from 1986 it was completely consolidated previously adopted legislation concerning animal welfare in unique legal act. [9]

[7] The member 1 of 1*Tierschutzgesets* in 1986 „ The purpose of this act is to protect animals and their health because of man's responsibility for animals as co-beings. No one must cause pain, suffering and injuries to animals without reasonable reason”.
[8] At least principaly (from invertabrates to primates), because later, many provisions are dedicated to vertabrates.
[9] In what extent the Act on Animal Protection in Sweden influenced breeding of some kinds of animals on farms show regulations which followed . Based on the member 4 of The Act on Animal Protection a provision on protection of domestic animals was addopted in 1988, which protects animals on farms and previoulsy mentioned European convention.

CRIMINAL OFFENSE KILLING AND TORTURE OF ANIMALS IN CRIMINAL CODE OF REPUBLIC OF SERBIA

In modern societies it is almost generally accepted that cruelty to animals is impermissible both from moral (ethical) and legal view. Psychological studies point at connection between cruelty to animals and violent behaviour towards people (Striving, 2002). Taking this attitude into account, prevention and punishment by criminal or penal sanctions of cruelty to animals should be viewed as one of preventive measures of violence and violent criminal offense in general.

According to our law, criminal offense Killing and torture of Animals was first stipulated in Criminal legislation of Republic of Serbia in Criminal Code from 2006 in XXIV chapter – Criminal offence against the environment. The legislator stipulated that the basic form of criminal offence Killing and torture of animals are performed by those who kill, torture or harming an animal violating regulations. For this offence, before amendments, it had been stipulated fee or 6 months imprisonment[10] and after amendments of Criminal Code of Republic of Serbia from 2009 it was exchanged for fee or imprisonment up to 1 year.[11] More serious form of this criminal offence is related to offences that resulted in killing, torture or harming of larger number of animals or if the offence is performed to the animal belonging to specially protected animal species. In such a case it is stipulated a fee or imprisonment up to 3 years.[12] By Amendments of Criminal Code of Republic of Serbia it is stipulated another form of serious criminal offence performed by those who, out of greed, organize, finance or host animal fights of the same or different species or those who organize or participate in bets during these fights. Criminal offender can be determined cumulative sentence by court –imprisonment from 3 months to 3 years and a fee.[13]

Basic criminal offence includes killing, torture and animal harming. Torture represents causing physical or psychic injuries to animals while harming includes harming animal bodies causing wounds, pause break and similar. It is emphasized in theory that harming is taken in broad meaning so it should not be related only to body wounds done to people in sense of criminal offence – serious and slight injuries (Lazarevic, 2006). It is also emphasized that this criminal offence implies suffering of high intensity and that it is caused without any rational reason and justifiable purpose (Batricevic, 2007). This criminal offence can be caused by failure to act or ommission, for instance, systematical non-giving food and water to animals (Stojanovic, 2006). According to law, criminal offence must be illegal, which means that this criminal offence exists only if some of these offences are performed against regulations governing what animals can be deprived of life, in what way and under what conditions.[14] Criminal offender of killing and abuse of animals can be animal owner or any other person.

Based on data of Republic Statistical Office Republic of Serbia, 2006, out of 32 people who were reported to competent authorities as criminal offenders for Killing and torture of animals only one was sentenced conditionally. (Statistic Bulletin –Mature Criminal Offenders Charge, Conviction-2006) However, the number of reported and sentenced offenders of this criminal offence is rising. In 2007, out of 80 reported people 11 were sentenced and 3 of them were imposed fines. (Statistic Bulletin-Mature Criminal Offenders-Charges, Conviction-2007) In 2008, for the first time imprisonment was imposed for this criminal offence in 4 cases, 10 people were imposed fines, 6 conditional sentence, 1 work in public interest and 3 offenders were freed from penalty. (Report „Mature Criminal Offenders , 2004-2008“), 116 people were reported for this criminal offence, 33 people were charged, 1 was imprisoned, 11 imposed fines, 15 were sentenced conditionally and 1was imposed judical admonition. (Report „Mature Criminal Offenders , 2005-2009“)

[10] Art. 269 (1) Criminal Code (2006).
[11] Art. 269 (1) Criminal Code (2009).
[12] Art. 269 (2) Criminal Code (2009).
[13] Art. 269 (3) Criminal Code (2009).
[14] As an example the following lows can be cited: Law on Animal Welfare from 2009, Law on Game and Hunting from 2010 and from 2005 amendments 2010.

ABUSE OF ANIMALS ACCORDING TO THE LAW ON ANIMAL WELFARE

The Law on Animal Welfare from 2009, regulates animal welfare, rights, obligations and responsibility of legal and natural persons, entrepreneurs related to animal welfare, treatment of animals and protection of animals from abuse, animal welfare related to deprivation of life, keeping, breeding, traffic, slaughter and tests on animals as well as other issues significant for protection of animal welfare.[15] Animal welfare regulated by this Law is related to animals which can feel pain, suffering, fear and stress.[16] Therefore, the Law is related to the following animal categories which are protected: animals used in production, animals used for scientific, bio-medical and educational reasons, animals used for exhibitions, contests, shows and other forms of public presentations, animals used for work and official purposes, pets, lost and abandoned animals, wild animals in captivity.[17] Welfare of animals is defined as providing conditions in which animals can satisfy their physiological and other needs appropriate to their species, such as feeding, accomodation, physical and thermal comfort, safety, expressing basic forms of behaviour, social contact with their fellow species, absence of unpleasant experiences such as pain, suffering, fear, stress, illnesses and injuries.[18] Beside minimum standards related to animal welfare, this Law establishes duty of relevant bodies to encourage strenghtening consciousness on animal welfare significance as well as obligation of all citizens to prevent and report to authorities cruel treatment of other people to animals.[19]

Unlike Criminal Code which does not explicitely state the animals that can be object of criminal offence Killing and animal abuse, the Law on animal welfare defines an animal as every vertebrate which is able to feel pain, suffering, fear and stress[20], and animal welfare is not related only to pets but, as said before, to animals used in production, animals used for scientific, bio-medical and educational reasons, animals used for exhibitions, contests, shows and other forms of public presentations, animals used for work and official purposes, pets, lost and abandoned animals, wild animals in captivity. For that reason, in our criminal legal theory there is an opinion, beside widely regulated legal formulation, that criminal legal protection of animals should be restricted only to those animals whose killing and torture cause compassion for most people. (Stojanovic, 2006) Misdemenour sanctions cam include wider range of offencive acts. On the contrary, sanctions, whether according to provisions of criminal or misdemenour low, would be related only to cruelty towards one category – pets- which surely does not mean a guarantee for animal welfare in any legal system.

Animal abuse can be physical and psychological. It is defined as any action of failure to act with animals which causes, on purpose or from negligence, pain, suffering, fear or stress, injury and which undermines genetic integrity of animals and causes death.[21] According to the Law physical abuse means undermining physical integrity of animals by harming tissues and organs, such as beating, kicking, whipping, sexual violence, forcing to work and exercises undrgoing animal's abilities, inadequate way of catching and restraining, taking activities on animals opposite to legal provisions and conscious reproduction of animals suffering from genetic illnesses if it is not performed within scientific experiments in accordance to the Law.[22] Legislator prescribes by low that psychological animal abuse represents violating its psychological integrity which can cause or causes conduct disorders – preventing animals to satisfy basic conduct needs, to use space for rest and shelter, infuriating animals by using physical force, other animals or stimulation inappropriate to animals, provoking suffering, pain, unsafety and boredom as well as preventing animals to make social relationship with animals of the same species.[23] Law on Animal Welfare explicitely forbids animal

[15] See: Art. 1. Law on Animal Welfare.
[30] Art 2 (1) Law on Animal Welfare.
[31] Art. 2. (1) Law on Aimal Welfare .
[18] Art. 5 (1) 4 Law on Animal Welfare.
[19] Art. 3. Law on Animal Welfare.
[20] Art. 5. (1) 13 Law on Animal Welfare.
[21] Art.5 (1) 18 Law on Animal Welfare.
[22] Art.5 (1)18 Law on Animal Welfare .
[23] Art.5 (1)18 Law on Animal Welfare .

abuse[24], by prescribing misdemenour sanction and a fee of 5.000 to 50.000 dinars for natural persons [25], and for legal entities a fee of 100.000 to 1.000.000 dinars[26].

As said before, according to Criminal Code of Republic of Serbia, killing, torture, injuring or abuse of animals is considered a criminal offence.[27] According to Law on Animal Welfare within 82 numbered activities considered as criminal offences and which are endangered by fines the following are included: killing animals against provisions of law[28], or at public places[29] as well as killing and abuse of animals for the sake of making films or advertisements[30], using poison and other chemicals than can cause pain, suffering and death (except when rodent control is in question)[31] and animal negligence by depriving them from satisfying basic needs[32].

Animal abuse in the sense of Law on Animal Welfare can be done intentionally or out of negligence[33], while criminal intent for a criminal offence Killing and animal abuse which must include consciousness related to breaking appropriate regulations is exclusivelly prescribed (Stojanovic, 2006). From this it follows that torture, or abuse done out of negligence represents an offence. However, it can be discussed about when premeditated or intentional conduct which may be also characterized as animal abuse according to provisions of Criminal Code or according to provisions of Law on Animal Walfare should be considered as criminal offence or misdemenour sanction. Law on Animal Walfare does not include provisions on the grounds of which could be possible to determine closely its relationship with norms of Criminal Code. The fact that Law on Animal Walfare represents *lex specialis* does not contribute to this problem solution because here is not a question about collision of two Criminal Codes but about provisions of criminal and misdeminour low. For all these reasons in the case of intentional abuse or torture of animals, the following rule should be applied: if a criminal conduct is in the same time prescribed as criminal offence and misdemenour sanction as well, then criminal offence as more serious one absorbs the sanction (Jovasevic, 2006). In other words, the fact that a person has been punished for criminal offence will represent a base that excludes punishability for a sanction. However, if a person has been punished for misdemenour act, misdemenour sanction will be included in criminal offence that will be sentenced by Criminal Court. It is not specified by provision of low what animals are related to this criminal offence. Since the legislator does not set explicite limits, it can be concluded that killing, torture or injury of any animal is incriminated by this criminal offence[34]. Such an attitude would be in accordance with the basic principles of biocentric ethics as well as with the principle of equality of species taking into account the ability to feel pain resulted from these principles (Paunovic, 2005). However, it seems that majority of current Criminal Legislations, despite general acceptance of human beings equality, do not leave their specific attitude (Paunovic, 2004), offering protection only to vertebrate – to domestic animals[35], pets[36], domesticated and captivated wild animals[37]. In this sense, crimina legal reaction is limited only to killing and abuse of the animals which are able feel torture and injuries (Lazarevic, 2006), or pain, suffering, fear and stress (Paunovic, 2004). Having in mind social reality and consciousness of people which, influenced by different cultural, social and economic circumstances lag behind world standards and opinions related to protection and welfare of animals, it is emphasized in our legal theory that only killing and abuse of the animals which provoke compassion of most people is criminally and legally sanctioned (Stojanovic, 2006). Real improvement of animal welfare in favour of all animal species requires

[24] Art. 7 (1) Law on Animal Welfare .
[25] Art. 85 Low on A nimal Welfare .
[26] Artl. 82 (3) Law on Animal Welfare.
[27] Art. 269 Criminal Code.
[28] Art. 7 (3) and Art. 82 (1) 42., 44. i 45. Law on Animal Welfare.
[29] Art. 82 (1) 43. Law on Animal Welfare.
[30] Art. 82 (1) 23 Law on Animal Welfare.
[31] Art. 82 (1) 28 Law on Animal Welfare.
[32] Art. 82 (1) 31 Law on Animal Welfare.
[33] Art. 5 (1) 18 Law on Animal Welfare
[34] In this sense: Art. 5 (1) 13 Law on Animal Welfare.
[35] Tierschutzgesetz, Bundesgesetzblatt 7833-3, IS. 1277 in 1972.
[36] See: European Convention for the Protection of Pet Animals.
[37] See: Texas Penal Code § 42.092. Cruelty to Non-livestock Animals

consistent implementation of relevant legal solutions in practice and further legislative regulation. This is not possible if some provisions are automatically taken over from legal systems with long and developed tradition without taking into account social, economic and other context in which they have to be implemented. Therefore, it should be emphasized that mere introduction of new criminal offence in criminal legislation and stricter punishment as well as adoption of the Law on Animal Welfare are significant but not sufficient. A precondition for their successful implementation is precise definition of relationship between their provisions related to torture or abuse of animals and definite determination what animal species can be considered the objects of criminal offence Killing and abuse of animals according to that provision, article 2. of the Law on Animal Welfare. It is also related to definition of certain legal standards which are only theoretically defined in these regulations, such as the notion of animal welfare[38]. It is of high significance to apply these provisions in practice.

CONCLUSION

Modern society is going from antrpocetntrism towards biocentric principles whose acceptance radically changes the relationship of individuals and the society towards the environment in general, and especially towards animal protection. If we take into account animal rights, this protection can be achieved by sanctioning the conduct that represents torture and abuse. Scientific knowledge has confirmed the fact that animals are able to feel pain, suffering, fear and stress and the change in ethical attitude on the global level supported and promoted through activities of national and international societies for animal protection have contributed to real changes in their legal position in a great number of legal systems. Firstly, Anglo-Saxon legal system is described, but since in the last several decades European countries lead in protecting animal rights and welfare, we paid special attention to continental system, with reference to good examples from German, Swiss and Swedish laws. New regulations in these countries anticipate completely new position of animals in legal relationship. In this way, legislations of European countries have improved in greatest extent towards the concept of protection of “animal rights”, so in this context we can talk about animals as passive subjects of law, but, first of all, we have in mind certain kinds of animals. Animal as “sensitive being” becomes a holder of rights and because of violation of these rights an offender should take responsibility for his deeds.

Real impovement of animal welfare requires permonent application of the relevant legal solutions in practice. It schould be emhersired that omere introductia of a new criminal offence in Criminal legal system and more severe sentence as well as adoption on of the Law on Animal Welfare represent a significant step forward although not a sufficient one. A preconditian for their successful use is a precise definitia of the relatioship of their provisians related to animal abuse and clear determination of animal species which could be objects of criminal offence- killing and abuse of animals according to the provisain of the Law on Animal Walfare.

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ICT IN THE ECOLOGY OF URBAN AREAS

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APPLICATION OF ICT AS A NECESSARY TOOL OF EMERGENCY RESPONSE IN URBAN AREAS

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ABSTRACT

Emergency situations in urban areas caused enormous consequences all over the world. Every society has to have appropriate counter measures in place, in order to mitigate its undesirable effects. In urban areas the issue of adequate disaster management is very complex due to numerous reasons. So this is the main point of this paper. In it authors present how useful are ICT as a tool of overall protection in emergencies. One of the chapters is devoted to the use of ICT in developed world in approaching the goal of better safety within the study communities through the use of a combination of modern early warning systems and other for forecasting. Systems of those kinds could be use for provided reliable information all phases of disaster management (before, during and after the disaster). Paper especially pointed the importance the use of ICT before and during emergency response. Special attention has been given to the use of geo-information, such as risk maps, topographical maps, etc. Conclusion remarks confirmed that despite Serbia faced with greatest budget shortfall, development and use of these systems could provide efficient and effective response of the institutions, agencies and individuals in all kind of emergencies.

Key words: *urban areas, information communication technology, emergency, consequence*.

INTRODUCTION

In the modern world cities and risks are growing hand by hand. In 2008, for the first time in history, half of the world's population, or 3.3 billion people, lived in urban areas. By 2030, at least 61 percent of the global population will live in cities. The cities are expanded without any plan and its population is exposing to the different kind of risks. In any emergencies if we combine this facts with inabilities of adequate governance it is clear that the vulnerability of urban population is enormous. In urban areas all those conditions caused a process of "risk accumulation." Those facts make the management of disasters in urban areas particularly complex. Nevertheless, urban areas can also provide opportunities for reducing risks but as some of the scientist pointed out we have to switch in thinking about the "cities as mechanism" to "cities as organism."

In current circumstances of global economic crises and multiplication of all kind of risk, situation gets worsening because large numbers of people are concentrated in megacities and cities. Decreasing the consequences of emergencies (disasters) in urban areas became a first top priority for policy makers and necessary condition to the future sustainable development. In developing countries emergencies cause setbacks to economy and social development. This fact is especially visible in the area of reconstruction of infrastructure after disaster. Urban infrastructure supplies population with essential services such as clean water, waste management, electricity, transportation, and telecommunications. Basic services such as these are often the main assets of the urban poor, which assist them to pursue livelihoods and improve their quality of life. Thus, it is essential to protect critical infrastructure from failures in order to prevent cities from slipping further into poverty. Unfortunately in some cases in the Republic of Serbia, like in Trgoviste after the flood in May 2010 is clear the way a poor community reacts to a natural disaster. The flood that had hit Trgoviste on May 15 (2010) caused the unprecedented damages. The flood caused suffering and sorrow, among many of its residents. The damages are estimated at about two million €, which is an enormous sum, bearing in mind the total municipality budget of 800 000 €. After only a few months, the information from the news showed a lessened degree of alleviation activities and measures taken to deal with the consequences so after all only one of the total previously existed bridges in the town was rebuilt thanks to the private donation. Hence, it is very important to educate policy makers about the connection between climate change and sustainable development, and to ensure that in future, the whole community will be included in discussions about policies that impact climate change (Kwan et al., 2005; Lee et al., 2005).

Emergency service and other stakeholders need access to the most accurate and timely information that is available to help them respond to these emergencies in urban area. The paper reveals use of ICT as a necessary tool in emergencies which represent one of the most pressing environmental, economic, political, and social issues in the Republic of Serbia (RS). Authors in the paper discusses the current state of using ICT in the process of disaster risk reduction in the developed countries as well as limitations of Serbian government to provide sufficient budget for emergency services and the ICT which will be used in the process of reducing risks in urban areas. The hypothesis of this article is: If we do not follow the experience of use ICT we will continue to pay for the consequences instead for prevention. As the policy makers decide to decrease the budget for the emergency services in the country (instead of 950 millions of dinars to 81,14 million) the situation could be worsened in future. Hence, the emergency services and experts have to convince the policy makers to find additional sources, and funds for including of ICT in future activities as a means of saving resources and increasing safety level in the country. The first chapter of this paper is devoted to presentation from current activities in disaster risk reduction in international arena. Second chapter discusses the few example of using ICT in the world as a means for decreasing risk in urban areas in different kind of emergencies and present how it is used in different phases of disaster management circle. The few last chapters are devoted to the discussion how Serbia has to move forward regarding the accepted information communication strategy as well as conclusion remarks and reference used in the process of paper preparation. The main goals of this paper are to attract the greater attention of all stakeholders in a process of development and application of ICT in future process of disaster management. The methodology used in this article is usual for social researchers: historical analysis, comparative analysis and data analysis. It allows authors to use various documents from electronic databases, books, scientific journals, official documents and positive practice from abroad. All data were arranged and used for the purpose of achieving article's objectives.

The conclusion shows that Serbia has to pass the gap as soon as it is possible between the declared Strategies in emergency protection as well as in the information communication development in emergencies, in general, but especially in urban areas. Serbia has to increase the financial capacity for inclusion of ICT as a profitable tool for adequate response to emergencies.

THE EFFORTS IN INTERNATIONAL COMMUNITY IN A PROCESS OF DECREASING RISKS IN URBAN AREAS

In order to increase the awareness of stakeholders regarding the urgency of creating new approaches in addressing urban vulnerability to emergencies many events were organized in the last few decades. One among the first was the International Conference the Aichi/Nagoya which is held in November 1993 under the theme of "Disaster management in metropolitan area for the 21-st century." A total of 1 100 experts from 46 countries and nine international organization participated. Based on the reports and discussion of that Conference, few measures were put forth.

The World Bank's Disaster Management Facility and the ProVention Consortium - a coalition of international agencies, nongovernmental organizations (NGOs), governments, the private sector, and academics - hosted a conference from December 4 to December 6, 2002. The conference explored a range of issues related to disaster vulnerability and identified priorities for development and disaster prevention activities to ensure safer cities in the future. Papers to serve as conference background materials were commissioned from experts, disaster management researchers, and development practitioners. The papers were complemented by presentations. Discussions revolved around a range of issues facing urban areas, including:

- Economic impacts and globalization;
- Adaptation to climate extremes and climate change;
- Preventive strategies to reduce disaster risk;
- Social infrastructure and the vulnerability of the poor;
- Social perception of risk;
- The impacts of disasters on critical infrastructure linkages and
- Threats to megacities from new types of hazards.

The most influent organization in the world The United Nation established the Secretariat of the International Strategy for Disaster Reduction (UNISDR). One of the most important events in the area of disaster risk reduction was The World Conference on Disaster Reduction which was held in January 2005, in Kobe, Japan. In this event the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters was established as the basic framework (Hyogo Framework for Action, 2005-2015). The priorities that are insisted on in the Hyogo Framework for Action 2005-2015 primarily emphasize the significance of national and local governments in reduction of hazard risks. This important document insists on the identification, evaluation and surveillance of hazard risks, and on creation and improvement in efficiency of systems for early warning. Knowledge and innovation, education and availability of information, research, discussions, and training are also top priorities in the fight against the catastrophes (Radovic et al., 2013). As an additional efforts in 2010 UNISDR were launching a new campaign in 2010 –Making Cities Resilient – to enhance awareness about the benefits of focusing on sustainable urbanization to reduce disaster risks. UNDP has implemented several urban risk management projects with a clear focus on local action. Risk in urban areas is a combination of two factors: first, location and exposure to hazards; and second, increased vulnerability due to poor local governance, environmental degradation, and the overstretching of resources. UNDP emphasizes that national risk reduction must also strongly incorporate reducing risks in urban areas. Recent project about reducing risks in the urban areas are developed by UNDP with partner governments and range from comprehensive national DRR programmes (which include urban DRR components) to city-specific urban DRR programmes. UNDP’s Bureau for Crisis Prevention and Recovery (BCPR) particularly stresses the importance of urban DRR action and is undertaking a series of activities to integrate DRR considerations into urban development processes, using global advocacy, regional partnerships and local implementation. Partners include: the Humanitarian Aid Department of the European Commission (ECHO), the Earthquake and Megacities Initiative, International Strategy for Disaster Reduction (ISDR), International Institute for Environment and Development, UN Habitat, and the ProVention Consortium.

Most disaster-prone cities are unprepared for future disasters and ill-equipped to reduce associated risks. Policy makers face numerous challenges with respect to urban risk management, including lack of adequate knowledge and administrative capacities; weak finances; lack of coordination between departments; weak law enforcement mechanisms; and corruption. There is an urgent need to promote a culture of prevention at all levels and to improve management practices. Local action is the centerpiece of UNDP’s approach to building disaster-resilient cities. UNDP promotes the establishment of legal and legislative instruments and technical tools that prioritize DRR as an integral part of the urban development process. Although seismic risks are of paramount concern in many urban settings, UNDP promotes a comprehensive multi-hazard approach that builds on risk identification and vulnerability assessments.

WHAT KIND OF ICT WE NEED TO DECREASE THE RISKS IN URBAN AREAS

Information and Communications Technologies (ICT) initiatives play a substantial role in global development. The role of ICT is even more significant in a process of improvement response of emergency services to disaster in urban area. Access to information resources provides substantial benefits to emergency services. Therefore, numerous stakeholders in the area of disaster management in academic and training programs included advanced module in ICT designed to improve the capabilities in dealing with hardware and software of the network of decision centers, collecting information to central level and diffusing relevant data and images. In those modules/courses interested persons gain knowledge about Geographical Information Systems-GIS, system for database management, systems for early warning, quality management system for operational rooms and prevention centers and other necessary tools for emergency coordination (networks, databases, remote sensors and etc.). Similar issues are also a part of numerous training programs for emergency responders all over the world. One of the most interesting example is noted in Italy: "Training program for civil protection managers created by CIMA Foundation" (www.cimafoundation.org). Hence, ICT are a part of critical infrastructure the stakeholders should consider its protected in disasters. There is a need for special policy in this area because despite tremendous value the deployment of ICT for managing urban risks has proven to be a significant challenge. This is due to factors such as high costs of technologies, regional shortages in a skilled labor pool to support deployment, poor physical security, and others. An array of additional economic, political, and social challenges has contributed to the additional difficulties (Lindroos et al., 2003; Pinkhasov et al. 2003). Useful explanation about the risk management decision making in ICT for development is presented by Paul Rohmeyer and Tal Ben Zvi (Rohmeyer et al., 2009; Ben Zvi et al., 2009).

ICT are an urgent need in the work of emergency service because the most important step towards reducing risks in urban area is to analyze the potential risk and identify measures that can prevent, mitigate or prepare for emergencies. ICT play a significant role in highlighting risk areas, vulnerabilities and potentially affected populations by producing geographically referenced analysis through, for example, a geographic information system (GIS). Another important use of ICT is in the area of timely disaster warning of affected population. Hence, local governments should be able to recognize the risks to which their communities are exposed. They must be actively involved in the design and maintenance of early warning systems, and understand information received to be able to advice, instruct or engage the local population in a manner that increases their safety and reduces the potential losses.

GIS can be loosely defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. GIS can be used for scientific investigations, resource management and development planning. As disaster management work usually involves a large number of different agencies working in different areas, the need for detailed geographical information in order to make critical decisions is high. By utilizing a GIS, agencies involved in the response can share information through databases on computer-generated maps in one location. Without this capability, disaster management workers have to access a number of department managers, their unique maps and their unique data. Most disasters do not allow time to gather these resources. GIS thus provides a mechanism to centralize and visually display critical information during an emergency. There is an obvious advantage to using a map with remote sensing or GIS inputs instead of a static geographical map.

The use of GIS is known in all phases in disaster management process. During the preparedness and response phases, GIS can accurately support better response planning in areas such as determining evacuation routes or locating vulnerable infrastructure and vital lifelines, etc. It also supports logistical planning to be able to provide relief supplies by displaying previously available information on roads, bridges, airports, railway and port conditions and limitations.

Apart from all mention forewords, GIS is extremely useful in evacuation. Since the early 1980's, much GIS-based research has been conducted to resolve evacuation problems at an urban scale. Evacuation tools have been implemented to prepare evacuation plans for evacuations in micro-space, such as the inside of complex buildings and ships. They are pre-defined evacuation plans designed to operate under ideal situations regardless of what has happened or is happening within the buildings, and are not intelligent emergency response systems. (Pu et al. 2005; Zlatanova et al. 2005) Kwan and Lee (2005) proposed GIS-based Intelligent Emergency Response System (GIERS) to evaluate the potential benefit of 3D GIS for improving the speed of emergency response. They proposed an 'intelligent' emergency evacuation system of complex buildings using 3D GIS and Intelligent Transportation System (ITS) technologies, called an Intelligent Building Evacuation System (IBE). The impact of two types of uncertainty was evaluated in this experiment: street network uncertainty (vehicle movements in 2D space) and route uncertainty within built environments (pedestrian movements in 3D space). The experiment demonstrated that response delays within multi-level structures due to indoor route uncertainty can be much longer than delays incurred on the ground. The results also showed that extending conventional 2D GIS to 3D GIS to represent the internal structures of high-rise buildings can significantly improve the overall speed of rescue operations.

GIS-based space technology solutions have become an integral part of disaster management activities in many developed and some developing countries. The United Nations Office for Outer Space Affairs has been implementing a Space Technology and Disaster Management Programme to support developing countries in incorporating space-based solutions in disaster management activities.

One of the most useful experiences from practice in the area of use ICT for a disaster management purposes have been seen in the United Kingdom. There is created the National Resilience Capabilities Programme (NRCP) which aims are to increase the national capability to respond to and recover from civil emergencies. The Programme is made up of a total of 22 capability workstreams. These fall into four groups:
1. Functional workstreams;
2. Essential Services workstreams;
3. Structural workstreams which ensure that the frameworks for coordinating and directing an emergency response are in place. There are two of these workstreams: Central (national) Response and Local Resilience.
4. Supporting workstreams.

Each of the workstreams is the responsibility of a lead government department, with the management of the Programme as a whole the responsibility of the Civil Contingencies Secretariat (CCS). CCS also works particularly closely with the Resilience and Emergencies Division in the Department for communities and Local Government (DCLG RED), which is able to feed in information about how the local level is building capability and how well the local and national levels are working together.

Structural workstreams ensure that the frameworks for coordinating and directing a response are in place. It is organized as a central response lead by Cabinet Office and as a local resilience lead by the Cabinet Office and Department for Communities and Local Government. The office aim is to support local resilience partners in England so they can carry out their duties under the Civil Contingencies Act (CCA) to plan for, respond to and recover from emergencies; encourage responders to work together across agencies and areas; and make sure that the local and national levels are joined up in the response to an emergency.

The Civil Contingencies Act in Britain includes public awareness and warning and informing as two distinct legal duties for Category 1 responders - advising the public of risks before an emergency and maintaining arrangements to warn and keep them informed in the event of an emergency.

Therefore, the use of ICT is the important for the success of all mentioned activities the Centre for the Protection of National Infrastructure (CPNI) and the Centre for Applied Science and Technology (CAST, formerly HOSDB) promoted the development of effective Video Analytics (VA) systems provide automated real-time video analysis and event detection. VA systems help in policing and counterterrorism operations (and other emergencies). To assist in this CAST, in partnership with CPNI they developed the Imagery Library for Intelligent Detection Systems (i-LIDS) as the government’s benchmark for video analytics (VA) systems. VA systems are required to detect defined ‘alarm events’ within a scene, for example the presence of a parked vehicle or a bag abandoned by its owner.

In urban area system was evaluated for one of two roles:
• Operational Alert - where the system provides live monitoring of a situation.
• Event Recording - where system acts as a trigger for automated recording of suspicious events to be reviewed later.

The system use a new technologies like near infrared in which is detected any persons, vehicles or boats in the restricted area in a near infrared modality. Also it could be use Medium Wave Thermal Imager were system detect any persons, vehicles or boats in the restricted area in a medium wave thermal modality and Long Wave Thermal Imager where system detects any persons, vehicles or boats in the restricted area in a long wave thermal modality.

To enable multinational sharing of disaster information, and collect and distribute the disaster information at real-time, group of researchers developed disaster reduction information distribution system. The system manages other systems: disaster information and geographical information at the server and distributes it promptly. This result is establishing the mechanism for disaster management administrators and researchers to obtain disaster information in real-time. This system called VENTEN (Vehicle through Electric Network of disasTer gEographical informatioN).

The use of this ICT is the most valuable for reliable response on any threat to the population or structure in the urban area (www.ilids.co.uk.andhttps://www.gov.uk/imagery-library-for-intelligent-detection-systems).

At the end authors also should mentioned the National aeronautics and space Administration (NASA) activities in this area. Knowledge resulting from NASA technologies and observations of the Earth`s planetary system harnessing to improve predictive capability at every level, from global to local. NASA contributes system integration to enable solution that result in socioeconomic benefits to society.

In the Republic of Serbia in this moment there is no evidence of using any similar ICT in activities of emergency services. The Sector for Emergency management as an organizational unit in the Ministry of interior affair faced with great budget deficit and therefore there is no a chance to see anything similar in future. The most important problem in its work is permanent budget shortfalls followed by unplanned and irrational spending for some procurement. In 2013 the planned financial means from the total sum of 1.7 billion dinars, was cut dawn on sum about 400 millions. This fact put the Sector in almost impossible situation to handle any kind of response in future emergencies. From all mentioned above is clear that system still need serious reforms in future.

CONCLUSION

The role of ICT, especially GIS in disaster management should focus on the integration of information from many diverse sources to produce interactive products for decision-makers. Also, it is important to have information at real-time. Emergency management programs are developed and implemented through the analysis of information. The majority of information is spatial and can be mapped. GIS allows emergency management needs to be identified prior to an incident. Emergencies in urban areas as well out of them can be modeled and displayed in GIS and other numerous ways. Emergency management personnel can use modeling for training, for actual tactical deployment during a disaster, or to analyze the consequences of a possible disaster in urban area. Today the Republic of Serbia doesn't use any ICT in emergency services, even there were few positive initiatives. The main reason is the lack of financial resources. We hope that this sector in the future will adpopt some of presented ICT as an urgent need to mitigate risks in urban and also on republic in general.

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USING BASELOG SYSTEM IN ECOLOGY

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ABSTRACT

Basic aim of this paper is to present the Baselog system that can be used as an expert system in ecology area. It is a complex software system developed at Technical faculty »Mihajlo Pupin« that can be used, for example, as an shell for analyses of air pollution data. This data for air pollutants in urban region is collected on Internet, at Provincial Secretariat site and its aqusition in a form suiatable for proccesing and analyzing is described. Baselog system is presented also, as well as collected and transformed data part to ilustrate air pollutants concentration analyses with rules that simulates expert knowledge and skills.

Key words: *expert system, baselog system, ecology, air pollution.*

INTRODUCTION

Baselog system is automated reasoning system developed for research purposes on University of Novi Sad, at Technical faculty in Zrenjanin. This system could help researchers in ecology and other areas to analyze various data and information from internal fact base. They, also, can create different answers on questions that require expert knowledge. Software can make conclusions from reasoning rules like human experts. The system will, in all cases where the request from real world considers “true facts” gave the answer – »Yes«, evidence was found. In the case of “false facts” - system was not able to prove a query, and that is not correct, so it will return the answer »No«.

BASELOG SYSTEM

Baselog system concept and its program implementation enabled the integration of good properties of Datalog, Prolog and ATP system, and so is realized a more flexible system in reference to the work in the closed, respectively opened world (Ceri et al., 1989). Specifical needs in the development for the work with databases ask just development and application of such system, and it makes it more superior in reference to Datalog, Prolog and ATP system, considered separately (Kowalski et al., 1971; Radulovic et al., 2000; Stonebraker et al., 1990; Radulovic 1998).

Some automated reasoning systems can give incorrect answers if they work in closed world concept (Bratko 1986), or correct answers if they work in open world concept where the answer depends on fact base completeness (Kowalski et al., 1971). If fact, the base is incomplete, some of automated deduction systems can consult facts from various extension files. In order to enable work with greater data amount there arose a need to access certain databases which can even be distant and then take the piece of data which could be used for deducting a conclusion (Hotomski 2004; Kazi, 2005).

For knowledge databases is also characteristic the open world assumption. In the open world regime works classic systems for the automatic theorem proving, especially, ATP system (Ullman 1994; Berkovic 1994). The knowledge bases contain limited knowledge segments from a certain field. They can be incomplete, i.e. they do not present total relevant knowledge. The applying of the closed world concept on such databases can bring wrong answers to the asked questions. Because of that the pure concept of the closed world can not be applied for the databases used in the education computing software.

Universal resolution systems from theoretic aspect totally support the work with databases as well, but they show a practical deficiency. It can be seen in the fact that because of the endeavoring to get a semantically expected answer, it is necessary to give a complete space description where the solution is claimed.

In the database area it is, for example, exposed through the necessity of proposing following axiom:

$$t \neq t_1 \wedge t \neq t_2 \wedge \ldots \wedge t \neq t_n \Rightarrow P(t) \tag{1}$$

Where t1 ... tn are the relation database tuples, and P(t) means the tuple t belonging to the database relation (~ is negation).

As it can be seen, already for little number of tuples in database, this axiom has big length, so this theoretic possibility is left in practical applications. Both in Datalog and in Prolog it is made the attempt for solving this deficiency in specific ways. In Prolog it is the strategy of definite failure (Radulovic 1998; Bratko 1986; Berkovic 1997) and in Datalog the CWA-principle (Stonebraker et al., 1990). Meanwhile, no one of these solutions can satisfy education needs in fullness, for the following reasons.

In reference to possible user's questions, there are following options:

1) the answer to the question is deducible from the base,
2) the answer to the question is not deducible from the base,

Where in 2) we differ:

a) The answer needs to be affirmative,
b) The answer needs to be negative.

In a) when the answer is deducible from the base; it will be found and presented to a user either Prolog, Datalog or Logpro are based on ATP-system.

Specificities are being reflected in b). According to the adopted the CWA-assumption in Datalog, respectively the definite failure concept in Prolog, there are possible incorrect or indefinite answers. So in b1) Datalog can generate the incorrect answer NO, while Prolog's answer "NO" can be interpreted as "*uncertain*". In b2) Datalog answer "NO" is correct, and Prolog answer "NO" can be interpreted as "NO". In both cases b1) and b2) Logpro based on ATP gives answer "*uncertain*".

We observe that in educative meaning Datalog according to the b1) does not satisfy, while Prolog and Logpro based on ATP give acceptible, but uncertain answers. In b2) Datalog gives correct and precise answer, while Prolog and Logpro based on ATP gives inadequately precise answers. From the educative aspect it is desirable to lessen the indefiniteness of the system answer and it is necessary to eliminate the unallowed answers. Otherwise, there is need to keep the definiteness present in Datalog for b2) and eliminate unallowed answer from b1). Implementing Baselog-system projected on the list of the CWA–predicate and the CWA–rule, a flexible concept has been realized. Such system all predicates which are in the CWA-list treats as Datalog, in closed-world, while all the other predicates treat in open world, i.e. works as ATP. With it, it is free of Prolog defects in reference to the negation treatment and the definite failure concept.

The basis for Baselog - system makes following components (Radulovic et al., 1997; Radulovic 1998; Radulovic et al., 2000):

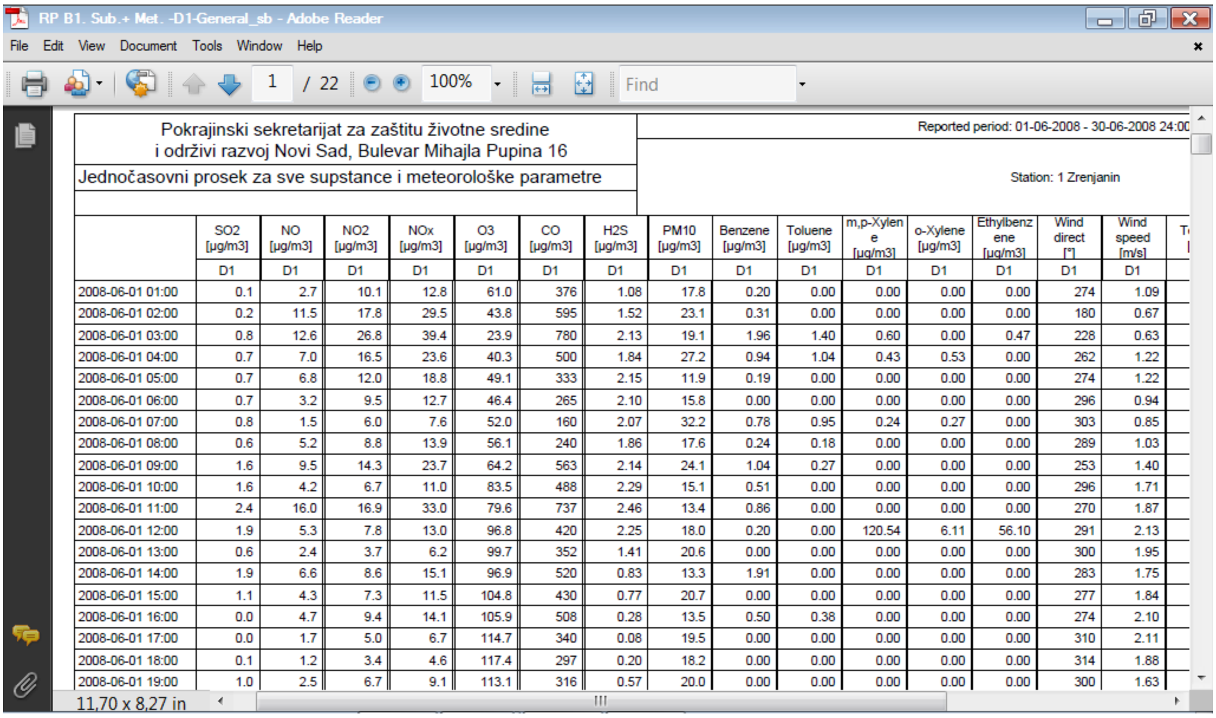
- The CWA–predicate list, which is a part of the program,
- The CWA–rule,
- The CWA–controller by which is enlarged ATP resolution system.

The whole Baselog - system is the extension of the resolution method by the concepts of the opened and closed world. By the CWA–controller one provides doing a degree of the world openness/closeness for the program predicates.

Every literal of the form $R(w_1,...,w_m)$ where R is predicate name mentioned in the CWA- predicate list, and $w_1,...,w_m$ are arguments, Baselog - system will treat in the closed system regime, while all the other predicates that are not in the CWA–predicate list, by the system will be treated in the open world regime. Here, the CWA–controller of Baselog-system uses the CWA–rule, formulated in the following way.

AIR POLLUTION DATA COLLECTING AND ACQUISITION

Air pollution monitoring is carried in order to obtain reliable and good quality data on environment. Air monitoring provides raw measurements of air pollutant concentrations and with appropriate analysis and interpretation these measurements can be transformed into useful information about air quality. The data measurement is carried out by monitoring with automatic measuring station in urban zone, in Zrenjanin (data source: Provincial Secretariat Internet site). Automatic station is designed to monitor pollution levels in residential and commercial zone that comes primarily from traffic and other sources.



Pokrajinski sekretarijat za zaštitu životne sredine
i održivi razvoj Novi Sad, Bulevar Mihajla Pupina 16

Jednočasovni prosek za sve supstance i meteorološke parametre

Reported period: 01-06-2008 - 30-06-2008 24:00

Station: 1 Zrenjanin

	SO2 [µg/m3]	NO [µg/m3]	NO2 [µg/m3]	NOx [µg/m3]	O3 [µg/m3]	CO [µg/m3]	H2S [µg/m3]	PM10 [µg/m3]	Benzene [µg/m3]	Toluene [µg/m3]	m,p-Xylene [µg/m3]	o-Xylene [µg/m3]	Ethylbenzene [µg/m3]	Wind direct [°]	Wind speed [m/s]
	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1
2008-06-01 01:00	0.1	2.7	10.1	12.8	61.0	376	1.08	17.8	0.20	0.00	0.00	0.00	0.00	274	1.09
2008-06-01 02:00	0.2	11.5	17.8	29.5	43.8	595	1.52	23.1	0.31	0.00	0.00	0.00	0.00	180	0.67
2008-06-01 03:00	0.8	12.6	26.8	39.4	23.9	780	2.13	19.1	1.96	1.40	0.60	0.00	0.47	228	0.63
2008-06-01 04:00	0.7	7.0	16.5	23.6	40.3	500	1.84	27.2	0.94	1.04	0.43	0.53	0.00	262	1.22
2008-06-01 05:00	0.7	6.8	12.0	18.8	49.1	333	2.15	11.9	0.19	0.00	0.00	0.00	0.00	274	1.22
2008-06-01 06:00	0.7	3.2	9.5	12.7	46.4	265	2.10	15.8	0.00	0.00	0.00	0.00	0.00	296	0.94
2008-06-01 07:00	0.8	1.5	6.0	7.6	52.0	160	2.07	32.2	0.78	0.95	0.24	0.27	0.00	303	0.85
2008-06-01 08:00	0.6	5.2	8.8	13.9	56.1	240	1.86	17.6	0.24	0.18	0.00	0.00	0.00	289	1.03
2008-06-01 09:00	1.6	9.5	14.3	23.7	64.2	563	2.14	24.1	1.04	0.27	0.00	0.00	0.00	253	1.40
2008-06-01 10:00	1.6	4.2	6.7	11.0	83.5	488	2.29	15.1	0.51	0.00	0.00	0.00	0.00	296	1.71
2008-06-01 11:00	2.4	16.0	16.9	33.0	79.6	737	2.46	13.4	0.86	0.00	0.00	0.00	0.00	270	1.87
2008-06-01 12:00	1.9	5.3	7.8	13.0	96.8	420	2.25	18.0	0.20	0.00	120.54	6.11	56.10	291	2.13
2008-06-01 13:00	0.6	2.4	3.7	6.2	99.7	352	1.41	20.6	0.00	0.00	0.00	0.00	0.00	300	1.95
2008-06-01 14:00	1.9	6.6	8.6	15.1	96.9	520	0.83	13.3	1.91	0.00	0.00	0.00	0.00	283	1.75
2008-06-01 15:00	1.1	4.3	7.3	11.5	104.8	430	0.77	20.7	0.00	0.00	0.00	0.00	0.00	277	1.84
2008-06-01 16:00	0.0	4.7	9.4	14.1	105.9	508	0.28	13.5	0.50	0.38	0.00	0.00	0.00	274	2.10
2008-06-01 17:00	0.0	1.7	5.0	6.7	114.7	340	0.08	19.5	0.00	0.00	0.00	0.00	0.00	310	2.11
2008-06-01 18:00	0.1	1.2	3.4	4.6	117.4	297	0.20	18.2	0.00	0.00	0.00	0.00	0.00	314	1.88
2008-06-01 19:00	1.0	2.5	6.7	9.1	113.1	316	0.57	20.0	0.00	0.00	0.00	0.00	0.00	300	1.63

Figure 1. Data measurement carried out with automatic measuring station

Collected data about air pollution that has been measured by automated monitoring stations accross the Vojvodina province in Serbia (Kazi et al., 2011). For each hour a day, automatic stations are designed to monitor pollution levels of values of following components: ozone (O_3), oxides of nitrogen - nitrogen monoxide, nitrogen dioxide (NO, NO_2, NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), particulate matter (PM_{10}, $PM_{2.5}$), hydrogen sulfide (H_2S), benzene, toulene, m.p-Xylene, o-Xylene and ethybenzene. Monitoring data were stored and published as Adobe Acrobat file format (PDF) at Internet portal of Provincial Secretariat for Protection of Environment and Sustainable Development of Vojvodina region, Serbia. We use public access of these data from http://www.eko.vojvodina.gov.rs. These measurements aquired data for each day (date) and appropriate time (hour, minute), having measurements each hour a day. These measurement data are concentrations of CO, SO_2, NO, NO_2, NOx, O_3, H_2S, PM_{10} (Particulate Matter 10), Benzene, Toluene, m.p-Xylene, o-Xylene and Ethybenzene, with other relevant data such as: air temperature, atmospheric pressure, wind speed and wind direction. All the measurement units of air pollutant values are [*µg/m3*] except for wind speed [*m/s*] and air temperature [*°C*]. We converted data from PDF format to simple ASCII text format using Adobe Acrobat Reader tool (Save as text option). This ASCII file is imported by Microsoft Excel tool to be transformed to Microsoft Excel table. Clauses form of data required in Baselog system are generated from Excel table.

AIR QUALITY STANDARDS

Air quality standards for European Union (European air quality database; Directive 2008/50/EC) or USA (U.S. Environmental Protection Agency) define air pollutants as components to be measured and the required levels of these air pollutants related to certain time period of measurement.

Table 1: European union air quality standard (Ionel et al., 2011)

Pollutant	Concentration	Averaging period	Permitted exceedences each year
Sulphur dioxide (SO_2)	350 µg/m3	1 hour	24
	125 µg/m3	24 hours	3
Nitrogen dioxide (NO_2)	200 µg/m3	1 hour	18
	40 µg/m3	1 year	n/a
PM10	50 µg/m3	24 hours	35
Carbon monoxide (CO)	10 mg/m3	Maximum daily 8 hour mean	n/a
Ozone (O_3)	120 µg/m3	Maximum daily 8 hour mean	25 days averaged over 3 years

"Under the new Directive the Member State was able to apply for an extension until three years after the date of entry into force of the new Directive (i.e. May 2011) in a specific zone. Request was subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (35 days at 75µg/m3 for daily PM10 limit value, 48 µg/m3 for annual PM10 limit value). Under the new Directive the member State can apply for an extension of up to five years (i.e. maximum up to 2015) in a specific zone. Request is subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (48 µg/m3 for annual NO2 limit value)." (Ionel et al., 2011)

BASELOG SYSTEM AS AN EXPERT SYSTEM IN ECOLOGY

Baselog system is consisted of three elements: basic axioms, self axioms and the CWA list. Users can enter this parts of program in a program that is called Baselog Editor. It is shown on figure 2. This enters could be formed on three different ways: like clauses, predicate calculus formulas or junctions.

After entering these three parts of program, that could be parts of an expert system schell, users can create different questions in a form of queries.

Answer to a user's query is accomplished by denial (refutation) of query's negation by deep strategy for arrayed axioms which make its own and base axioms. Proof is inferred with help of OL-resolution with marked literals with CWA rule. Activation of CWA rule erases last literal in central junction. This rule is activated only if OL-resolution cannot be applied, which is when last literal of central junction consists a predicate which cannot resolve with other predicates. That means that refutation of that literal is not possible. It still doesn't mean that negation of that literal is not refutable in given axiom system. If it comes up that negation of the literal itself is TRUE as a logical consequence of given axioms (for that reason OL-resolution couldn't refute it) and it implies that its negation is not a logical consequence of given axioms, so it is FALSE and must not be used as an additional conjecture, and CWA rule must not be used in this case! If it is impossible to refute the literal OL resolution will abandon the junction and skip to another one. Having in mind that the junction is a tautology, because it has the last literal which has TRUE value T (qVT = T) it can be erased from the set of resolutions, because tautologies are not used for refutation. Still, if it appears that even negation of the last literal in junction cannot be refuted with resolution, as well as the last literal itself, then within concept of closed world it can be taken as an additional conjecture that the negation of the literal is TRUE.

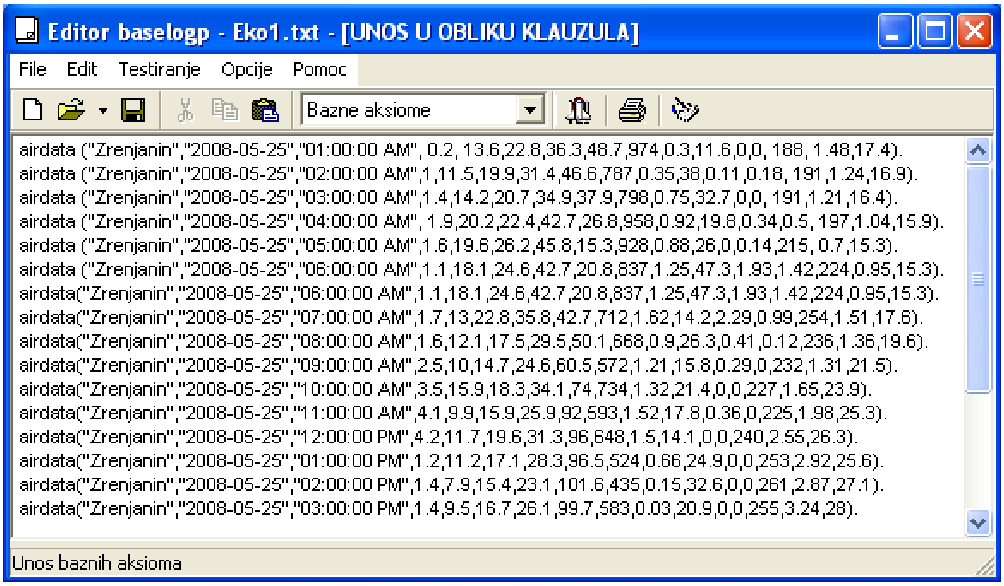


Figure 2. Ecological data as base axioms in Baselog editor

Testing result of chosen or created paradigm can be:
1) Regular work and end of Baselog program where the result is Yes, No or Not Deducable.
2) Irregular work, when procedure work stops due to incorrect data input. There is often a message with explanation for occurred error cause. If an error occurs program stops its work and warns user about the type of error. If the error is corrected and testing procedure starts again, program will continue its work only if correction satisfies criteria check of input correctness.

Predicate needed for axioms handling within the system is called »airdata« and it has following form and arguments:

airdata (Station Code, Measurement Date, Measurement Time, SO2 [µg/m3], NO [µg/m3], NO2 [µg/m3], NOX [µg/m3], O3 [µg/m3], CO [µg/m3], H2S [µg/m3], PM10 [µg/m3], Benzene [µg/m3], Toluene [µg/m3], Wind Direction, Wind Speed [m/s], Temperature [°C]).

Example of basic axioms, created in a form of clauses, showing measured air pollutants values for one hour:

airdata (zr,"2008-05-25","01:00:00 AM", 0.2, 13.6,22.8,36.3,48.7,974,0.3,11.6,0,0, 188, 1.48,17.4).

Values of all arguments of this predicate are listed bellow:
Station Code=zr (X1),
Measurement Date=2008-05-25 (X2),
Measurement Time=01:00:00 AM (X1),
SO2=0.2 µg/m3 (Y1),
NO=13.6 µg/m3 (Y2),
NO2=22.8 µg/m3 (Y3),
NOX=36.3 µg/m3 (Y4),
O3=48.7µg/m3 (Y5),
CO=974 µg/m3 (Y6),
H2S=0.3 µg/m3 (Y7),
PM10=11.6 µg/m3 (Y8),

Benzene=0 µg/m3 (Y9),
Toluene=0 µg/m3 (Y10),
Wind Direction=188 (Y11),
Wind Speed=1.48 m/s (Y12),
Temperature=17.4 °C) (Y13).

Self axioms, also created in a form of clauses, created from European union air quality standard for air pollutants maximum allowed concentrations (Table 1.) for CO, NO2, SO2 and O3 are :

```
pollutionCO:-airdata(X1,X2,X3,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13),Y6>1250.
pollutionNO2:-airdata(X1,X2,X3,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13),Y3>200.
pollutionSO2:-airdata(X1,X2,X3,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13),Y1>350.
pollutionO3:-airdata(X1,X2,X3,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13),Y5>1250.
pollutionhigh:-pollutionCO,pollutionNO2,pollutionSO2,pollutionO3.
```

CWA list for this example is empty, because we do not have all the knowledge from this area.

Writing and defining query as an question to the Baselog system is shown on Figure 3.

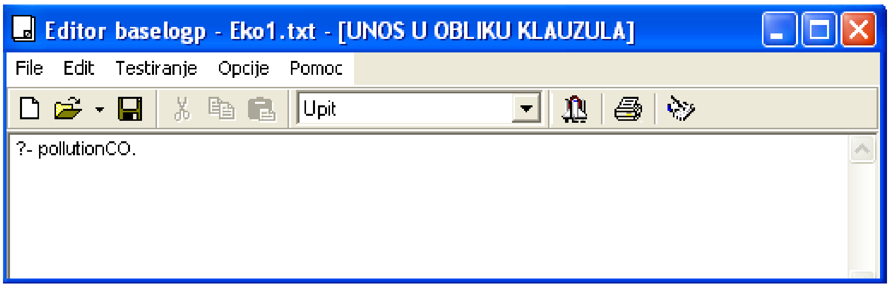


Figure 3. Query in Baselog editor

Examples of queries:

a) »Is concentration of Carbon monoxide (CO) for one hour higher than allowed?«

```
?- pollutionCO.
```

Answer for this query is “YES” if the value of this pollutant is greater from the given value in self axiom. In this case the proof is found and we can certainly say that the concentration of Carbon monoxide is very high. In other cases, when this value is smaller than given value, system answers “NO”. In our example answer is “NO”, so we can conclude that the concentration of this pollutant is not high in searched period.

b) »Is concentration of Ozone (O3) for one hour higher than allowed?«

```
?- pollutionO3.
```

Answer for this query is “NO”.

c) »Are concentrations of all observed air pollutants higher than allowed?«

```
?- pollutionhigh.
```

Answer for this query is also “NO”, so we can say that for this small data segment of air pollutants measured in one day, the required levels of these air pollutants are consistent with air quality standards for European Union.

Further work for serious usage and implementation for this kind of computer software in ecology area is projecting transformation proccess of measured air quality data from stations to the form of program axioms in Baselog editor.

CONCLUSION

The aim of this paper is familiarize readers with Baselog system for the purpose to create an expert system schell that can be used in ecology and environmental protection projects. Baselog system concept is a flexible system in reference to the work in the closed, respectively opened world. In our example it works in opened world. It could be applied in the following branches of any science area: generation of answers to questions asked by researchers, testing hypothesis, finding contradictions in answers and discovering gaps in knowledge.

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ACCIDENTS IN URBAN AREAS

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THE SIGNIFICANCE OF BIOINDICATORS IN THE PREVENTION OF ENVIRONMENTAL DISASTERS

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ABSTRACT

The presentation is about the significance of the bioindicators concerning environmental protection. Qualifying the environment biologically and evaluating conditions ecologically might be the solution to avoid and prevent environmental disasters in some situations. The biological quality of an environment is defined as the condition reflecting the quantitative representation of living organisms in a given space and time. My lecture presents how to qualify the environment of a biocenosis synbiologically, in other words, on the supraindividual level. In this case, qualifying the environment in practice means that both the quantitative and qualitative composition of the biocenosis, and also the factors responsible for their distribution in space and time are considered and evaluated as characteristics. The ultimate goal of examining conditions is to evaluate, in other words, to determine relevancy and significance in a given biocenosis. We are facing the problem that in Hungary at present the biological survey methods are not standardized, and they are highly varied. An environmental information system however cannot function before appropriate methods of biological survey are created. The lack of such methods would result that one of the three major, organically complementary sources of information (i.e. the abiotic sphere, the biosphere, and human society) is completely missing. From a different aspect, ecological survey studies are different from the rest of environmental survey studies, inasmuch as they study living organisms and their communities, thus inevitably utilizing the results of other environmental survey studies that evaluate different components. This indicates that the ecological section of all environmental survey studies is vitally important due to its complexity, and should be considered primarily decisive.

Keywords: *the bioindicators of environmental; qualification of natural habitat; ecological qualification of environment; supraindividual biological qualification of environment; ecologically evaluated conditions.*

INTRODUCTION: THE QUALIFICATION OF NATURAL HABITATS, AND NATURAL WATERS

Basically, there are two approaches to examine and determine natural habitat and water quality, and in a broader sense, environmental quality.

One approach makes the qualifications based on the indicators of end use (e.g. the parameters of drinking, industrial, irrigation, and sewage water), and interprets the data according to the appropriate standards. This approach is not quite operative because of its oversimplification. Obviously, any entity in the environment has a “quality” not only if it is used for some purpose. This is to confuse quality with the concepts of practicability, adequacy or utility.

The other approach determines environmental quality as the totality of attributes. This means that environmental quality is not determined based on a single characteristic, and it does not single out one variable, e.g. the temperature, the light conditions, the phosphorus content, etc.

Water as an environmental element can be defined as the sum of hydrological, physical, chemical, and biological characteristics. Some factors to be considered are: the properties of currents, the temperature and translucency of water, its free oxygen content, its ionic composition, its richness in different organic matter and living organisms, and various other factors.

If one wants to determine the actual quality of an environmental element, one cannot be limited to the examination of the relevant properties of the components separately. The qualitative “junctions” of any material system are not only, and moreover not primarily, characterized by the number of and the values of the components, but rather by their specific structure, i.e. the particular system of interconnections of the components within the domains of the given system. To analyze and interpret the complexity of the specific particularities created by the interactions of the individual constituents is significantly more complicated and more intricate than to study the idiosyncrasies of the individual components.

According to contemporary ecological concepts the natural relief entities can be classified into three types regarding types of habitat *(Dévai, 2004):*

- Aquatic habitat, with surface-ratio average depth of more that 2 meters at mid water level where no macrovegetation can be found
- Semi-aquatic habitat are natural entities, which average depth at mid water level does not exceed two meters, or such parts of deeper water basins which have at least one-third of their surface covered by macro-vegetation (tang, sea-weed, marsh or margin plants), and also areas which surface is covered with hydromorph soil (reed and marsh plants or soft or tough wood)
- Terrestris habitat are areas with no water surface, and where upper layers of soil are not constantly waterlogged (only temporarily and for a short period).

In my presentation among the examinations aiming at the state of the non-living environment I have pointed out the living creatures as examination modes measurable by indicators.

These proceedings do not require serious chemical analysis or complex technical equipment, therefore they are significantly cheaper. Nonetheless they provide reliable information about the state of the environmental aspects.

Biotechnological proceeding are becoming more widely-accepted; for water- and soil qualification the application of biological indicators is indispensable nowadays.

BIOLOGICALLY QUALIFIED ENVIRONMENT

The biological quality of an environment is defined as the condition reflecting the quantitative representation of living organisms in a given space and time. The object of our examination can be a living being, a single individual, or a single part of an individual (e.g. an organ, a cell, a gene), or a single characteristic of the individual (e.g. its metabolism, its perception.) In the latter case, the biological environment qualification deals with the infraindividual, or "below" the individual level.

The object selected can be a population of a single species, or a group of populations. A population is an isolated group of individuals of the same species, existing together in space and time, thus creating an actual reproductive community. A group of different populations existing together in space and time is called a biocenosis.

My lecture presents environment qualification in a biocenosis synbiologically, i.e. on the supraindividual or "above" the individual level.

Figure 1. The condition of natural waters evaluation by observing bioindicators
(The figure 1 is the author's work)

Zoocoenoses can be characterized by defining the animal species, which they comprise of, and the number of individuals, which live within the biocoenosis (number of individuals and frequency of appearance).

The characteristics of quantity conditions of animal associations, their numerical values can be acquired by recording data of zoocoenoses. Thus, various animal associations can be compared:

Formula of Sorensen: $K_s \quad \frac{2cX100}{a + b}$

In this formula „a” is the number of taxons recorded in the first zoocoenosis ont he basis of the survey, „b” signifies the number in a different zoocoenosis, „c” signifies the number of taxons which can be found in both „a” and „b” associations. The two survey result can be considered similar if Ks. The two survey result can be considered similar if Ks >50%.

During recording data of zoocoenoses quantity data refers to numerical characteristics. The absolute characteristics are abundance and production, relative characteristics are dominance and weight-dominance.

Among structural charcteristics the most importatnt is constancy, which expresses the percentage of the examined area (or cubic content) where a species (type) appears.

Determination of the ecological state of natural water currents, the quality of water with the help of BISEL method

The BISEL method is suitable for ascertaining the fact of water contaminationon the basis of the reaction of macro evertebrate indicators. Biological Index calculated on the basis of the bioindication of low tolerance special species, where variations in the quality of water are marked by different colours.

In the case of a large quantity of organic substances as a result of biological disintegrating processes the oxigen content of the water decreases, therefore some species among the macro evertabrate decrease by number, or the species may disappear entirely from the water.

The most sensitive species are Plecoptera (*Figure 2 and 3)*, Trichoptera (*Figure 4)* and Ephemeroptera (*Figure 5*), the most tolerant are Tubificidae (*Figure 6)*, Chironomidae (*Figure 7)*, and Syrphidae.

Biotical Index is a scale numbered 1-10, where the higher number denotes the availability of more sensitive species, which expresses the level of water adequacy (small amount of contamination). Values 0-5 denote contaminated water, at value 0 all species are absent from the water, except the the group of Eristalinae (Syrphidae). Applied together with chemical methods, this method allows the deduction of the causes of contamination.

Figure 2. ***A*** *Capnura manitoba male larva,* ***B*** *Capnura manitoba adult (www.discoverlife.org)*

Figure 3. ***A*** *Alloperla petasata larva* ***B*** *Alloperla petasata adult (www.discoverlife.org)*

*Figure 4. **A** Phryganea grandis larva, **B** Phryganea grandis adult (www.discoverlife.org)*

*Figure 5. **A** Ameletus browni larva, **B** Ameletus browni male adult (www.discoverlife.org)*

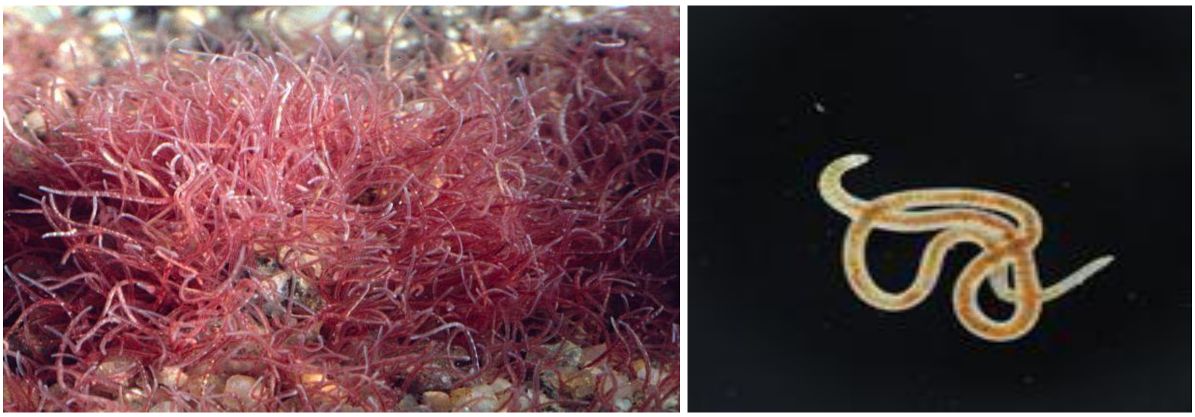

*Figure 6. **A, B** Tubifex Worm Tubificidae (www.animalsandearth.com)*

*Figure 7. **A** Chironomus plumosus larva (www.natur.cuni.cz), **B** Chironomus plumosus adult (no.wikipedia.org)*

Guideway for BISEL method:

1). Defining number of considerable toxons (crossing out toxons, which are represented in the sample by only one piece)
2). Defining the most sensitive toxon (Plecoptera /*Figure 2, 3*/, after that Trichoptera /*Figure 4*/)
3). Calculating the biological Index denoting the water quality by observing the number of types of toxons and the number of pieces of the most senstivie toxon.

Defining the anaerobic state of the water, demonstrating its sulphur-hydrogen content

Significant presence of sulphur-hydrogen in the water suggests anaerobic conditions. The lead-nitrate is blackened by the influence of sulphide ions.

Sulphur bacteria, Thiocystis, Chromatium, and Beggiatoa species *(Figure 8)* point to insufficient clarification level, the formation of hydrogen sulphide, and the stage of putrefaction due to oxygen deficiency. A significant increase in the number of these bacteria results in a white, “furlike” coating. The presence of nematode bacterium Thiotrix nivea *(Figure 9)* is an indication of the final stage, the ultimate putrefaction of water: hydrogen sulphide indicator. This stage can be avoided if the other indicators are paid attention to in a timely manner.

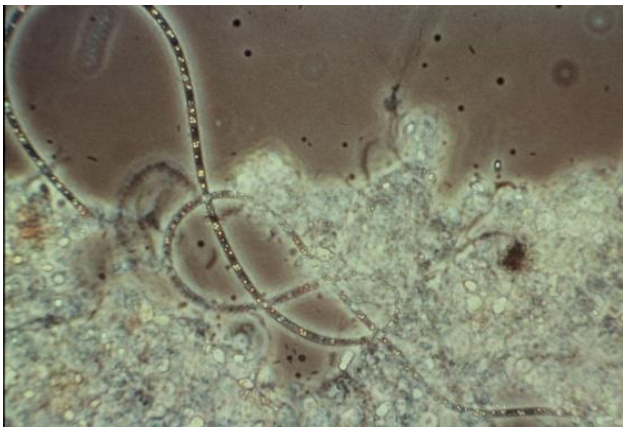

Figure 8. Beggiatoa thread (magnified 400 times)

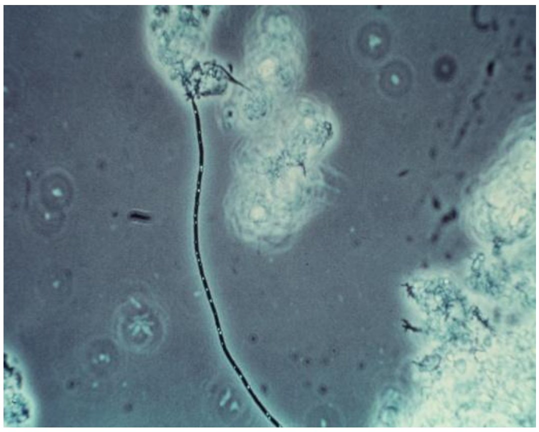

Figure 9. Thiotrix nivea (magnified 400 times)

CONCLUSIONS

Qualifying the environment biologically and evaluating conditions ecologically might be the solution to avoid and prevent environmental disasters in some situations.

Ecological survey studies are different from the rest of environmental survey studies, inasmuch as they study living organisms and their communities, thus inevitably utilizing the results of other environmental survey studies that evaluate different components. This indicates that the ecological section of all environmental survey studies is vitally important due to its complexity, and should be considered primarily decisive.

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ENVIRONMENTAL IMPACT ASSESSMENT OF ACCIDENTS IN FOOD PROCESSING INDUSTRY - EXAMPLES OF GOOD ENGINEERING PRACTICE

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ABSTRACT

Environmental impact assessment of accidents includes the identification of possible accidents as well as protection measures. As potential causes of accidents can be listed: the human factor (inadequate management of technological processes, inattention, lack of training, failure to comply with the rules for safe work, irregular and inadequate maintenance of equipment and machines, etc.), mechanical failures, natural disasters (floods, thunderstorm, thunder, etc.), fueling problems and possible wartime situations and destructions. The key task is to apply protective measures and regular control measures. In this way, acceptable risk level is provided. In recent years, in most food processing industries, modern technologies with almost fully automated working process are represented. However, the potential risk of accidents, particularly of hazardous substances and fire is always present.

Key words*: accidents, environmental impact assessment, food processing industry.*

INTRODUCTION

The intensive urbanization, as well as modern requirements of life and work, lead to degradation of the environment, particularly of air, water and soil.

In western countries, for over 20 years, the government institutions, as well as various non-governmental institutions or investors are engaged in environmental impact assessment caused by capital investments and industrial plants. The technical committee (ISO / TC 207) of International Organization for Standardization has made a series of regulations related to the management of environmental quality.

In recent years in our country, great attention was paid to preventive action within an integrated system of environmental management. Consequently, in many cases there is a requirement of the Environmental Impact Assessment (EIA) Study, for all objects that can significantly compromised the environment. In this way it can prevent and stop further degradation of the environment, the importation and introduction of obsolete and so-called "dirty" technologies and systems, which are great and potentially dangerous environmental pollutants, as well as to prevent chemical or environmental accidents. Possible plant's impact on the environment may arise within its normal operation or in the event of accidents. The most common accidents related to hazardous materials, fires, and the failure of regulating selectors and safety equipments.

The objective of this paper is to give an overview of the main problems in the field of food processing industry in Serbia, during their usual working process and in the case of accidents, from the aspect of environmental impact. Also, some solution from the standpoint of the environmental impact assessment of accidents are presented.

RESULTS AND DISCUSION

Environmental impact assessment of accidents involves the identification of possible accidents as well as protection measures.

The sugar production factory AD "Fabrika šećera TE-TO Senta" and factory "Dijamant" Zrenjanin-sunflower warehouse are good examples for environmental impact assessment of accidents

In the factory AD "Fabrika šećera TE-TO Senta" identification of potential hazard sources included identification of critical points, activities and processes of plant and equipment, objects within a particular plant or warehouse, and industrial complex as a whole, including the risk of accidents during decanting hazardous substances (www.zenta-senta.co.rs).

Accidents caused by hazardous materials may differ, consequently varies the intensity of the environmental impact. In the case of local leaks and spills of small quantities of hazardous materials, the air would be most affected. Their evaporation cause possible, slight air pollution in the vicinity of spillage. Soil contamination would be insignificant due to the concrete base in factory complex.

In the case of small-scale fire, due to heat release, the temperature of the environment increase. Also, gaseous and solid combustion products (with varying degrees of toxicity) primarly pollute the air, followed by deposition of water and soil. Accidents can occur owing to failure of the metering regulation selector and safety equipment.

As potential causes of accidents can be listed: the human factor (inadequate management of technological processes, inattention, lack of training, failure to comply with the rules for safe work, irregular and inadequate maintenance of equipment and machines, etc.), mechanical failures, natural disasters (floods, thunderstorm, thunder, etc.), fueling problems and possible wartime situations and destructions.

The key task is to apply protective measures and regular control measures. In this way, acceptable risk level is provided. In the factory AD "Fabrika šećera TE-TO Senta" there are modern technologies with almost fully automated working process. However, the potential risk of accidents, particularly of hazardous substances and fire is always present.

Given the fact that the corrosive and toxic substances are used in technological processes, there is a risk of chemical accidents. In case of leakage of hazardous substances, primarily hydrochloric acid, sulfuric acid, sodium hydroxide and formaldehyde special tub were made (Vitorovic et al. 1996, „Službeni glasnik RS", br. 36/09, 88/10, 92/11 i 93/12). In this way there is no possibility of soil and groundwater pollution, but exists a risk of toxic and corrosive effects on workers. Also, the fumes of hazardous substances can affect air pollution and workers intoxication.

Besides the chemical accident at the factory, there is a risk of fire or explosion. Fortunately, most fires can be categorized as initial and as such may be damp down by workers trained in the field of fire protection, without major adverse effects. The potential danger is the situation in which these fires can get out of control and take on larger proportions. Flammable materials which may cause fires and explosions are an explosive mixture of gases, vapors and dust, as well as substances that can make an explosive mixture with air (Službeni glasnik SRS″, br. 44/77, 45/85 i 18/89 and ″Službeni glasnik RS″, br. 53/93, 67/93, 48/94; 101/05). One of the main causes of fires is failure on the installation of natural gas (used as fuel for drying pulp and steam boilers). Fires can also act indirectly to chemical compounds, whereby toxic gases ensue. Serious explosion risk arises from the possibility of creating sparks caused by static electricity (flow of the sugar particles through the installations). Considering mentioned facts, the sugar factory rated as one of the factories where the risk of fire and explosion is very strong (second category of objects affected by the fire).

Bearing in mind the risk of chemical accidents, fires and explosions, it is necessary to assess the impact on air, water, soil, health of the population, protected natural and cultural resources, noise, eco-systems etc. (www.zenta-senta.co.rs). In this paper some of them will be explained.

Air pollution impact assessment - Gaseous pollutants are usually present in air, when pipe or tanks that contain chemicals are damaged. In the case of factory AD "Fabrika šećera TE-TO Senta" as the most important gaseous pollutants should be noted: sulfuric acid fumes (aggressive, irritating, toxic in certain concentrations), heat resulting gases of hydrochloric acid (corrosive and toxic), formaldehyde (build an explosive mixture with air). In the event of an explosion or fire, air contains smoke, which would include a number of substances of different degrees of toxicity (soot, ash, dust, CO, SOx, NOx, etc.). The concentration of pollutants depends on the weather. Having in mind toxicity and the mass of gaseous substances, heat and burning rate, usually weather conditions in a given area, it is estimated that in the event of a fire can be local, but not long-term air pollution, with no lasting consequences („Službeni glasnik RS", broj 36/09 i 10/13).

Soil and wather pollution impact assessment – At critical points in the factory, where there is the possibility of spills of hazardous materials, impermeable tub are are made. The possibility of contamination of ground water is excluded while the pollution of surface water is insignificant. Releases to groundwater and surface water is possible in the event of diversion and large-scale natural disasters. Particles due to air after the fire, fall and accumulate on the soil and buildings. Through soil they can reach in surface and ground water. Contaminants may enter in the soil and water over acid rain, which affect a much wider area. In this case the effects are long-lasting (″Službeni glasnik RS″, 30/10 i 93/12).

Health impact assessment – The consequences of accidents would be reflected primarily in the respiratory tract and skin. Inhalation of vapors of acids and bases can cause coughing, nausea, vomiting, and even pulmonary edema. Inhalation of vapors of corrosive substances can lead to effects ranging from mild irritation to severe tissue and respiratory organs damage. Workers are primarily exposed to these effects, rarely local population. In event of fire, poisoning the population by toxic gases is unlikely, because the factory is located about 700 m from the first housing facilities (″Službeni glasnik RS″, br. 101/05).

Noise impact assessment – In the case of accident followed by an explosion, the moment of its creation is followed by the noise of great intensity, about 120 dB. However, this effect was immediate („Službeni glasnik RS", broj 88/10).

After the impact assessment of accident, it is necessary to prescribe the measures envisaged by the Act and regulations, in order to prevent, reduce and where possible elimination of harmful environmental impact.

Another example of good practice is the factory AD „Dijamant“ Zrenjanin (www.zrenjanin.rs). The Environmental Impact Assessment Study of the company „Dijamant“ AD in Zrenjanin - sunflower warehouse was done in September 2008 (no. IV-05-01-501-35, 16.10.2008).

CONCLUSION

The last year large economic systems in Serbia, including food production factories, must adjust their activities with requirements of environmental and legal regulations in the field of environmental protection, which impose numerous obligations to companies. Mentioned economic systems have serious attitude and commitment to proper application of the basic principles of environmental protection as one of the fundamental steps towards sustainable development with minimal environmental impact. The sugar production factory AD "Fabrika šećera TE-TO Senta" and factory "Dijamant" Zrenjanin- sunflower warehouse are good examples of responsible management, which is related to the environment. Based on the Law on Environmental Impact Assessment (″Službeni glasnik RS″, br. 135/04 i 36/09) and the Rulebook of the contents of the Environmental Impact Assessment

(EIA) Study (″Službeni glasnik RS″, br. 69/05), Environmental Impact Assessment Study was made. After completion of air, water, soil, health of the population, protected natural and cultural resources, noise, eco-systems impact assessment, measures that may be implemented in order to prevent, reduce or eliminate harmful effects, were proposed.

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Zakon o zaštiti od buke u životnoj sredini („Službeni glasnik RS", broj 88/10).
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ARROGANT URBANISM AND DISAPPEARING OF GREEN OASES IN RESIDENTIAL AREAS

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ABSTRACT

Independent project of the Collective for development and sustainability - bahatoparkiram.com, not only give us a picture, but also tries, through its activities, to stop bad sides of the incorrect stopping of cars, lack of culture and irresponsibility of individuals in traffic. Stationary traffic is a burning problem of many cities and dissolving this problem demands strict measures, which must be conducted on all levels, starting from urbanistic plans of the highest rank to the inspections in charge. This work was inspired by the name of this site. Besides arrogant parking, by construction of new buildings, disappearing of green oases, losing the right to have a view, insulation and ventilation, the arrogance of this act, stays unnoticed. Bringing regulation plans in, the previous zones of individual residency on Vracar and Zvezdara (the examples will be displayed) these parts of wider center of Belgrade are becoming zones of collective habitants, usually four story buildings, with garages in basements and commercial facilities on the ground floors. Through this paper we will analyze the special aspects of arrogance which lead to ecologically unsuitable and often unrepairable situations with newly-build blocks of flats.

Key words: *arrogance, habitation, ecological, unsuitable, plans*.

INTRODUCTION

The objective of architecture is not only designing of functional and aesthetically designed buildings, but within a given area, creating a healthy environment which will allow users to conduct all of their activities and to meet the needs of the facilities provided.

Effect of Architects includes a broad field, encompassing different levels of spatial and urban planning, design and construction of buildings, and in all these planes imperative must be securing a healthy life. The first step towards healthy living is determined by location, which began tentatively provision of living conditions in the facility itself. Natural location factors - climate conditions, morphological and geological characteristics of the soil and vegetation, although not necessarily, become degraded by urbanization, while created location factors related to the quality of air, soil and water, microclimate changes, noise and radiation are primarily targeted modification of sites, caused by human factor.

ARROGANCE FIRST-THE LOST GARDEN OF BELGRADE SUBURB

The end of the nineteenth century was marked by the work of Ebenezer Howard, the creator of the idea of the garden city. Going back to the ancient ideal of human measurement, he gives the organic form to the city, limits the number of inhabitants and population density, integrates all the essential functions of the community and surrounds area with permanent agricultural green ring. This green ring area also represents a convergence of the rural environment and the separation of the city from the surrounding urban areas.

At the same time, at the end of the nineteenth century, the Serbian capital makes great efforts transforming Belgrade into a modern city, by introducing electric lighting and tram traffic, regulating, leveling and cobbling streets and arranging park sites. Although the resolution of communal issues, approaches systematically and planned, the citizens of some parts of the city feel the need to establish their own associations, which would address issues that Belgrade service could not manage at the time. Society for Beautification of Vračar that was founded in 1884., has greatly contributed to this part of the city, to this day, to be an attractive and the most popular part of Belgrade to many citizens. In the early years of foundation, questions of everyday life were occupying this association, pharmacies, post offices, newsstands were opened. Later, this association participated in sponsoring the construction of still important structures, such as the Third Belgrade High School, Sokolski dom, or Old DIF. Special attention is paid to the Vračar’s greenery and tree-lines. Tree planting started in 1891. when especially lime planters of Vračar streets emphasized and it finds its reflection on the facade of the Society home, the work of architect Antonovic Milan, where branched crown as a symbol of Vračar’s tree-lines was painted.

Figure 1 and 2. Society for Beautification of Vracar and detail of the facade with mosaic lime

Today we read with the sentimentality The Monument of the Society for Beautification of Vracar, because the construction of new buildings already limited green space, which mostly sacrifices naturally reduced. With increasing population, there are requests for housing and other necessary areas, and higher living standards resulting in need for more housing units and better technical equipment. Vračar and the part of the today's Zvezdara municipality around the Red Cross, are attractive locations for new investors, not only because of the proximity to downtown, but just because the dominated space-detached family building with landscaped gardens and tree-mentioned.

We are witnessing the disappearance of family housing from this area, trying not to be nostalgic and to accept objective reasons for the arrangement defined by plans of regulation, and the replacement of tree lines with horticultural monsters (pic. 5, 6 and 7), we can hardly rationally accept. .

Figure 3 and 4. Scenes that disappear-family homes, green and Vracar’s limes

"Unsolvable" problem is that the regulatory plan envisages the construction of underground parking, and the space in front of the building is not on the field, but over parking space. For the growth of trees or any "serious" green arrangements, greater amount of land is needed, which is always a potential threat to the weakness called insulation works, so that often becomes pavement area with a couple of flower pots that are ash-tray-sized, and eventually (by technical acceptance) they gain it function. There is no rebellion against this way of dealing with green space has, as former tenants of old houses themselves got a decent modern apartments, and sitting and children play in gardens will soon become part of the memory. Unfortunately, the new green space is not planned, on the contrary, we have witnessed their removal. "The existing avenues to keep within the gradual replacement of old and dry trees. In the streets of the Central and Medium zones, where is possible, to expand the network of trees." These words taken from the General Plan, remain only on paper.

Figure 5, 6 and 7. Greenery trace, which disappears by neglecting

ARROGANCE SECOND – PARKING

Solution to the parking problem is one of the central issues in the traffic system of Belgrade. According to current applicable standards, for residential zones it is anticipated mandatory capacity building for parking, depending on the planned population density and type of housing, taking into account the forecasted level of motorization that is - one passenger car per household. Detailed regulation plans typically provide one parking space for activities on the ground floor areas of 60m2. This way planned area for parking, should gradually resolve parking in residential areas and minimize driver’s arrogance.

Figure 8 and 9. "I park arrogant on the pedestrian walkway, entrance..." (www.bahatoparkiram.com)

The problem that arises, which seems as if the developers of the plan did not register, is that buying an apartment does not include garage in apartment price. Prices of garage park spaces range from 15-25000 € at Vračar, almost as much as the studio on the outskirts of the city. Many garages are running low, and at the same time arrogantly parking is everywhere on the streets. If the law prescribes mandatory planning garages, it may be a solution and the obligation to purchase a garage, which would be included in the purchasing price of housing unit. Of course, prices of apartments in Belgrade are insanely high (although lately they have decreased on the real estate market, than the decline of price!), so this additional cost burden the square meter price.

GARAŽA 25 000 EUR(1 250 EUR/kv.m) **grad Beograd, Vračar – Hram Katanićeva**

Figure 10. Ad for a garage sale

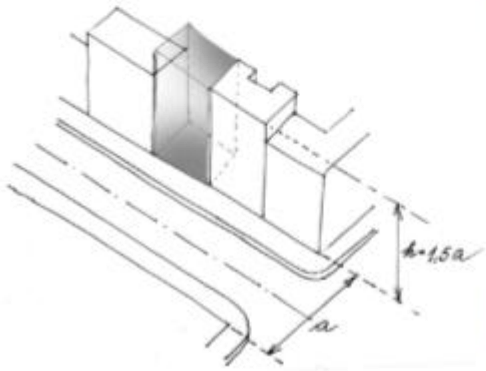
There is another kind of selling parking spaces, which could be characterized as brutal takeover of land around the building. In Figure 11 and 12 the parking lots are shown, which are also on sale (slightly more favorable, from € 10-15000), that plan envisages as green areas above underground garage. These parking lots are with the entrance gates, mostly with the flower pots in which the plants were planted and no one cares about them anymore, and a short time afterwards it is as shown in Figure 12.

Figure 11,12 and 13. Arrogant to park in an area that should be a green area and a mural that speaks most clearly

ARROGANCE THIRD – VIEW FROM THE HEIGHTS OR NO.1 GOLUBACKA STREET CASE

The third arrogance is about analyzing a specific case-upgrading already built facility, GF+4 with three more floors in Golubacka Street at the Red Cross. This street, that used to be family housing area, about 10m wide, has become a zone of collective housing by Detailed regulation plan adopted in late 2003. The plan aimed at "preserving the identity and quality of the neighborhood, whose urban matrix are determined by the first half of 20. century, and the building fund, mostly old and unmaintained, " we will consider whether it comes to keeping the identity and quality of living or the protection of other values, meaning personal and material.

Immediately when the plan was adopted, intensive construction in Golubacka Street and neighboring streets began. By 2010. as almost all buildings in the street were built and the implementation of the plan in the street mentioned was almost completed, except for one object, which surprisingly went under Žička street zone, although it is not "house on the corner ". We do not know how the development of a traffic plan for Slavija-Žička direction, managed to assimilate the existing, recently adopted plan and the facility exempt from this plan, but we got detailed information from Zvezdara municipality, and we sent a letter about this issue. By adopting the Detailed regulation plan Slavija - Zicka, in 2011. it was established regulation of the street and so the conditions are met to establish new rules of order and rules of construction for the area mentioned, and the CP 7141 KO Zvezdara in the Golubačka street no. 1, which are defined by the following rules of construction: max number of floors 6+Pk+P (Ps), and maximum occupancy index is 70%. So everything was done by the law (we did not think that the construction of so many floors could move as illegal construction, it would be too bold venture), but for all the many stunts adoption and cancellation of plans, which is, of course, someone's interest.



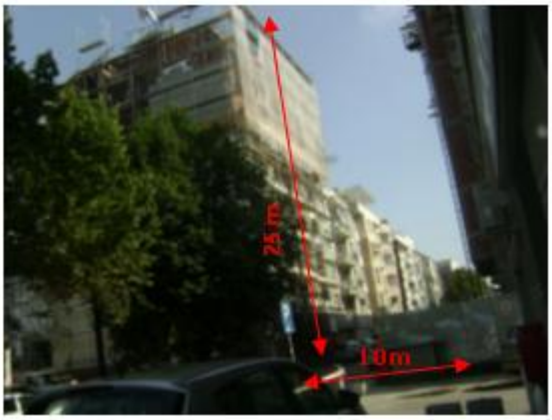


Figure 14 and 15. "In the existing fabric the maximum height of new buildings to the regulation, regardless of the purpose, is equal to 1.5 if the width of the street there are no other restrictions." According to the General Plan of Belgrade, building height in Golubačka Street no. 1 is about 25m and the width streets about 10m

Upgrades of newly built buildings do not contribute to the preservation of the identity of urban development, and these heights (over 20m) in street which is 10m wide, represents destroying of the urban matrix and that is inappropriate for all environmental standards. As the problems of parking and upgraded flats are solved, but will surely represent usurpation so-called green space on the plot, which has been done so far. What can be described as positive, is a rapid response of authorities to comment on the upgrading of this facility, with a detailed explanation of adoption and termination of plans related to this location. In this case the Government did not show the usual arrogance, because they made the effort to explain us this strange decision.

ARROGANCE QUARTER – BIOPATHOGENS OF THE SPACE

The fact that this topic is discussed in Neufert, a designing "Alphabet", the validity and severity which is believed of many generations of architects, is not a guarantee of scientific value and acceptance by many experts, and reasons are certainly radiesthesical methods for harmful radiation detection, which are confusing. Exploring the suitability of sites for people's lives, some architects, in their scientific works open the door to this intriguing topic by analyzing the impact of the environment on humans, the effect of ground water, electromagnetic radiation, and global network of cosmic radiation.

Primarily, the role of radiesthesy in our tradition meant a search for water and ore, as well as researching sites for the construction of residential buildings or temples. According to radiesthesy interpretations, the human body as an energy potential, reacts to the energy resources of the environment, and radiesthesical tool (sinker, rod), are used as an enhancer of these vibrations. Close to this notion of vibrations that act on the human body is oriental Feng Shui, a skill that brings harmony to the space with the interests of its inhabitants.

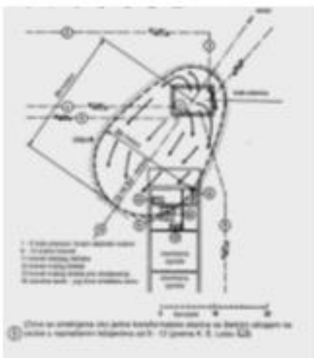


Figure 16 and 17. Neufert – manual for design, Space Biology

What causes suspicion to these traditional methods, are a series of pseudoscientific explanations, which usually flood the press and popular literature, offering all-powerful solutions, which are revealed by turning the plumb, from the quest for a successful career, to determination of treatment for a serious illness. As the idea of this text is not a dilemma whether to accept unquestioningly the traditional method or wait for scientific truth to prove the influence of these factors, electric power plants, power lines and cables, except for a strong and measurable electromagnetic field, are also sources of distortion of acoustic comfort, as well as sources of noise and vibrations. Every investor whose building received a building permit, and then use permit, shell document that all measures are taken to eliminate risks and hazards that may occur during the use of the building, and that the building is completely safe to use. What is happening after the warranty period, is no more the responsibility of investors, and household health disorder, no one associated with the housing in such facilities. Power lines, whose air routes, replacing underground, still remain for what is left of facilities and construction sites. An additional confusion on poles and in the air box makes installation of cable television network, which was at one time the momentum of its expansion project and no plan, at the discretion and arbitrariness of its filters, implanted at the most impossible places and crossbreeding with all the pre-installation.

Figure 18,19 and 20. "spiderman" nets and multi-story building with a sub-station on the ground floor

CONCLUSION

Protests in Turkey have started a movement fighting for the protection of the park in Taksim Geza, who opposed the forced urbanization of the city core. After the repressive measures of the police and the authorities it has grown into an all-out protest, which has, with its strength and the idea, managed to mobilize over two million people in 40 cities in Turkey in only a few days. Why is conclusion associated with the protest in Turkey? Because of **solidarity and protest motives**. Solidarity is expressed in Frankfurt, where 3. 500 people peacefully marched in solidarity with the Turkish people, in Berlin is about 600 people gathered in front of the Turkish Embassy, and here in about twenty members of the Serbian Green Youth protested outside the Turkish Embassy in Belgrade. This country has enough to demonstrate and motivation for this kind of a way to show the people's will, just this time it lost all the sense. We do not blame "young green protestants" which gathered in small numbers, do not blame for not raising their voices because Belgrade urban arrogance (and they would have reasons for every day’s gatherings!), but we regret that we are so accustomed to the unscrupulous individuals and authorities, since we gave up from all forms of anti-arrogance fight. We know that the solution to the problem is acting through institutions, but we are often completely lost in the maze of desks and hallways of public services, helpless and without significant support of environmental organizations inside the system.


Figure 21 and 22. Symbol of Turkish protest and support in Belgrade

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ENVIRONMENTAL ASPECTS OF TRAFFIC IN URBAN AREAS

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HEAVY METALS ACCUMULATION IN ENVIRONMENTAL OBJECTS OF AREAS ADJACENT TO THE HIGHWAYS

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ABSTRACT

From the ecological aspect the highways are considered as an object of interaction with the environment, the impact of which on the environment depends on the location, the road width, the intensity of use, the technical and operational characteristics. In this work the heavy metal contamination of the roadside soil of interstate and local highways are analyzed. The observed combined contamination of plants consists of the dust and aerosols directly deposited on the surface of leaves and of root absorption of heavy metals accumulated in the soil for a long time of deposition atmosphere. The transition coefficients of heavy metals in the chain "soil-plant" (in the branches and needles of greenery, fodder) are evaluated. The measures to minimize the harmful effects of road transport sector on the environment are proposed.

Key words: *highways, heavy metals, transition, soil, plants, snow.*

INTRODUCTION

Environmental in Republic of Belarus causes the increasing concern in the population and experts. And if pollution of lands in the republic the radioactive substances which have dropped out after the Chernobyl accident, has restricted character, existence in soils of heavy metals is characteristic practically for all farmland of the republic (Mirontchik et all., 2012). First of all, danger is constituted by those metals which are widely used in production and as a result of accumulation in environment constitute serious danger from the point of view of their biological activity and toxic properties. Copper, zincum, molybdenum, cobalt, manganese and the iron being a constituent of enzymatic systems and participating in transfer of oxygen, energy are carried to this group, movement of electrons through the membranes of cages influencing synthesis and transfer of heritable information, i.e. being irreplaceable in the vital processes. Their deficiency or surplus leads to development of the pathological processes called microelementosis, one of which main reasons is both low, and the high maintenance of these elements in the soil (Dmitriev et all., 1989).

Most the strong negative impact of anthropogenous load of a surrounding medium tests a soil cover in which pollutants including heavy metals concentrate. Heavy metals in it undergo changes therefore occurs both their destruction, and strengthening of toxic properties. Soils, unlike other environments, possess weak ability to a self-cleaning and resistance to destruction.

One of paths of intake of heavy metals to the soil and, as a result, in plants is the atmosphere, the main sources of pollution bound to activity of the person which thermal power and other plants (27 %), the enterprises of ferrous metallurgy (24,3 %), on processing and oil production (15,5 %), transport (13,1 %), the enterprises of nonferrous metallurgy (12,4 %), and also the enterprises for production and manufacture of structural materials (8,1 %) are. And, from 10 to 30 % entered in the atmosphere heavy metals are settled apart by 10 km from a polluter (Nemchinov et all., 1997). The combined pollution which was observed thus of plants develops of leaves which have immediately settled on a surface of aerosols and a dust and root digestion of the heavy metals which have collected in the soil for an appreciable length of time of losses from the atmosphere.

Highways in ecological aspect are usually considered as object of interaction with the surrounding medium which influence on Wednesday depends on an arrangement, width of the road, intensity of its use and technical production characteristics. The total area of the agricultural grounds polluted by emissions of motor transport and the enterprises of the cities, exceeds 0,8 million hectares in Belarus. Quite nonuniform distribution of the polluted soils on republic regions (in Vitebsk area about 14,7 thousand hectares, in Mogilyov more than 467 thousand hectares or 47,1 %) is thus observed. Combustion gases of motor transport pollute ecosystems and soils adjacent to roads mainly lead and to a lesser extent cadmium, zincum and other metals. Pollution of soils of roadside strips of highways interstate (Brest - Moscow, St.Petersburg - Odessa), republican (Minsk - Mogilev, Borisov - Berezino) and local value (Gorky - Lenino, Mogilev - Slavgorod) is observed apart to 250 m from a roadbed depending on a land relief, existence of forest shelter belts, intensity of a traffic and duration of operation of the highway. For example, the maximal content of lead in the soil is noted apart 5 - 10 m from a highway that above background value on the average by 2 - 2,5 times, but is slightly lower or is close to maximum-permissible concentration (Mirontchik, 2004).

THEORY

The motor transport is a source of 45 - 50 % of all toxiferous emissions in the territory of Belarus (in the large cities to 70 - 75 %), and a contribution of this type of pollution in a roadside strip it is incommensurable above average values. On this space limited to the reference for Republic of Belarus to simulated and natural afforestations, almost constantly there are inhabitants of nearby settlements to trasses, long – drivers and passengers. From total of toxiferous emissions to the share of the fulfilled gases falls to 65 %, karterny gases – to 20 % and gasoline evaporations – about 14 %.

Mobile sources of technogenic pollution throw out in a surrounding medium with spent gases about 200 various chemicals. White damp, nitrogen oxides, lead and its connections, hydrocarbons, aldehydes, soot and benzapyrene which are the main toxiferous pollutants of roadside zones released by motor transport into the atmosphere, collect in the winter in snow cover, and during the spring and aestivo-autumnal period are washed away by an atmospheric precipitation or besieged on the earth in the form of dry losses. Some of them possess the strong carcinogenic and mutagen action (Evgenev et all., 1989). For example, the production technology of the fuel used by transport on highways of Belarus existing until recently, caused the high content of lead in emissions and, respectively, the considerable receipt it to the soil. Lead long remains in the soil, intensively collects in vegetation and on food line-ups enters in a human body. Danger of effect of lead on a human body consists in depressing of a hemopoietic and function a caries. The specified coefficient of toxicity of compounds of lead in relation to basic ($k = 1$ for CO) is equal to 22400.

Peculiar indicators of ecological wellbeing are indexes of a state of environment whom treat as indexes of quality of free air, green plantings, and the soil (the content of heavy metals, salts of the chlorides used in winter time, hydrocarbons). In the winter they collect in snow cover, and during the spring and aestivo-autumnal period are washed away by an atmospheric precipitation or besieged on the earth in the form of dry losses. The combined pollution of green plantings which are accumulators of emissions by the motor transport of harmful chemicals (oxides of heavy metals, carbon) is thus observed. It develops of an immediate sedimentation of aerosols and a dust on a surface of leaves and root digestion of the heavy metals which have collected in the soil for an appreciable length of time of receipts from the atmosphere. Combustion gases of motor transport pollute ecosystems and soils adjacent to roads cadmium, zincum and other metals. The production technology of the fuel used by motor transport on roads of Belarus applied until recently, caused the high content of lead in emissions and, respectively, the considerable receipt it to the soil. Lead long remains in the soil, intensively collects in vegetation and on food line-ups enters in a human body. Danger of effect of lead on a human body consists in depressing of a hemopoietic and function a caries (Dmitriev et all., 1989).

Pollution of a roadside strip by transport and road emissions depends besides intensity of driving of vehicles on duration of operation of the highway. Pollution by heavy metals of a grassy cover is observed apart to 100 - 150 m on both sides with a maximum on removal about 10 - 20 m from the region of the carriageway.

METHODS

For definition of conversion factors of a number of heavy metals in a link "soil plant" during the periods of 1987 - 1995 and since 2001 - 2003 selection of soil and vegetable tests immediately at edge of a road cloth, and also apart 10, 25, 50 and 100 - 150 m from a roadside of the largest highways passing through the territory of the Mogilev area, polluted ^{137}Cs ranging from 55 kBq/m^2 to 1221 kBq/m^2 was made. Exemplars for monitoring were selected on the cultivated haymakings and the pastures located on cespitose and podsolic sandy soils on removal of 500 - 1000 m from highways. Tests selected the drill in the high 20-centimetric layer during the pasturable period according to the practical standards, vegetable tests in the form of proportionated samples of the herbs corresponding to average botanical structure of a strip.

The content of heavy metals in the selected vegetable tests is determined by an atomic absorption method in the Belarusian research and design-technology institute of the meat and lactic industry and the Belarusian research institute of the experimental veterinary medicine of C.H. Vyshelessky. Soils are analysed on the maintenance of the relative frame forms of elements (in an extract 1n by HCI) and bulk quantities after decomposition of tests by a mix of concentrated acids (HF, $HClO_3$, HNO_3). In plants the common content of heavy metals after a mineralization of tests is defined by the diluted (1:1) hydrogen nitrate.

FINDINGS AND DISCUSSION

Among the main sources of violation of natural equilibrium (the industry and a power engineering, rural and housing and communal services) transport constitutes significant danger as the Mogilyov area possesses a developed transport network where highways with a solid covering have common extent more than 7,5 thousand km. It, first of all, M-8 St.Petersburg – Odessa, M-4 Minsk – Mogilev, M-5 Minsk – Gomel, R-43 Podolsk – Krichev – Ivatsevichi, R-122 Mogilev – Cherikov – Kostyukovichi, R-93 Mogilev – Bobrujsk. Highways in ecological aspect are usually considered as object of interaction with the surrounding medium which influence on Wednesday depends on an arrangement, width of the road, intensity and duration of its operation, technical production characteristics.

The purpose of researches was studying of influence of motor transport on soil pollution by heavy metals and their accumulation in natural herbage, and also in the crops growing on fields, adjacent to roads. Tests (soil and vegetable exemplars) were selected along highways Brest – Moscow (a site Zhodino – Borisov), St.Petersburg – Odessa (a site Mogilev – Dovsk), Minsk – Mogilyov (a site Belynichi – Mogilev), Borisov – Berezino, Gorky – Lenino, Mogilev – Slavgorod on removal of 25 m, 50 m, 75 m, 100 m, 150 m, 200 m from a roadbed. Soil exemplars are selected at a depth of 0 - 20 cm and 20 - 40 cm.

The analysis of the soil tests which have been selected in 1987 - 1995 and 2001 - 2003 along highways stated above, showed what exactly on the sites adjacent to highways with intensity of movement 100 - 300 and more of cars at an o'clock, is noted the greatest environmental by products of an emission of motor transport with a maximum on removal of 10 - 15 m from the region of the carriageway. By rough estimates cooperative emission of the motor transport moving on these roads, makes 80 - 85 % from the total amount of emissions of motor transport of area (without city transport). The obtained data are confirmed by the calculations carried out in the Belarusian research center «Ekologiya» for determination of volumes of emissions of harmful substances with the fulfilled gases of cars (table 1).

Table 1: Calculated volumes of emissions of harmful substances with the fulfilled gases of cars on the main roads of the Mogilyov area

Number and road name	Volumes of emissions, 10^3 kg/year				
	CO	NO_2	C_nH_m	Benzapyren, 10^{-3}	Pb
Minsk - Mogilev	8922,1	1465,8	570,3	6,0	4,4
Sankt-Heterburg - Odessa	20463,2	2734,7	1222,6	12,9	9,2
Minsk – Gomel	15590,3	2801,0	958,2	10,7	8,4
Podolsk – Krichev – Ivatsevichi	29654,7	3980,1	1740,1	18,6	13,2
Mogilev – Bobrujsk	24628,0	3434,8	1498,7	16,4	11,4
Mogilev – Cherikov – Kostjukovichi	29176,1	3952,4	1760,8	18,6	13,3

It is characteristic that sites with the highest content of lead are located or on the under sites of a relief, either at industrial facilities or near city line (figure 1). On existing gradation studied soils fall into to group of soils with the raised content of lead (from 3 to 6 mg/kg of the soil). The most polluted according to the maintenance of the relative frame and bulk forms of lead there were the soil exemplars which have been selected along the highway St.Petersburg - Odessa on a site Mogilyov - Dovsk (the area of of Bykhov).

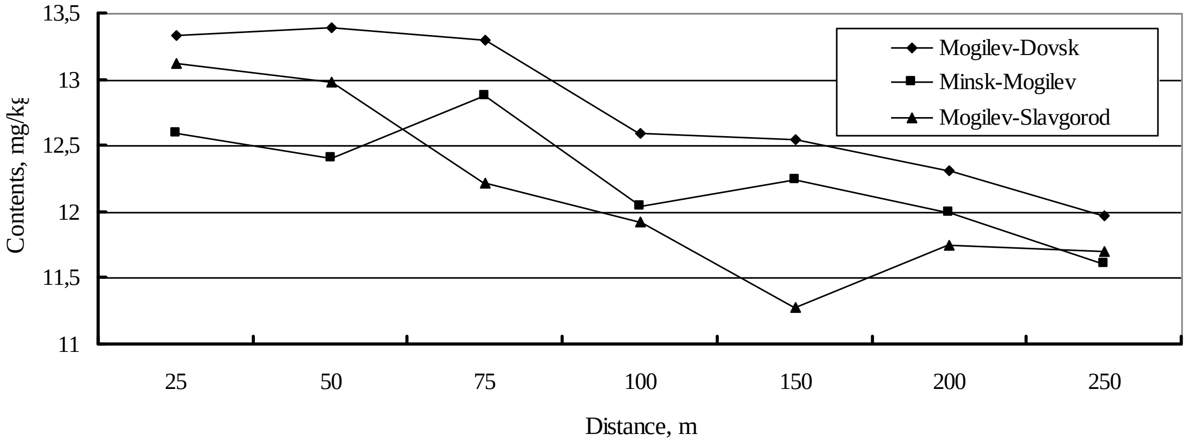


Figure 1. Remoteness influence from the highway on the contents in the soil of bulk forms of lead (a layer of 0-20 cm)

The analysis of vegetable exemplars showed that the content of lead in them was considerable above the mark (maximum concentration limit 0,2 mg/kg) (figure 2). For part of vegetable tests the content of lead exceeded admissible norm by 1,3 - 14,2 times. Between the content of lead in the soil and plants close direct correlative dependence (r = 0,438 - 0,541) is established. The combined pollution of plants by an immediate sedimentation of aerosols and a dust on a surface of leaves from the atmosphere and root digestion of the heavy metals which have collected in the soil for an appreciable length of time is thus observed. The maximal content of lead in the soil which above background value on the average by 2 - 3 times, is noted apart 5 - 15 m from a highway.

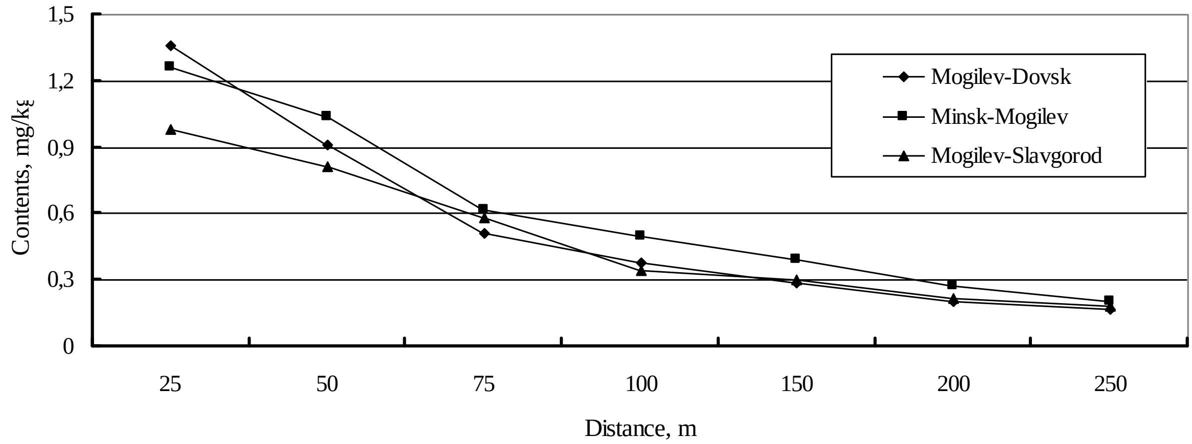
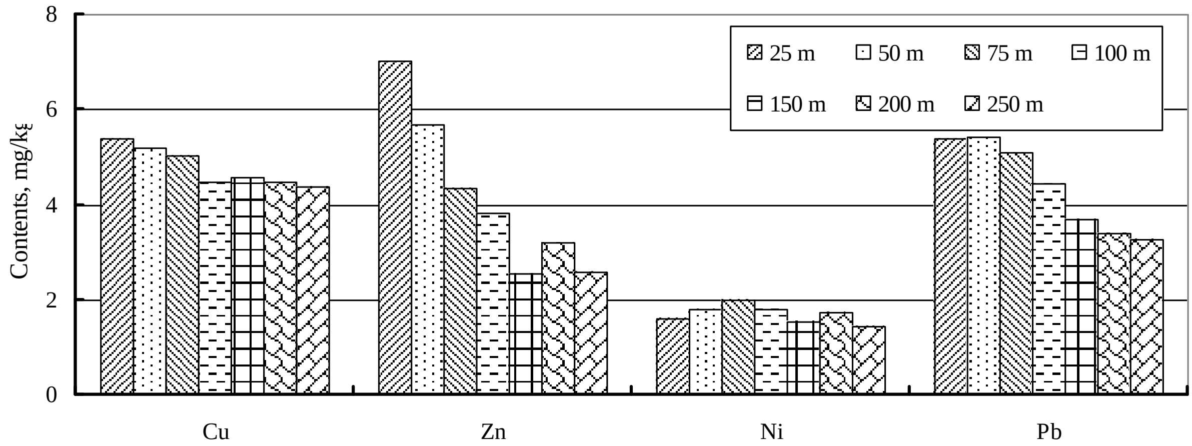


Figure 2. Remoteness influence from highways on accumulation of the relative frame forms of lead in natural herbage

The maintenance of the relative frame and bulk forms of copper in the soil practically did not change depending on remoteness to highways (figure 3). Besides, on existing gradation studied soils fall into to group average income according to the content of copper. As for zincum, that, similar to copper, legible influence of motor transport on the maintenance of this element in the soil is not revealed. On gradation these soils fall into to group low-provided with zincum. The maintenance of the relative frame and bulk forms of nickel in the soil also was in limits of admissible norms. However, unlike copper and zincum, nickel more collected in the subarable horizon. The contents in the cadmium soil in studied exemplars was background though apart 25 m from the road are slightly higher, than in other tests. According to the carried-out analysis of the soil and vegetable exemplars which have been selected in studied territories about highways Brest - Moscow (a site Zhodino - Borisov), St.Petersburg - Odessa (a site Mogilev - Dovsk), Minsk - Mogilev (a site Belynichi - Mogilev), Borisov - Berezino, Gorky - Lenino, Mogilev - Slavgorod, in the majority of tests it is not revealed impurities of soils and plants copper, zincum, cadmium and nickel above maximum-permissible concentration.



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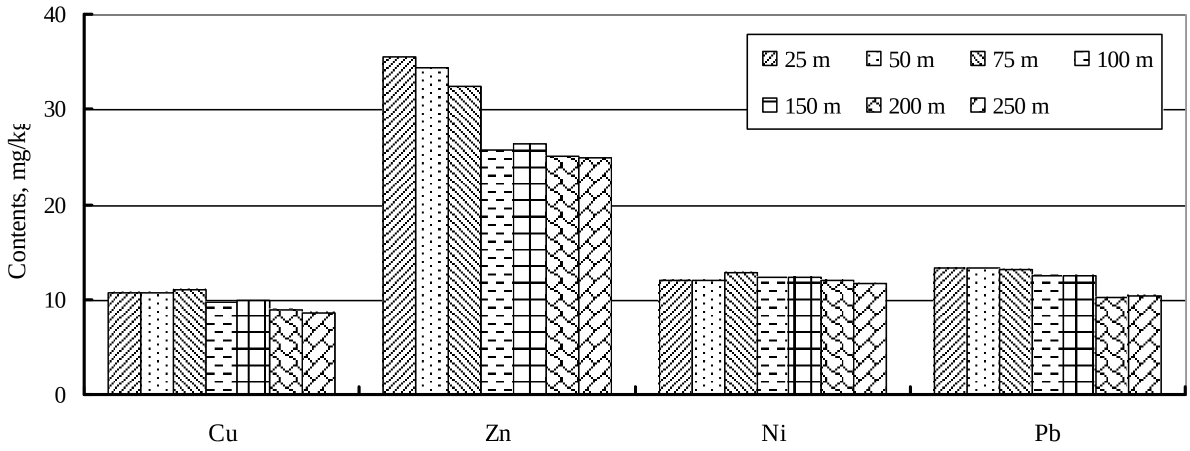

b

Figure 3. The maintenance of the relative frame (and) and bulk (b) of forms of elements in the soil depending on distance (a layer of 0-20 cm, a site Mogilev-Slavgorod)

The analysis of the selected exemplars showed that in the soil and natural herbage of roadside strips of the surveyed sites of highways the raised content of lead is noted, and more it is observed on removal to 75 m from a cloth (depending on a land relief, existence of forest shelter belts, soil type).

The bulk content of lead in soil tests was in limits 15,1 - 107, zincum – 28,3 - 78,8, cadmium – 1,1 - 3,2, coppers – 6,2 - 21,7 mg/kg of the soil. The analysis showed that the maximal pollution of the soil by products of an emission of motor transport is on removal of 10 - 20 m from the region of the carriageway. The majority of tests the relative frame contain in the increased quantity lead (50 % of tests, more than 6,1 mg/kg) and zincum (13 % of tests, more than 5,1 mg/kg). It is characteristic that sites with the highest content of zincum are located or on the under sites of a relief, either at industrial facilities or near city line. In large part (more than 85 %) vegetable tests the content of lead exceeded admissible norm (0,5 mg/kg) by 1,3 - 14,2 times.

Approximately the same picture was observed at definition of the content of heavy metals in milk and meat of krupnorogaty cattle, выпасавшегося and a forage consuming in the stall period, prepared in roadside strips of highways. The main elements pollutants are lead and zincum, to a lesser extent cadmium and copper. The content of lead in milk in 21,1 % of cases exceeded the most admissible level, zincum in 4,3 %, cadmium in 1,9 %, copper in 0,6 % of cases.

Between the content of lead in the soil and plants close direct correlative dependence (r = 0,438 - 0,541), and between the content of lead in milk and meat (beef) both green sterns respectively 0,571 - 0,646 and 0,768 - 0,832 is established.

It should be noted that in some tests concentration of heavy metals in a roadside strip of roads of republican value considerably exceeds admissible norms not only in the soil for which their long-term accumulation, but in snow cover and afforestations is characteristic. For example, apart 20 m from the region of the carriageway in tests of snow water are revealed lead of 8,7 mg/l (maximum concentration limit – 0,01 mg/l), aluminum of 14,8 mg/l (maximum concentration limit – 0,04 mg/l), coppers – 4,6 mg/l (maximum concentration limit – 0,005 mg/l), manganese – 74,6 mg/l (maximum concentration limit – 0,01 mg/l), a tungsten – 20,0 mg/l (maximum concentration limit – 0,01 mg/l) (table 2).

Table 2: The content of heavy metals in snow water

Distance to a brow of a roadbed, m	Content of heavy metals, mg/l							
	Pb	Al	Sn	Cu	Mn	Ni	V	Ti
	Maximum concentration limit (marginal concentration), mg/l							
	0,01	0,04	0,66	0,005	0,01	0,01	0,01	0,15
	Actual contents							
20	8,7	14,8	4,1	4,6	74,6	9,6	20,0	3,6
50	8,7	11,8	4,0	3,4	11,6	3,0	10,8	3,6
75	7,4	6,4	3,8	3,2	5,9	2,7	8,4	3,2
150	7,4	3,1	-	2,4	2,3	1,9	4,6	1,2

In branches and needles of green plantings of roadside strips noticeable difference in the content of heavy metals is recorded from the road in comparison with their contents from fields (table 3).

Table 3: The content of heavy metals in roadside plantings

Object	Content of heavy metals, mg/kg of dry weight		
	Pb	Zn	Cd
Aspen branches	10*/5**	40/28	0,65/0,32
Needles	11/6	64/41	0,33/0,28
Willow branches	6/4	130/40	0,54/0,34
Designations: */**; * - from the road; ** - from a field			

Despite the absence of effect of influence of availability of heavy metals in the soil on transition of radioactive substances to herbage, decrease of negative influence of emissions of the motor transport by a surrounding medium and health of the person (Mirontchik, 2003). The most actual and economic at this state of the economy of area and the state a path, in our opinion, is two-row landing of green plantings (the first row – high deciduous plants apart 8-10 m from the carriageway; the second row – the dense fence from fir-trees apart 20-30 m from a roadbed).

CONCLUSIONS

Principal direction of protection of lands from pollution there is an identification and elimination of sources of intake of heavy metals to the soil. In this plan prime value is gained by the organization of monitoring of pollution of soils heavy metals and other toksikant and development of a complex of nation-wide actions for protection of lands.

The main actions directed on minimization of harmful effects of a road and transport complex on a surrounding medium, can become:

- development and perfecting of the normative and legal documentation regulating norms accepted from the ecological point of view and standards;
- perfecting and keeping of norms and technologies at construction and operation of transport highways;
- modernization of fleet of vehicles;
- specification existing and development of new techniques of carrying out complex monitoring and an assessment of an ecological situation in a zone of influence of a road and transport complex;
- expansion of a network of public and individual pollution-free transport in the large cities;
- perfecting of infrastructure of transport highways in the large cities.

It will be promoted also by gradual increase in quantity of the motor transport with diesel engines which consume smaller amount of fuel in comparison with the cars equipped with engines, working at gasoline. However in this case the arising problem of the content in solar oil of aromatic hydrocarbons demands the decision. Such actions as application of baric antismoke additives to solar oil and use of the alternate types of fuel (the methanol, the liquefied natural gas), also can be demanded for significant improvement of ecology of roadside strips of large highways of the region.

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III International Conference
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IMPROVEMENTS OF NEW ECE REGULATION FOR BETTER ASSESSMENT OF VEHICLE NOISE EMISSION IN URBAN AREAS

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ABSTRACT

This paper deals with on-going changes in vehicles' legislation procedure which intension is to enable reduction of traffic noise in urban areas. The current noise Regulation No 51 (R51) of the Economic Commission for Europe (ECE) has been in force since 1970 (Directive 70/157/EC) with several amendments since then. The measurement method is based on ISO 362:1998 and seeks to measure the highest noise levels produced in urban traffic with a focus on driveline noise, i.e. full throttle acceleration in urban areas. Therefore, the test method is based on a full throttle acceleration test with starting speed which depends on the vehicle category. Since the technical design of vehicles as well as traffic conditions in urban areas changed significantly over the last decade, the correlation between the test conditions for type approval and the conditions for normal urban driving has gradually decreased. New test conditions were therefore required to be more representative of normal urban driving behaviour in order to affect noise exposure in urban areas more efficiently.

Key words: *Noise in Urban Areas, Traffic Noise, Vehicle Noise Emission, Noise Regulations.*

INTRODUCTION

For a long time communal noise, especially traffic born communal noise, have been known as cause for different psychological and pathological effects to the humans. Exposing the humans to the noise above particular limit in the amplitude, frequency and duration causes the serious acute or chronic diseases. Acute affects are mainly related to high amplitudes at particular frequency range while chronic diseases are related to long exposure to the noise.

One of the main instruments in reducing traffic born communal noise is related to the vehicle certification before they enter to the market. The vehicle certification process considers the set of procedures, testing and audits related to the conformity of production which has to be performed with positive results. The purpose of certification process is to check does the product meet qualification criteria.

It is important to be recognized that nowadays regulations for passenger and commercial vehicles in categories M1 to N3G don't call for checking driver perceived and passenger perceived noise. The regulations are strictly related to the so called "pass-by-noise" i.e. vehicle's noise emission to the road and city area. The reason for that approach in regulations is: (i) related to expectation that vehicles with high level of driver perceived noise would be not accepted by the customizers, (ii) related to expectation that even if they would be accepted the negative effect of the noise would be limited to the interior area of the vehicle and (iii) based on the general intention of the EC/ECE regulations to prevent entering to the market unsafe and environment unfriendly products.

ECE NOISE REGULATIONS

With intention to control and reduce high level of traffic born communal and on-road noise the UN Economic Commission for Europe since 1970 has established vehicle approval legislation for all new vehicles, as laid down in ECE Regulation 51 (UN/ECE R51). Here it has to be noted that that "ECE" has to be not misunderstood. The total number of states which nowadays follow the regulation is 56. That means, not only EU and not only European states but also Japan, Australia, Republic of South Africa, Israel, etc. Consequently, in spite that in the regulation name is mentioned “Economic Commission for Europe“ the same is open to other countries and widely used in many developed countries out of Europe. Many other countries like India, China, Brazil and other nations follow ECE Regulation 51 in non-official way i.e. without being signatories.

Regarding measurement method, instrumentation and measurement procedure the UN/ECE R 51 is based on the ISO standard 362 which does not specify the maximum noise limit which is published by European Council or by governmental bodies.

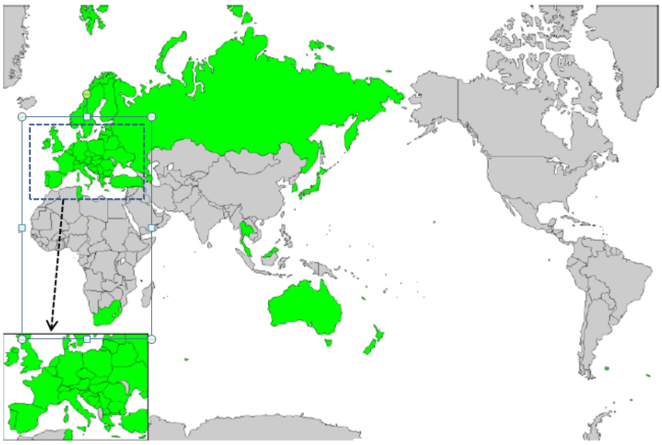


Figure 1. Members of the “Agreement 58” which follow noise regulation UN/ECE R51

FULL THROTTLE APPROACH AND SPL LIMITS IMPORTANT FOR COMMUNAL NOISE CONTROL

From 1970 to 2012 vehicle’s pass-by noise emission has be measured in so called full throttle acceleration test which is given in fig. 2 and text bellow. Based on this testing method the vehicle with manual gear box shall to approach the line AA at speed of:

(i) Va = 50 km/h or

(ii) (ii) VA = x/4 of engine speed at rated power and Va < 50 km/h, where x depends on vehicle category and can take value of 2 or 3.

(iii)

Gear ratio in which vehicle will approach AA can be: 2nd (for vehicles with 4 or less gear ratios) or 2nd and 3d (in last case average value of sound pressure level measured in each gear ratio will be taken as the result of the test).

After approaching AA line the vehicle has to perform full throttle acceleration up to the BB line i.e. for 20 m. During that acceleration the measurement of SPL (Sound Pressure Level) has to be performed with acoustic weighting in line with A filter characteristic and with fast response peak detector. SPL has to be done at distance 10 m from AA line at two positions which are 7.5 m aside of straight central line of vehicle path. Reported results have to be max. value observes during above explained measurement.

As it is specified, approach speed and overall ration between vehicle power unit and wheels depends on category and concept of the vehicle power train. But, the most important is to be noted that measurement procedure has intention to simulate real situation in traffics: the SPL measurement shell be done at distance of 7.5 m aside of vehicle centre line which corresponds to reality i.e. common distance from pedestrians and passing vehicle in the cities.

Prediction of expected SPL can be provided by different methods including one suggested by J. Huijssen, P. Fiala, R. Hallez and W. Desmet (see references) in which transient SPL radiated by vehicle can be split in steady state, multiple position (with time difference τ) sound pressure level signals (p) which correspond to SPL exponentially averaged under time T:

$$SPL^2(t) = \frac{1}{T}\int_{-\infty}^{t} p^2\, exp^{(\tau - t)/T}\, dt \qquad (1)$$

Some results of experimental investigation done by author in pass-by noise measurement (see figure 2) give good correlation with the theoretical model.

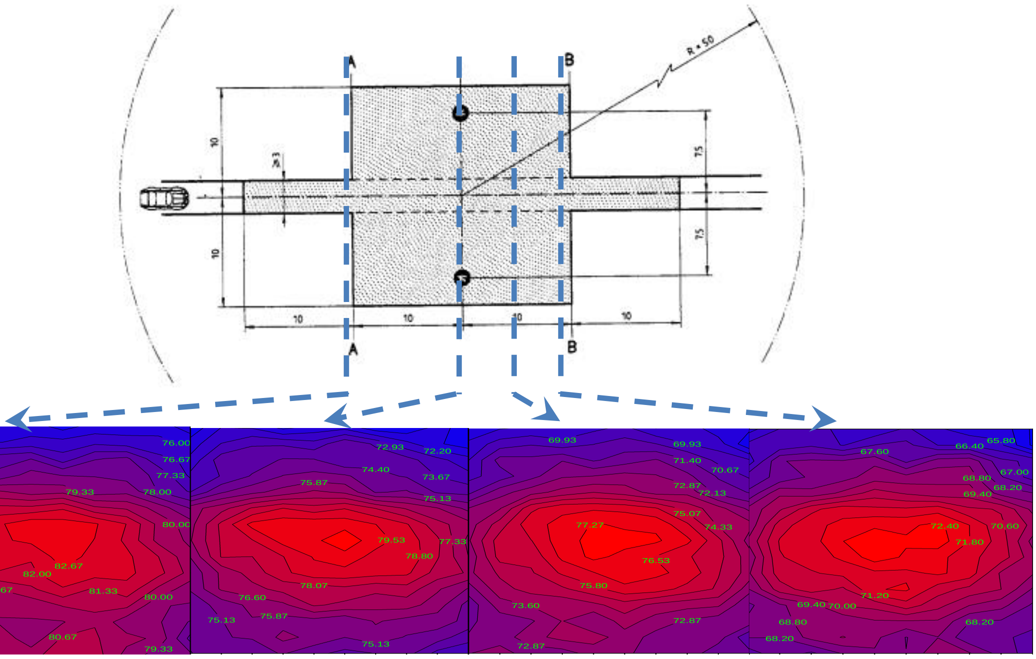
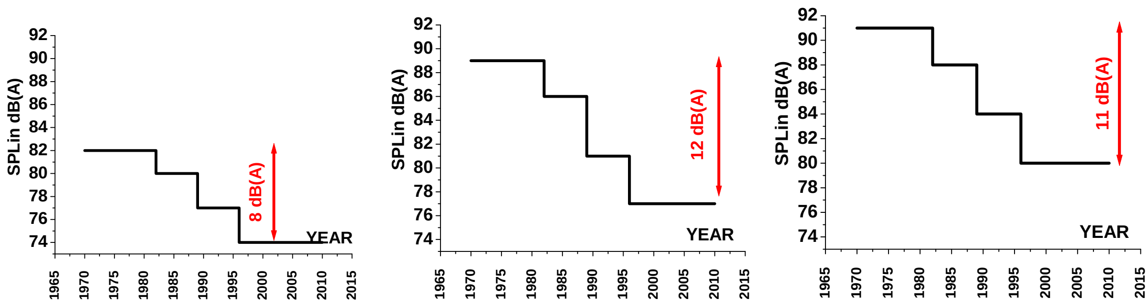


Figure 2. Mandatory test track for pass-by noise (as per ECE R 51) and results of radiated sound energy per sqm (SI)- measurement done at 4 different positions, during pass-by test at 1 kHz for vehicle category M1

Limits for full throttle method (also called Method A) have been dramatically reduced since 1970 – see figure 3. For example for heavy lorries the limit values has been reduced for 11 dB(A): from 91 to 80 dB(A)



a) M1 (M cat. , passenger cars) b) M3 (M cat. Mass > 5 t) c) N3 (Lorry Mass > 12 t)

Figure 3. Reduction in EU noise limits for ECE R51 – Method A (full throttle acceleration)

PARTIAL THROTTLE APPROACH AND SPL LIMITS IMPORTANT FOR COMMUNAL NOISE CONTROL

As it can be recognized full throttle acceleration in pass-by noise test doesn’t correlate with nowadays traffic conditions in urban areas. Within last 30 years the max. speed in urban areas has been reduced to 50 km/m what is nowadays limit worldwide. Consequently, acceleration from 50 km/h lost correlation with the way in which vehicles accelerate in urban areas today.

To enable adequate testing procedure ECE R51 has been upgraded in the way that method B has been developed. This method was established based on driving at partial throttle 50 km/h for light vehicles (M1, N1 and M2<3.5t) and at 35 km/h for heavy vehicles. That, in much better way represents normal urban driving condition. It ensures a better consideration of all noise sources emitted by road vehicles in urban traffic than the method A (full throttle acceleration).

Table 1: EAMA proposed noise limit values

Vehicle category	Vehicle sub-category	Limit values expressed in dB(A)		
		Stage 1	Stage 2	Stage 3
		Valid 2013	Valid 2015-2017	Valid 2020-2022
M	Vehicles used for the carriage of passengers			
M1	no of seats < 9; power-to-mass ratio < 150 kW/ton	70	68	66
	no of seats < 9; power-to-mass ratio > 150 kW/ton	71	69	67
M2	no of seats > 9; maximum mass < 2,5 tons	72	70	68
	no of seats > 9; 2,5 tons < max. mass < 3,5 tons	73	71	69
	no of seats > 9; 3,5 tons < max. mass < 5 tons;	74	72	70
M3	seats > 9; max. mass > 5 tons; rated engine power < 250 kW	75	73	71
	no of seats > 9; maximum mass > 5 tons; rated engine power > 250 kW	77	75	73
N	Vehicles used for the carriage of goods			
N1	Maximum mass < 2,5 tons	71	69	67
	2,5 tons < max. mass < 3,5 tons	72	70	68
N2	3,5 tons < max. mass < 12 tons; rated engine power < 150 kW	75	73	71
	3,5 tons < max. mass < 12 tons; rated engine power > 150 kW	77	75	73
N3	maximum mass > 12 tons; rated engine power < 250 kW	77	75	73
	maximum mass > 12 tons; rated engine power > 250 kW	79	77	75

Based on that test methodology the new limits value have been suggested by European Automobile Manufacturer Association (EAMA) – see table 1.

IMPACT TO REDUCTION OF DAY-NIGHT COMMUNAL NOISE

Essential approach in assessment for noise in urban areas is: (i) equivalent sound level Leq which describes a receiver's cumulative noise exposure from all events over a defined period and/or day-night sound level Ldn which describes a receiver's cumulative noise exposure from all events over full 24 hours in which all night time levels (between 10 p.m. and 7 a.m.) has to be increased for 10 decibels.

$$L_{eq} = 10 \log [(1/T) \int p_A^2 \, dt/p_{ref}^2] \qquad (2)$$

where:
L_{eq} = equivalent sound level (dB(A))
T = time period (s)
p_A = sound pressure (Pa, N/m^2)
p_{ref} = reference sound pressure (20 10^{-6} Pa, N/m^2)

$$L_{dn} = 10 \log \left(1/24 \left(15 \left(10^{Ld/10}\right) + 9 \left(10^{((Ln + 10)/10)}\right)\right)\right) \quad (3)$$

where:
L_{dn} = day-night sound level (dB(A))
L_d = daytime equivalent sound level (dB(A))
L_n = night-time equivalent sound level (dB(A))

Consequently, it is of essential interest what can be expected attenuation in Leq and Ldn in future, when all vehicles in a city would fulfil latest changes in ECE R51 including method B and limits given in table 1.

In this moment prediction can be done only by different models since in reality still it is not possible to find a city with all operating vehicle which are in-line with new approach in vehicles legislation. As it comes from figure 4 (left), prediction is that Ldn would be reduced for 3 to 5 dB(A). That will be respectable achievement.

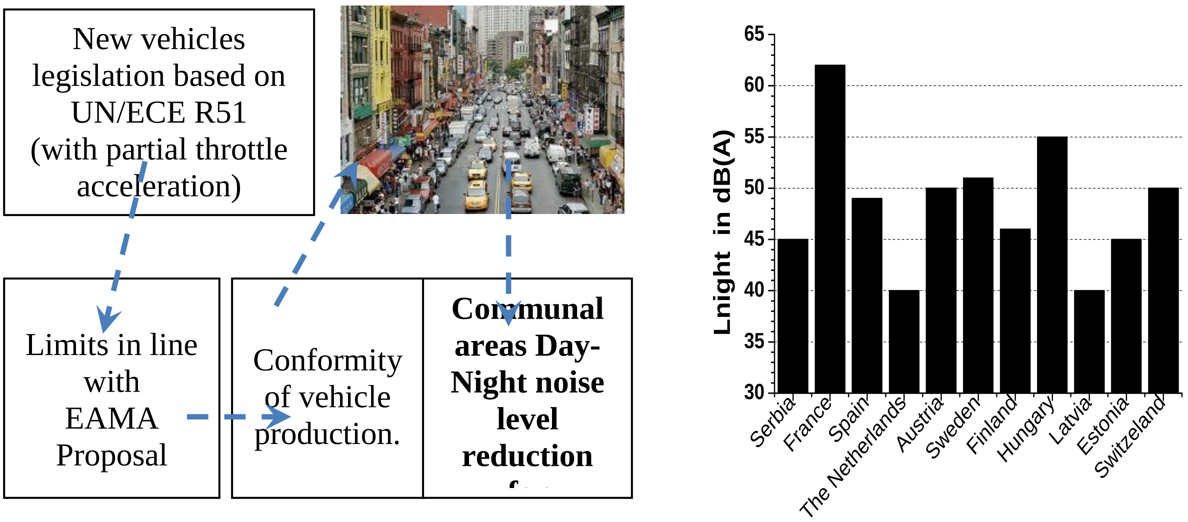


Figure 4. Expected impact of ECE R51 Rev. 2 to communal noise level (left), and Lnight limit values for residential areas (right)

Here it has to be noted that Republic of Serbia, through mandatory regulations, follows approach in which different limit values are given for day + evening time (6 a.m. to 6 p.m. + 6 p.m. to 10 p.m.) and different for night time (10 p.m. to 6 a.m. next day) in which evening values are measured values + 5 dB(A) and night values are measured values + 10 dB(A). This approach is in-line with directive 2002/49/EC.

Process of implementation of new R51 regulation in Serbia in will enable Ldn reduction for more than 5 dB(A). The main reason is that Serbia is nowadays with extremely old vehicles. Based on that any improvement in vehicle technology which will be implemented would enable much higher reduction of Ldn than what will be reduction in well developed countries. Definitely, actual level of Ldn would be again higher than in well developed countries but, level reduction will be higher.

Based on limited space, here it will be drawn attention only to comparison of actual night limit levels for residential areas in some EU countries and Serbia (see fig. 4, right). As it can be recognized Serbia limits is on 45 dB(A) while countries like Germany, Switzerland, Sweden, Austria, etc. are with higher allowed levels. Actually there are only two countries with significantly less levels, the Netherlands and Latvia.

Discrepancy between limit values given as mandatory and real values in urban areas in Serbia is obvious from figure 4 (right) and 5. No one measured value is under the limit and in some residential areas (Banovo Brdo) night noise level is 19 dB(A) above limit! Specified status has to be taken in serios consideration. Conseqvently, application of new ECE regulation related to vehicle legislation in Serbian is esential.

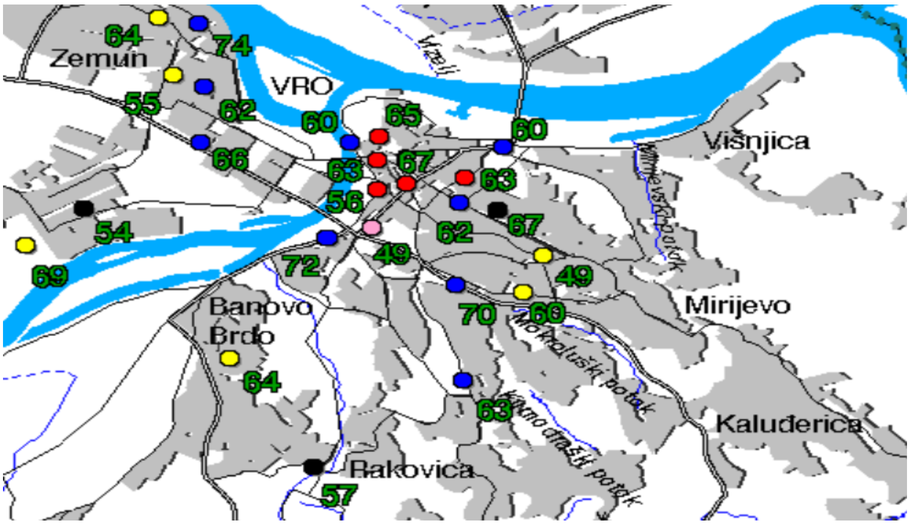


Figure 5. Reported night noise levels (Lnight) for Belgrade – yellow points are residential areas

CONCLUSION

The paper reviews the significant improvement in reduction of traffic born communal and on-road noise done by UN/ECE through establishing new methodology and regulation for vehicle approval legislation. Clear technical procedures for measurement and assessment of the pass-by noise were established and defined in standards and regulations. Accordingly EAMA lunched proposal for limit values which are liked with new UN/ECE Regulation 51 Rev.2.

It is expectable that, once when the new regulation will be fully implemented the day-night noise level in cities will be reduced for 3 to 5 dB(A). Based on the present status in cities in Republic of Serbia, which was given in the paper through Belgrade example, it is clear that implementation of new UN/ECE Regulation 51 will enable extremely significant reduction in communal noise and much easier achieving of mandatory day-night noise limit values.

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MANAGING THE YELLOW LANES BY MEANS OF "CAR SHARING" STRATEGY AND BY APPLYING FUZZY LOGIC

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ABSTRACT

A very important fact is that the road transport represents one of the key sources of many pollutants, especially in urban areas. The European Union has, via the so- called "White Book, 2005 defined the obligations when it comes to the highway transport policy (Auto-Oil I and Auto-Oil II).According to that, the EC supports all the activities leading to the pollution reduction in transport and meeting the standards concerning the emissions (using the vehicles with new generation engines, alternative fuels, taxes for using the transport infrastructure for heavy vehicles etc.)The objective of this paper is to point out how, by applying the traffic-urban measures, the influence of traffic on the sustainable development of cities by distributing vehicles on the network after establishing the yellow lanes network can be reduced. Its objective is, also, to suggest which streets will get the priority status, to improve the movement of the public transport vehicles, to reduce the jam on city streets and the noise and emission of exhaust gases. If we assume that motorcars can also use the yellow lane, but under the condition that that they carry two passengers minimum, it is clear that this way the drivers are encouraged to make deals and "pair up" when traveling to work. The aim of the "car sharing" strategy is, primarily, to influence the commuting because it is the main cause of city streets congestion.

Key words: *"Car sharing", yellow lanes, approximate reasoning, congestion on the network, fuzzy logic*.

INTRODUCTION

There are different strategies of the traffic jam reduction and, therefore, of its influence on the environment. Beside the "*congestion pricing*" strategy, as a potential option for the parking requests reduction in the zones of high attractiveness and, consequently, the car influx (inflow), there is also the "*car sharing*" strategy. If the city management made a decision to assign the yellow lane system to the traffic network in the zones of high attractiveness, the question arises which streets should be chosen and according to which criteria that choice would be made.

Many authors, such as Steininger et al., (1996), Prettenthaler and Steininger (1999), Fellows and Pitfield (2000), Seik (2000), Huver (2004), Katzev (2001, 2003), Wagner and Shaheen (1998), Meijkamp and Theunissen (1996), Bonsall (1980, 1982) and Meijkamp and Arts (1999) and others, dealt with changes in drivers' KPIs. They mostly studied the connections between the application of "*car sharing"* and the exhaust gases emission, the influence on sustainable transport, the influence on micro economy and we can conclude that the "car sharing" strategy had a favourable influence on economic and social situation in the environment where applied. The number of cars reduced up to 4.1% compared with the previous number, there was no negative influence on public transport functioning etc.

As we are dealing with managing the uncertainties, the changing of corresponding mathematical models is necessary because we cannot predict with certainty how people will accept the "car sharing" strategy. Fuzzy logic is applied on the car distribution approximation on an urban network provided that the car movement in the yellow lanes is permitted, and that there is more than one passenger in the car. So, we are talking about an uncertain situation where it is not possible to determine the exact number of people who will accept the suggested strategy. The uncertainties appearing in this case are different (somebody likes traveling alone, somebody isn’t in good relations with his travelling companions or, on the other hand, there are more than two individuals living nearby and working at the same place, there is the possibility of giving a lift to someone etc.) and all of it depends on the type of personality i.e., on individual decisions and arrangements of individuals, which can be a very complex topic for analysis and simulation.

On the other hand, the uncontrolled traffic has considerable consequences on the sustainable development of cities where the sustainable road transport has the greatest influence. The sustainable transport refers to any vehicle with a minor influence on the environment and includes walking and bicycle riding, green hybrid and electric vehicles, construction or protection of the urban transporting systems which are economical, space conservation and the healthy living promotion etc. The transport systems have a significant influence on the environment, concerning the fact that they consume between 20% and 25% of the world’s energy consumption and carbon-dioxide emission. The traffic emission of gases which create the greenhouse effect grows faster than the gas emission from any other sector. Road transport is still the main cause of local air pollution and noise creation in the cities because it makes 85% of total energy consumption in the traffic sector of developed countries.

THE SUSTAINABLE TRANSPORT IN THE CITIES

The sustainable transport is, by itself, a fluid concept which will keep developing and changing in accordance with the general and economic circumstances. Starting from the premise that the sustainable development is a well-balanced and harmonious development which integrates the economic, sociological and ecological objectives, it is necessary to develop strategies which will find a «compromise» between the benefits that the traffic offers and the negative effects which it causes. One of the possible ways of caracterization the tri-dimensional context of the sustainable transport development strategy is the balance of the economic, ecological and sociological development through three main areas: Economic – Development, Sociological – Equality, Ecological – Responsibility. The more specific conditions which transport should «fullfill» in the context of sustainable development would be:

In regards to economic sustainability:

- providing the expense efficient transporting services with the increase of the infrastructure capacity,
- reduction of energy consumption the quantities of which were limited, with the reduction of CO2 emission of cars up to 120 g/km,
- supporting the sustainable economic development,
- concerning the sociological sustainability,
- the availability and financial accessibility of transporting services to all the social categories,
- supporting the social development and cohesion, as well as a choice of ways to travel,
- the reduction of the excessive number of casualties and injured people in traffic accidents,
- the increased capacity of roads,
- reduction of space occupation by the means of transportation land use changes and its degradation.

Concerning the ecological sustainability:

- land usage with minimum influence on the eco system integrity,
- using of renewable sources of energy,
- reduction of emission and waste at least to the level which the environment can absorb and a considerable reduction of air pollution (national standard 50g/m^3), especially on the local level and the global heating, which all lead to the reduction of respiratory diseases, stress;
- noise reduction to the levels which minimize the effects on human health (max. 75 dB).

Plans of transport sustainability actually use combinations of these objectives which are characterized by the coincidence in their values. Because of that, a method is required that can be used for solving various types of uncertainty which occur every day. An approach using the fuzzy logic was suggested for managing of uncertainties in the regulation of traffic by using the object strategy.

SETTING THE PROBLEM AND A MODEL FOR SOLVING IT

With the assumption (adopted by the city management) that a vehicle that has at least 2 or more passengers may use the yellow lane, it is necessary to allocate the movement of vehicles in the area concerned. According to researches, the average number of people in the vehicle is about 1.2, which varies from city to city and from one country to another. Thus, the city wants to reduce the number of vehicles in the areas of high attractiveness by this measure and that will also reduce the hazardous gases emissions. The objective is , primarily, to influence the working population trends (commuting), by "pairing people up" and make them use one car instead of two when going to work and coming back home.

The application of the object strategy and establishing the yellow lanes network will also affect the schedule of the public transportation lines in the city. We can assume that the demands for transport will change and, thus, the reorganization of the public transport lines will be needed. Of course, it is not possible to predict with certainty what the response to such a proposal will be.

But, according to the researches mentioned in the introduction, people are interested in accepting something like that. So, we are talking about stochastic here and, in a way, about managing the uncertainties which it implies.

If we have i links on the network of streets which we consider, and a flow q is on each of them, as well as the distribution of motion for the purpose of travel, we can propose the following mathematical model on the whole network level (1) for the distribution network that emerges after the introduction of yellow lanes and the application of the object strategy when it comes cars:

$$Q_i^* = q_i \cdot \alpha \cdot \varphi_r + q_i \cdot \beta \cdot \varphi_k + q_i \cdot \chi \cdot \varphi_{re} + q_i \cdot \delta \cdot \varphi_o + \theta_i \tag{1}$$

Where: Q_i^* is the flow of cars on the link after the introduction of the yellow lanes system and the object strategy in a unit of time; q_i is the flow of cars on the link before introducing the yellow lanes system and the object strategy in a unit of time *;* $\alpha, \beta, \chi, \delta$ are the factors related to the percentage of working movement, movement for shopping, recreation and movement for other purposes, respectively; θ_i is the value of the diverted flow on the link when allowed to use the yellow lane in a unit of time.

As this strategy has a positive effect on the citizens' budget, which was concluded in the paper of Fellows and Pitfield (2000), we can also consider the increasing demands for the taxi rides when it comes to movements for the purpose of recreation and rest. Of course, the new state will also affect the number of taxis moving on the network. The proposed mathematical model for the distribution on the network that emerges after the introduction of yellow lanes and the application of strategy concerned in the case of public transport vehicles has the following form:

$$V_i^* = J_i + \theta_{jp} + T_i + \theta_{tx} \tag{2}$$

Where:

V_i^* -the number of public transport vehicles on the link after the introduction of the yellow lanes system and the respective strategy in a unit of time, - Ji - the number of public transport vehicles before the introduction of the yellow lane system and the respective strategy in a unit of time; θjp -the number of additional vehicles of public transport on the link after the introduction of the object strategy in a given time, where the factor can take integer values in the interval (-n, + n), where n is a finite integer; Ti - a number of taxis before the introduction of the yellow lanes and the respective strategy in a given time θtx - the number of the additional taxis on the link after the introduction of the subject strategy in a given time. Where the factor can take integer values in the interval (-n, + n), where n is a finite integer.

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Table 1: The base of fuzzy rules

Ordinal nr.	If Q_i^{*is} (veh/h)) is	And if V_i^{*is} (veh/h)	Then IP is	The weigh factor
1.	small	small	medium	1
2.	medium	small	medium	1
3.	large	small	large	1
4.	small	medium	medium	1
5.	medium	medium	medium	1
6.	large	medium	large	1
7.	small	large	small	1
8.	medium	large	small	1
9.	large	large	medium	1

The input parameters into the fuzzy logical system are the values Q_i^*, V_i^* , while the output value will be the index of performance (IP) of the system. The performance index will represent the value which determines the degree of usefulness for one of the links to be assigned a yellow lane. The applied fuzzy sets have their base of fuzzy rules which are modelled by "MATHLAB" (Figure 1). The idea of this fuzzy rules setup is that we assign the higher index of performance (IP) to the lanes which have a greater value Q_i^* and a smaller value V_i^* ,which results in the fact that we choose the yellow lanes for as many cars as possible, and the smallest possible number of public transport vehicles.

This gives priority to the implementation of the "car sharing" strategy and that is the idea of this paper. Of course, if the network is unloaded of cars, the public transport vehicles will gain the greater autonomy. Fuzzy Mamdani type reasoning system, based on the fuzzy rules and input / output variables with performed defuzzification, resulted in obtaining the approximate values of the output variable, given the inputs. The following figure (Figure 1) shows an example of the approximation from the programming environment "MATHLAB", i.e. the IP value (7.69) at the set input values Q (270) and V (20).

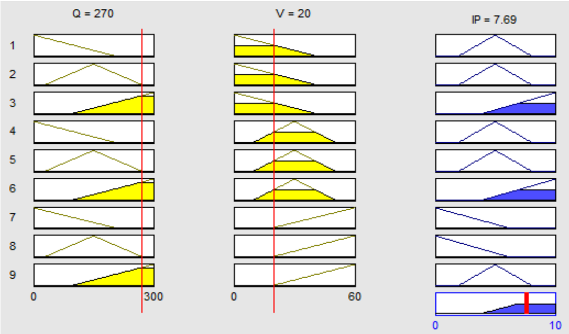


Figure 1. Fuzzy Mamdani type reasoning system

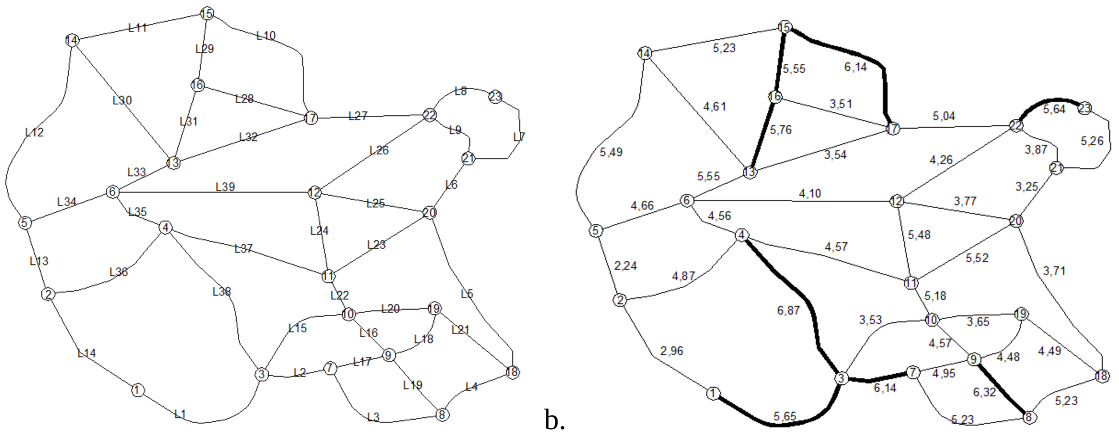
The proposed algorithm for the assigning of yellow lanes on the network comprises the following steps:

1. For each link separately calculate the value of IP.
2. Define the relationship between the number of links with yellow lanes and "ordinary" links (parameter defined by the city authorities).
3. According to the largest value of IP assign the yellow lanes on the network and finish up with an algorithm.

Such an approach provides an opportunity for city authorities to study and monitor the effects that have been achieved, so it is possible to make adjustments of the proposed relation in the second step of the algorithm. After some time (2 or 3 years), it is possible to change the ratio and to increase or decrease the number of yellow lanes.

TESTING THE MODEL ON A HYPOTHETICAL NETWORK

A test network was proposed (Figure 2a.), with hypothetical input parameters, shown in Figure 2. It is necessary to implement an algorithm described in the previous section to a given hypothetical network and to suggest links which the yellow lanes will be assigned to.



a. b.

Figure 2. The appearance of the test network (a) and of the network with assigned yellow lanes

As the output results from the fuzzy logical system, the values of IP were presented, distributed by the branches of a hypothetical network (Table 2.). This clearly reflects the universal approximator characteristic of fuzzy logic. In other words, the values obtained at the output stage of the fuzzy logical system, when the network is loaded, we obtain the basis for the final step in determining which links the yellow lane will be assigned to.

Table 2: The hypothetical test network parameters

Link	q_i	J_i	T_i	α	β	γ	δ	φ_r	φ_k	φ_{re}	φ_o	θ_i	θ_{ip}	θ_{tx}
L1	216	7	15	0,77	0,08	0,05	0,10	0,70	0,83	0,79	0,64	45	3	4
L2	216	2	10	0,77	0,10	0,09	0,04	0,69	0,83	0,88	0,74	33	0	-9
L3	169	7	18	0,75	0,10	0,05	0,10	0,64	0,7	0,90	0,71	40	4	-2
L4	245	12	27	0,75	0,09	0,06	0,10	0,83	0,67	0,81	0,88	26	1	1
L5	71	5	30	0,75	0,07	0,05	0,13	0,64	0,77	0,88	0,85	29	-1	5
L6	153	4	40	0,70	0,06	0,10	0,14	0,68	0,88	0,78	0,83	40	-4	8
L7	115	5	14	0,71	0,07	0,08	0,14	0,90	0,76	0,74	0,72	29	-1	4
L8	154	9	17	0,73	0,05	0,08	0,14	0,72	0,79	0,79	0,60	44	1	-5
L9	81	2	38	0,66	0,06	0,10	0,18	0,79	0,64	0,90	0,62	49	-4	3
L10	213	1	29	0,72	0,08	0,07	0,13	0,66	0,78	0,80	0,78	30	-1	-10
L11	244	11	32	0,66	0,07	0,06	0,21	0,90	0,63	0,80	0,61	45	1	0
L12	100	4	15	0,75	0,06	0,10	0,09	0,87	0,83	0,79	0,64	50	-1	-6
L13	103	9	40	0,69	0,07	0,08	0,16	0,70	0,9	0,89	0,87	20	2	3
L14	83	5	33	0,73	0,07	0,06	0,14	0,70	0,84	0,67	0,76	34	1	7
L15	211	12	36	0,77	0,10	0,09	0,04	0,83	0,66	0,69	0,77	35	-2	6
L16	104	12	19	0,77	0,05	0,07	0,11	0,85	0,81	0,75	0,76	49	-5	8
L17	179	2	25	0,68	0,06	0,09	0,17	0,76	0,78	0,69	0,90	22	-2	8
L18	161	11	30	0,79	0,10	0,07	0,04	0,77	0,8	0,73	0,90	39	4	-4
L19	212	5	18	0,72	0,08	0,05	0,15	0,71	0,8	0,67	0,87	44	0	-6
L20	185	2	40	0,67	0,06	0,07	0,20	0,89	0,66	0,72	0,88	49	4	7

L21	78	2	35	0,66	0,06	0,07	0,21	0,82	0,69	0,67	0,77	47	1	-9
L22	99	4	22	0,78	0,09	0,08	0,05	0,68	0,87	0,69	0,76	43	-5	-8
L23	229	3	13	0,74	0,06	0,09	0,11	0,60	0,65	0,74	0,65	36	1	10
L24	209	11	11	0,69	0,06	0,07	0,18	0,90	0,61	0,65	0,82	22	0	10
L25	112	11	25	0,77	0,08	0,05	0,10	0,68	0,71	0,63	0,63	34	5	-1
L26	235	9	39	0,79	0,10	0,10	0,01	0,67	0,63	0,68	0,65	23	4	-8
L27	225	10	26	0,71	0,10	0,06	0,13	0,73	0,79	0,86	0,79	30	4	-1
L28	73	5	31	0,77	0,09	0,06	0,08	0,69	0,76	0,86	0,70	45	4	1
L29	201	5	19	0,76	0,09	0,08	0,07	0,70	0,84	0,74	0,70	24	-5	6
L30	132	3	28	0,71	0,05	0,08	0,16	0,72	0,68	0,73	0,86	31	-1	2
L31	217	11	17	0,80	0,08	0,10	0,02	0,66	0,85	0,86	0,60	50	2	-2
L32	180	4	38	0,71	0,08	0,10	0,11	0,90	0,87	0,68	0,67	42	0	7
L33	122	1	10	0,79	0,10	0,05	0,06	0,86	0,66	0,74	0,78	35	4	1
L34	136	7	17	0,68	0,10	0,09	0,13	0,84	0,82	0,68	0,79	31	0	10
L35	220	12	25	0,74	0,09	0,10	0,07	0,84	0,74	0,62	0,73	29	-3	9
L36	175	12	24	0,66	0,08	0,07	0,19	0,64	0,6	0,70	0,80	42	2	-4
L37	240	3	39	0,79	0,05	0,09	0,07	0,84	0,87	0,73	0,68	42	-3	9
L38	246	4	16	0,74	0,05	0,10	0,11	0,83	0,69	0,74	0,78	34	3	-7
L39	71	1	33	0,76	0,10	0,05	0,09	0,79	0,74	0,64	0,62	35	2	-4

If the city management decided that 20% of the network should be covered by yellow lanes (step 2 of the algorithm) according to the values of IP, which are also shown in the following figure for each link separately. Thus, 8 yellow lanes were obtained on the network. As the output from the algorithm ,the links proposed for the allocation of yellow lanes are marked L1, L2, L8, L10, L19, L29, L31 and L38 (Figure 2b).

CONCLUSION AND THE FURTHER RESEARCH DIRECTIONS

The developed European countries and the countries in transition try to minimize the adverse effects caused by transport, so that its further development complies with the principles of sustainable development and to find effective goals and righteous actions to achieve the sustainable development of transport.

The objectives of the "car sharing" strategy, and its contribution to the sustainable transport are reflected in several aspects: economically, the reduction of external costs of transport is expected (for example, the cost of eliminating the environmental pollution, less fuel consumption ...); from the social point of view , the average time of travelling on the network is reduced ; ecologically, the emission of hazardous gases is reduced due to fewer vehicles on the network, as well as the noise reduction and, technically and exploitationally, the level of occupancy of cars is increased ,which is one of the basic ideas of the strategy.
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An algorithm for the implementation of the yellow lanes on the existing street network in function of applying the "car sharing" strategy which allows the yellow tapes to be used by those vehicles with two or more passengers was proposed. In this paper, fuzzy logic was applied because of the fuzziness of input parameters and for the approximation of distribution of network traffic after introducing the object strategy. The justification of applying fuzzy logic is that it is almost impossible to predict with certainty exactly the number of cars which will be reduced, i.e., how many people will agree to go to work by one car. And, of course, what amount of the generated traffic will occur on this link because of the ability to use the yellow lane if there are two or more passengers in the car. Therefore, fuzzy logic, as a universal approximator, finds its place in modelling this type of problems. It should be noted that in the test example, the parameter values were adopted as random variables, but within the expected values. Of course, for each zone you want to apply the proposed algorithm on, it is necessary to research, in order to obtain the approximate values of the input parameters provided in the model.

City authorities, according to their policy, make decisions on the number, ie., the percentage of the number of yellow lanes over the entire network. This decision is left to the city management, to manage the strategy, ie. to determine the extent to which they want to promote the "pairing up” of cars, which would reduce their number in the zones of high attractiveness (often city centres) . The policy adopted should be researched after a while, ie. it should be checked whether its effects produced the expected results. If this is the case, it should be continued with a given policy and worked on its improvement and, if we're not satisfied with the effects, something should be changed. As the period after which the adopted policy should be checked and a period of two years was proposed.

Further research could move in the direction of finding the optimal distribution of yellow and "normal" (lanes) compared to the results of applying the object strategy. In this case the methods of heuristics and metaheuristics find their application.

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REGIONAL CLUSTER AS AN ORGANIZATIONAL MODEL FOR INCREASING THE EFFICIENCY OF THE MOTOR VEHICLES RECYCLING

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ABSTRACT

The one of the basic forms of the self-sustainable business politics is the regional strategic networking in the form of business clusters. There is one cluster for the management of the End-of-Life Vehicles in Serbia, which gives the new initiative impulse in this industrial branch. It promotes and supports the improvement in this sector by proposing the initiative in the areas of the legislation, technology, human resources, material resources improvement and by promoting the examples of good praxis in the developed countries. This paper analyzes the positive influence of the cluster on the related business surroundings.

Key words: *cluster, organizational model, vehicle recycling.*

INTRODUCTION

Definitions of what exactly constitutes a cluster vary greatly. It can be said that clusters represent local concentrations of linked firms that specialize in related areas of business, together with supporting organizations. Porter (1998a) said that clusters are concentrations of interconnected companies and institutions in a particular field. It is worth noting that industry clusters are more than a group of companies within the same industry. The cluster represents a synergy, a dynamic relationship and a network between not only the companies that comprise a cluster but also the successful partnering of the stakeholders (government, education, and other supporting organizations).

Jacobs and De Man (1996) noted that there is not one correct definition of the cluster concept. They concluded that there were a set of dimensions to which tailor-made policies could be developed. The dimensions identified were:

1. Geographical – spatial clustering of economic activity,
2. Horizontal – relationships between industry sectors at similar stages in the production process,
3. Vertical – relationship between industry sectors at different stages along the production process,
4. Lateral – relationships where different sector share certain capabilities that lead to performance gains in the form of economies of scope,
5. Technological – around a basic technology,
6. Focal – a cluster of firms around a central actor,
7. Quality of the network – the way in which firms cooperate and the relative benefits that they receive, will determine whether the network will be sustainable and stimulating.

CLUSTER MODELS AND CLUSTER BENEFITS

Clusters may vary greatly in their size, type and internal organization, but it is possible to make a general classification. Markusen (1996) defined four models of clusters, based on the role of different cluster members and the interaction between them:

1. Marshallian cluster model (figure 1),
2. Hub-and-Spoke cluster model (figure 2),
3. Satellite Platform cluster model (figure 3),
4. State Anchored / State centered cluster model (figure 4).

Marshallian cluster model is homogenous, comprising of small firms that collaborate with each other. In this model, none of the firms has the size and the force to control directly the cluster. In a hub-and-spoke cluster, there are few dominant firms that represent the core of the cluster and are surrounded by numerous small firms that are linked directly to them. The most part of the cluster firms represent suppliers of raw materials, of externalized services or are specialized in a particular phase of the hub production process. In a satellite platform cluster, a group of branch facilities of externally based multi-plant firms are located in a particular geographic region in order to benefit from governmental facilities or low costs with supplies and workforce. State anchored cluster is defined around a public, governmental or non-profit organization that dominates the region and the economic relation between cluster members, (Markusen, 1996).

Clusters form in vast variety of industrial sectors, e.g. aerospace, agriculture, biotechnology, chemicals, IT, telecommunications, metallurgy, medical, automotive and recycling industry sector.

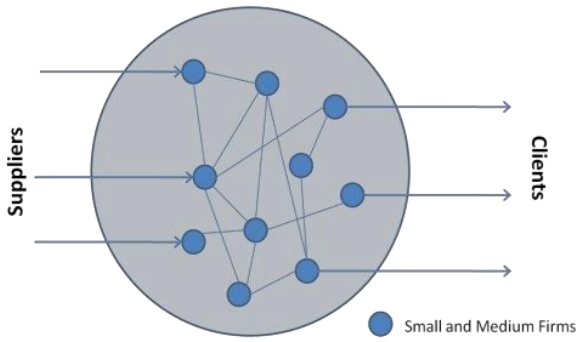

Figure 29. Marshallian cluster model

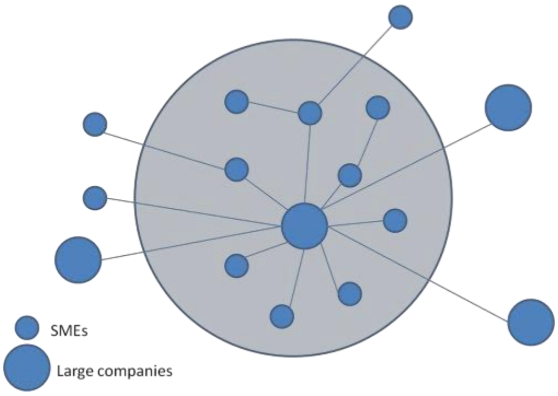

Figure 30. Hub-and-Spoke cluster model

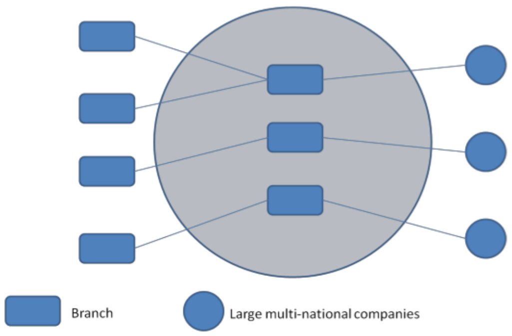

Figure 31. Satellite Platform cluster model

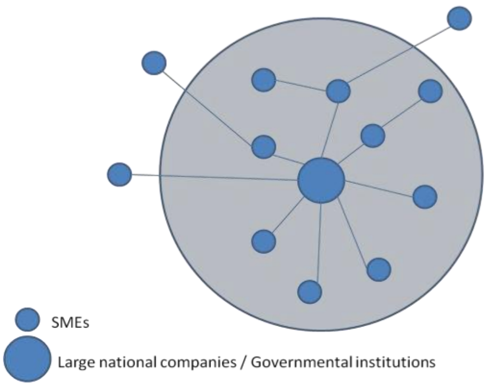

Figure 32. State Anchored cluster model

The goal of industrial clusters is creation, preservation and increase of competitiveness. That competitiveness can be achieved in three ways: by increase in productivity, by innovation and by formation of new companies.

Porter (1998b) noted that regional clusters have the ability to offer local things such as knowledge, relationship, and motivation, which cannot be matched by distant rivals. In other words, benefits of cauterization, beside the increase of competitiveness, are numerous: increase in export, increase in production, creation of framework for cooperation and joint activities, availability and access to information networks and new data, better education of workforce, greater diversity of processes, increase in number of jobs and access to specialized labor force, better knowledge and innovation management, access to specialized suppliers, development of entrepreneurship and SME sector, directing and coordinating the use of limited resources, integration with other clusters, development and improvement of infrastructure and local environment, revival of traditional underdeveloped regions, etc.

CURRENT STATE OF ELV RECYCLING IN SERBIA

Current state of recycling of end of life vehicles in Serbia can be described as unorganized and chaotic. Old and broken vehicles are often left on the streets and in nature. Most of the time, depollution of hazardous fluids is not applied, so car fluids are being released in soil. Similar situation is occurring with nonmetal, plastic and glass parts, e.g. they are freely disposed on unsanctioned landfills and green areas. All of this is causing great pollution of environment and on the other hand, a large amount of resources are being wasted and thrown away.

In the 2010, Republic of Serbia adopted the law on recycling of end of life vehicles: “Pravilnik o načinu i postupku upravljanja otpadnim vozilima”. Besides that law, there are also laws about disposal of batteries, tires and hazardous fluids, all of them adopted in 2010. Those laws define exact procedures for recycling of ELV-s, both for metal and nonmetal parts. Unfortunately, these laws are rarely followed.

Even with above-mentioned laws, ELV recycling is still unorganized. Collectors of old vehicles and scrap metal are usually gypsies, without legal firms and any knowledge on legal procedures, environmental and health safety. On the other hand, those who possess legally registered firms, often ignore the law and procedures on ELV recycling. It is usually said that they work in gray economy zone. At the other end of the recycling industry are firms that do the recycling itself. They are facing problem with low supply of input materials, low demand for their products in Serbia, and fierce competition abroad.

By observing the current state of the industry, the following conclusions can be drawn:

1. Lack of systematic approach to ELV recycling,
2. Legal procedures and laws are not followed,
3. Many companies work in so-called gray economy zone,
4. Unsanctioned landfills are causing big environmental pollution,
5. Car manufacturers in Serbia are not following the sustainable development model,
6. Low energy efficiency in car manufacturing and absence of waste reduction,
7. Uninformed society.

CLUSTER MODEL FOR ELV RECYCLING IN SERBIA

The proposed solution for the problems in the ELV recycling sector is formation of an industry cluster. Naturally, cluster would consist primarily from companies that are actively involved in the recycling business, i.e. waste collectors, dismantlers and recyclers. Beside them, members of the cluster should also be resellers of used and new vehicle parts, manufacturers of vehicle parts, car services…

University level institutions (Faculty, or Institute) would be a great addition to the cluster, offering the valuable knowledge, experience and insight in new technologies.

Proposed model for ELV recycling cluster is hub-and-spoke cluster model (figure 2). Many automotive clusters in the world have this kind of structure, most famous of whom is Detroit Auto Cluster. As it was stated above, in a hub-and-spoke cluster, there are few dominant firms that represent the core of the cluster and are surrounded by numerous small firms that are linked directly to them. The most part of the cluster firms represent suppliers of raw materials, of externalized services or are specialized in a particular phase of the hub production process. The small firms trade directly with the large ones and depend on their client strategy. The hub firms define the relation inside the cluster and its dynamics.

In the case of ELV recycling cluster, recyclers would represent dominant firms, and waste collectors and dismantlers would represent small firms that are directly linked with big firms. Small firms (i.e. waste collectors and dismantlers) would supply the recyclers with raw materials, hence they would depend on the strategy of the big firms. Faculties and Institutes would help with the implementation of new technologies, improvement of energy efficiency and operational efficiency. In addition, cluster would have one independent central office that would serve as a middleman between small and big firms. The mission of the central office, besides communication with and between cluster members, would be promotion of ELV recycling, media campaigns, political lobbying, education of cluster members and general public, search for national and European projects and funds.

Based on the examples of good practice in the world, ELV recycling cluster in Serbia should focus on the following items:

1. Providing support, organization and coordination of activities of cluster members in the fields of research and development, information, education, public relations, marketing, and promotion of international cooperation,
2. Quality professional subordination and efficient accumulation of knowledge, skills, information and capital in the recycling of end of life vehicles,
3. Increase in productivity and utilization of potentials in the sector of recycling end of life vehicles,
4. Adoption of European standards in the field of ELV recycling in Serbia,
5. Quantitative and qualitative increase in business start-ups in the field of recycling of end of life vehicles,
6. Popularization of recycling models from developed countries in local professional and general public,
7. Contribute to the development of the secondary materials market,
8. Transition into legal economic business models for most of the recycling sector, which is currently located in the gray economy zone,
9. Raising environmental awareness and environmental protection level in the field of recycling and ELV-s,
10. Increase of competitiveness in domestic and foreign markets through joint participation in the market,
11. Achieving better working conditions, and promoting employment,
12. Encouraging innovation,
13. Providing easier access to specialized suppliers (e.g. for used parts),
14. Providing technical and technological knowledge transfer, lower development costs of new products / services,
15. Increasing the capacity of production, sales, exports,
16. Represents the interests of all members whose activity is collection, transport and recycling end of life vehicles,
17. Promotes dialogue and cooperation between the members of the clusters, small and medium enterprises and research and educational institutions and organizations, as well as between external influential group,

18. Provides training programs for companies in the field of vehicle recycling, training and education of employees in small and medium-sized enterprises (on topic of proper waste handling and disposal).

CONCLUSION

Benefits of clusters in industry are wildly known and documented. All the models are well described, so we should pick the right one and implement it. In this paper we gave short overview of cluster basics, we proposed the rough structure of ELV recycling cluster in Serbia, and listed the potential benefits of this particular cluster. Our proposition is based on the good practice examples in the world, e.g. Detroit Auto Cluster. ELV recycling cluster can help in the law and procedures enforcement, it can increase the number of recycled vehicles, reduce pollution, increase profits and export.

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FACTORS THAT INFLUENCE THE VULNERABILITY OF THE MOTOR VEHICLES RECYCLING SYSTEM IN SERBIA

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ABSTRACT

The vast variety of materials is generated through the end-of-life vehicle (ELV) recycling processes, various types of ferrous and non-ferrous metals primarily. The economical self-sustainability of the latter processes depends on the development of the repaired second-hand spare parts market, stock market prices of the recycled materials, national legislation and the government stimulus packages for this industrial branch. This paper treats the influence of these factors on the ELV recycling processes.

Key words: *end-of-life vehicle (ELV), factors, vulnerability, recycling.*

INTRODUCTION

The sustainability and progress of the mankind depend of recycling industry. The reason for this is based on the sustainable production of materials, which implies the preservation of natural resources and energy, as well as the decrease of the emmision of pollutants. A branch of the recycling industry that treats End-of-Life Vehicles (ELVs) is one of the most influental branches because of the varieties and amounts of treated materials, the waste volume reduction and a prevention of the environmental pollution. The ELV recycling, through the amounts of secondary materials obtained in the recycling process, presents a significant economic contribution to the world economy. The number of ELVs has been increasing, thus, based on the (Andersen, M., et, al., 2008) it is estimated that there will have been 20 milion of ELVs by the year of 2020. Besides the number of ELVs, their mass has been increasing as well. Thus, in order to treat all ELVs, it is necessary to establish a sustainable system that will be able to follow new technological, ecological and economic demands.

The sustainability of a system depends on:

- The national legislation acts and government stimulus packages;
- Prices of secondary materials;
- Posibilities to use second-hand spare parts;
- Posibilities to use repaired second-hand spare parts;
- Drawing the line between waste and secondary materials;
- Restrictions and controls;
- Monitoring the statistic data on national resources and needs in the ELV recycling industry;
- The constant development of the recycling centers.

The recycling in Serbia faces many challenges, where one of the major is the illegal work in the ELV recycling. These challenges do not give a chance of creating the productive business environment in which ELV recycling will be sustainable in economical, technological, technical and environmental terms, with minimum chances of obtaining hazardous situations. The Serbian recycling industry faced serious challenges when the work of the Environmental Protection Fund was canceled. This caused delays in paying the compensations for waste treatment, which have eventually stopped. However, the payments started again in the first quartal of 2013. Still, the sustainable system has not been established.

This paper presents the main influence factors that increase the vulnerablitity and prevent the establishement of a sustatinable ELV recycling system in the Republic of Serbia.

RELEVANT DOCUMENTS OF THE NATIONAL LEGISLATION

The main legislation document that regulates waste management problems in Serbia is *Zakon o upravljanju otpadom* („Službeni glasnik RS”, broj 36/09 i 88/10). The document regulates: types and classification of waste, waste management planning, waste management subjects, responsibilities and obligations in waste management, special waste stream management, terms and procedures for obtaining waste management licences, cross-border waste transport, reporting and data base establishing, waste management funding, supervisions, penalties, ect. Based on the national legislation the Ministry of Environmental protection gave the document *Uputstvo o uslovima koje moraju da ispune ovlašćeni operateri za reciklažu otpadnih vozila (2009),* which is the manual about terms that licenced ELV recyclers have to fulfill. The legislation act that treats ELVs directly is *Pravilnik o načinu i postupku upravljanja otpadnim vozilima, „Sl. glasnik RS “ br. 98/2010*. This document regulates the ways and processes in the ELV recycling through the activities that owners, collectors, recyclers and government officials have to conduct. Some of the most significant demands are:

- no later than 1 January 2015, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 85 % by an average weight per vehicle and year;
- no later than 1 January 2019, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 89 % by an average weight per vehicle and year.

The distinction of waste and secondary materials is defined, in the economic terms, by the *Pravilnik o utvrđivanju sekundarnih sirovina i usluga koje su neposredno povezane sa sekundarnim sirovinama (Sl. glasnik RS 107/2012).*

The latter legislation acts are based on the European Directive 200/53/EC, thus they carry many challenges. The implementation of the legislation acts demands thorough changes within the system, technologies, concence and habits. Thus, currect conditions do not follow legislation terms, so the set conditions can not be accomplished in time. This is the consequence of the absence of the recycling system, as well as the social and economic condition. These factors slow down the development of the ELV recycling system, which causes degradation in technical and expert terms.

ECONOMIC SUSTAINABILITY STRATEGY FOR THE ELV RECYCLING SYSTEM

An end-of-life vehicle is considered as a hazardous waste. Because of that, it is necessary to conduct an operation called depollution, before any other operation. After the depollution is done ELV becomes non-hazardous waste. There are two main approaches to the ELV recycling (Marjanović, Z., 2009), shredding and dismantling principle. It is worth of mentioning that many automotive companies have manuals for the optimal separation of their vehicles when they finish their life cycle. Serbian recyclers, most often, combine these two methods. First, a vehicle is dismantled and all usable and valuable parts are taken away, then the rest of it is either pressed or shredded with the main purpose to use available ferrous metals. A vehicle itself presents potential source of many secondary materials, both organic and inorganic nature, however the accent is placed on the use of ferrous metals and copper, because of the economic reasons. Figure 1 shows a scheme of the ELV recycling process, which presents the starting point for conducting costs and benefits analysis.

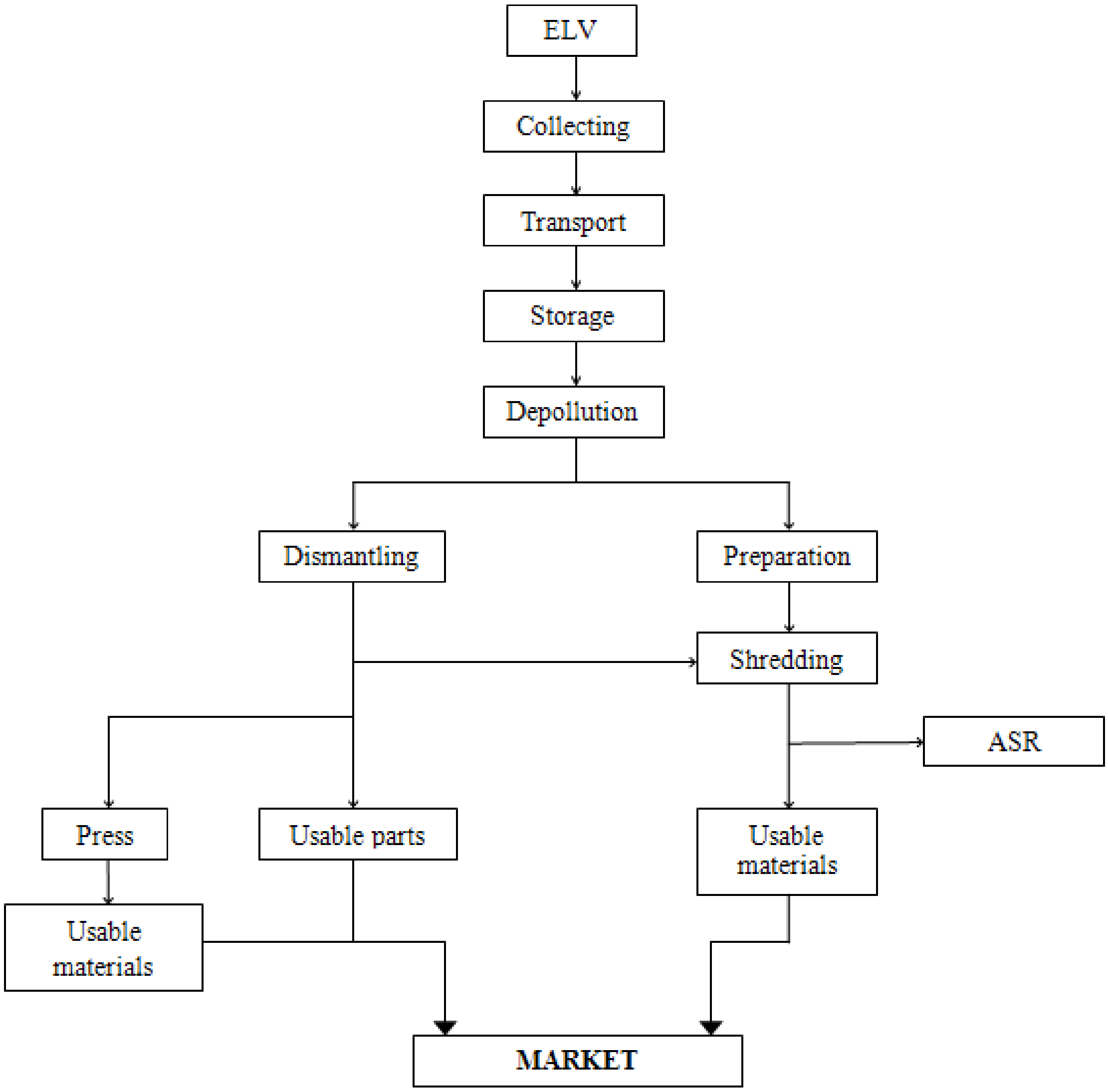

Figure 1. Processes in the ELV treatment

The utilization of secondary materials depends on the efficiency of recycling centres. A by-product of the shredding process is called automotive shredder residue (ASR) which is (15-20) % of an average vehicle weight. Thus, the treatment of ASR has a very significant role in fulfilling the legislation terms.

European legislation acts are based on models which observe the recycling industry through the economic and environmental factors. In order to achieve the economic sustainability on the national level it is necessary to implement legislation acts based on the costs (C) and benefits (B) that are achieved in the ELV recycling. In general, there are three possible scenarios:

- *B>C, the recycling system is economically sustainable;*
- *B=C, the economic profit of the recycling industry is zero;*
- *B<C, the recycling system is economically unsustainable.*

Influence factors that affect benefites may be given with the relation:

$$\boldsymbol{B = B(a, b, c, d, e, f, g, h, i)} \quad (1)$$

Symbols used in (1) are:

- *a, stock prices of secondary materials;*
- *b, amounts of treated materials;*

– *c, situation on the second-hand spare parts market;*
– *d, number of sold second-hand parts;*
– *e, producers and importers subventions;*
– *f, national stimulus packages;*
– *g, fundings from ecological funds;*
– *h, consumption of secondary materials by the national economy;*
– *i, number of ELVs.*

Influence factors that affect costs may be given with the relation:

$$\boldsymbol{C = C(\alpha, \beta, \gamma, \delta, \varepsilon, \epsilon, \zeta, \eta, \theta, \vartheta, \iota, \kappa, \lambda, \mu, \nu, \xi, o, \pi, \varpi, \rho, \varrho, \sigma, \varsigma, \tau)} \tag{2}$$

Symbols used in (2) are:

– α*, collecting costs;*
– β*, transport costs;*
– γ*, storage costs;*
– δ*, depollution costs;*
– $\boldsymbol{\varepsilon}$*, dismantling costs;*
– $\boldsymbol{\epsilon}$*, costs of transport to shredding facility;*
– $\boldsymbol{\zeta}$*, press operation costs;*
– $\boldsymbol{\eta}$*, costs of cleaning and reparation of parts;*
– $\boldsymbol{\theta}$*, costs of preparation for shredding process;*
– $\boldsymbol{\vartheta}$*, shredding costs;*
– $\boldsymbol{\iota}$*, costs of treatment and storage of ASR;*
– $\boldsymbol{\kappa}$*, material separation costs;*
– $\boldsymbol{\lambda}$*, product storage costs;*
– $\boldsymbol{\mu}$*, human labour costs;*
– $\boldsymbol{\nu}$*, energy costs;*
– $\boldsymbol{\xi}$*, equipment amortization;*
– $\boldsymbol{o}$*, number of ELVs;*
– $\boldsymbol{\pi}$*, taxes.*

Depending on the approach to the recycling process type of costs may differ significantly. In the dismantling approach human labour costs are much higer than in the shredding approach. However in the shredding approach energy and equipment costs are dominant ones.

The sustainable ELV recycling in terms of economy is obtained when B>C, without the necessity of subventions (e,f,g) from the equation 1.

THE UTILIZATION OF SECOND-HAND PARTS

Second-hand parts are those directly taken from an ELV, as well as those that are repaired and ready to use, with the warranty for their functionality. These parts are one of the products of ELV recycling system with the dismantling approach. One of the greates patrons on using second-hand spare parts is EGARA (European Group of Automotive Recycling Associations), which has developed a network of distributers of repaired parts on the European ground. There are three main reasons for vehicle owners to use second-hand repaired parts: technical, economical and ecological. Nowdays, many people use them due to the problems caused by the world economic crisis.

From technical aspect, functionality, safety and reliability are not dangered with the use of repaired used parts, as long as they are tested before being used. Furthermore, a part is fully functional and safe with the characteristics of new one. This is confirmed with a certificate which follows the part. Based on the certificate, the origin of a part may be determined. The economic reasons for using used parts are numerous. When bying a used repaired part its price may be two times lower than of a new one, yet its life cycle is shorter than a life cycle of a new part. Based on the environmental aspects it is the most accessable way of obtaining a “new” part. That may be supported though the reduction of the amount of generated waste and consumpted materials. Thus, resources, energy and emission of pollutants are reduced.

The market of used parts is not centralized and there are no legislation acts that regulate this field in Serbia. Thus, there is an open space for the illegal work, especially in using the parts directly taken from ELVs without any testing. Parts like these may cause serious problems in the functionality of a vehicle. There are workshops that do reparation of some parts and they give a warranty to their functionality. Yet, they do not have stocks of repaired parts, so an owner of a vehicle has to wait for the reparation of his own part. During yhe reparation time a vehicle is not functionable. Further research is needed in order to form a model which would cover the needs for used parts, which would make the ELV recycling industry in Serbia much stronger.

PRICES OF METALS

Prices of metals on the national and international level have been constantly changing (Xiarchosa, I., 2009), this directly affects the ELV recycling industry. Variations of steel prices are the most influential ones, so their positive and negative fluctuations have been monitored. More important than short term fluctuations is the average value of the prices of input materials. As a reason for reducing production in recycling centres (Majinski, N., 2009) states the fact that input and output prices are almost the same. This is caused with the low consumption of secondary materials during the world economic crisis, which may be observed through the ferrous metal prices (Majinski, N., 2009). The reduction in their consumption may cause the overbalance on the market which affects ELV recycling directly.

The market demand for copper and aluminium is stable and there are no significant fluctuations of their prices (Majinski, N., 2009). ELV recyclers should orient their production toward these metals in order to obtain sustainable production, because the stock market prices of these metals depend on their scrap (Xiarchosa, I., 2009). Table 1 shows the prices of aluminum and copper scrap that recyclers pay to the collectors.

Table 1: Average price of scraped Aluminium and Copper in the time period of six months

Time period	Aluminum, din/kg	Copper, din/kg
Jan – Jun 2011	115,97	524
Jul – Dec 2011	101,06	490,73
Jan – Jun 2012	117,25	534,88
Jul – Dec 2012	121,14	548,21
Jan – Jun 2013	119,45	505,2
Jul – Sept 2013	108,24	456,53
Average	113,85	509,93

Source: *Centar za reciklažu, Srbija*

IMPROVING POSSIBILITIES OF THE ELV RECYCLING SYSTEM IN SERBIA

It is possible to improve Serbian recycling industry by increasing the level of organization of the recycling centres as well as with the improvement of relevant legislation acts. Serbian recyclers face a problem with selling their products, because the national economy does not have facilities for their further treatment. After the reduction of work capacity of the steel mill “Smederevo” recyclers faced a problem how to sell their secondary ferrous metals. The largest amounts of secondary ferrous metals have been currently exported to Turkey, where no high quality of material is needed. This has endangered the bussines of well-equiped recycler that have invested in the modern technology. Furthermore, it has made national economy weaker because it has to export secondary materials and to imprort final products. So, one of the main pillars of creating a strong ELV recycling system in Serbia is the development of national metallurgy.

Most of the Serbian recyclers do not posess modern equipment that can produce quality products, it is very old equipment that requires lots of labour. Many aren’t able to obtain the modern equipment due to the high prices, customs and credit interests (Majinski, 2009). Thus, they face two problems, lost of labor, and expensive equipment, which is not affordable for many. In order to increase the use of human labour the system should be oriented toward dismantling procedures. Still this requires a system of control, storage and market of used repaired spare part. Spare parts taken from ELVs in Serbia are very old mostly, so their usability is questionable (Arsovski, S., et, al., 2009).

The recycling industry is directly related to the environmental protection. However, this has often been neglected, due to the wish of profit increasement. Thus, ELVs are not depolluted and many scrap yards do not have a hydrophobic ground. ASR is classified as a hazardous waste which causes certain economic costs (Passarini, F., 2012). In order to reduce its amount many plants have been constructed such as those by a company „SiCon“. Unfortunatly, there are no capacities like this in Serbia.

CONCLUSION

The market of secondary materials has been destabilized by the world economic crisis. Together with high production costs, it makes Serbian recycler not concurrent on the free market. This disables the investments in technological development and personell trainings. It is necessary to conduct a detail analysis of costs and benefits in order to notice weak points of the current recycling system. Once noticed, a wide set of activities should be conducted in order to correct them. The national legislation acts which should contribute to the establishment of the sustainable national ELV recycling system.
The trade with the used spared parts is very significant in the organization of the ELV recycling system. Yet, it is not regulated so consumers can not be sure in their quality and durability. Thus, many car owners avoid using these parts.

In general, national recycling industry is covered with legislation acts, yet many of them are not really implemented. This causes direct negative effects to the national economy as well as to the European integration. The development of new acts and implementation of old ones is a prerequisite for fulfilling the needs in the field of ELV recycling which are necessary for joining the EU and establisement of a sustainable recycling system.

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TRANSFER STATIONS IN THE SYSTEM OF MANAGEMENT OF SOLID COMMUNAL WASTE

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POLYOLEFINS' PROCESSING IN TERMS OF ENVIRONMENTAL PROTECTION

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ABSTRACT

The polyolefin abundance in solid waste is constantly increasing with the growth of standard, population and industrialization. The interest in recycling the polyolefins is rising. The solutions in poliolefins recycling as an approach for reducing the solid waste are constantly increasing. Described are the results of the physical and mechanical properties of polyolefins after recycling. Suggested is the possible used of the recycled polyolefins as secondary plastic.

Key words: *polyolefins, environmental protection.*

INTRODUCTION

An increase in the production of polymer products has led to a significant amount of plastic waste. This waste is generated during the production of polymers and during the use of the polymer products. Amount of plastic waste generated is increasing and becomes a danger to the environment. Plastic waste can be used as a secondary raw material. This paper describes the characteristics of the multiple recycled polyolefin waste.

THE FORMATION AND THE POSSIBILITY OF USING THE SECONDARY PLASTIC MATERIALS

Polyolefin polymers are the major component in the municipal waste. The total volume of waste polymers in the communal waste presents 7% (Starke, 1984; Starke, 1988). The composition of polymer waste is: polyolefins (PE, PP) 65 %, polystyrene (PS) 15%, poly(vinyl-chloride) (PVC) 10%, poly(ethylene-terephthalate) (PET) 5% and the other entire polymers 5%. The approach for the solution of polymer plastic waste is by collecting it. From an energetic point of view the recycling of the plastic waste significantly reduces the consumption of natural resources, oil and gas, which are used in plastic production. From a technical point of view developed processing procedures reduce the amount of the plastic waste. In Table 1. are shown the sources of formation and properties of secondary plastic raw materials (Starke, 1984).

Table 1: Sources and characteristics of secondary plastics

Source	Purity degree
Industry of plastics	Clean
Plastic processing industry	Clean
Plastic products from the production	Clean
Plastic products in general consumption	Mixed, combined, damaged

The recycled plastic materials should provide up to 15 % of the need of the plastic materials. It should involve the use of technologies that do not produce waste, the reduction of the plastic materials waste during the production, collection and processing of the polymer waste, the preparation and its use as a raw material (Dvorkin et al., 1986). The addition of granules to the recycled plastic material is the possibility of its re-use.

EXPERIMENTAL PART

The changes in tensile properties of the processed polyolefin plastic material and the influence of processing on the physical and mechanical properties of polyolefins were investigated. The experiments were done with the following plastic materials: PE-LD, PE-HD and PP. Processing of the polyolefin waste was done with the automatic pressing. The used plastic material was grounded with the mill. Polyolefins were crushed at the specific temperature. Measurements of tensile properties were done in accordance with DIN 53504.

RESULTS AND DISCUSSION

The plastic processing is significantly affected by temperature, strain and oxidation. The temperature, strain and oxidation lead to the degeneration of plastics. The reduction of high molecular weight during processing causes loss of physical and mechanical properties of polyolefins. The consequence of the tensile change properties are fracture toughness and thermal stability. The results suggest that secondary polyolefins can be re- used in the production with the addition of fresh granules. The results suggest that there is a relatively small loss of properties caused by multistep processing. Table 2 shows some applications of a secondary PE -LD reinforced with various fillers.

Table 2: Examples of application of fillers in secondary PE -LD

Filler	Field of application	Products
Chalk	Consumer goods	polyethylene film
Talc	Civil engineering	plates , profiles
Talc	Chemical Industry	tubs, tanks
Silica filler	Chemical Industry	ventilation systems
Fiberglass	Civil engineering	lining
Wood flour	Agricultural machines	elements of the tractor cab

When material degradation is caused by the processing there was a loss of polymer properties. Such materials can be used for the production of elements for thermal and acoustic isolation.

The experimental results indicate that the changes in hardness cut of the investigated polyolefins are influenced by the multistep recycling (Figure 1). That indicates that there is a possibility in controlling the quality of the recycled polyolefins. The relative elongation of the recycled polyolefins can reach the characteristics of polyolefins by addition of additives (Figure 2).

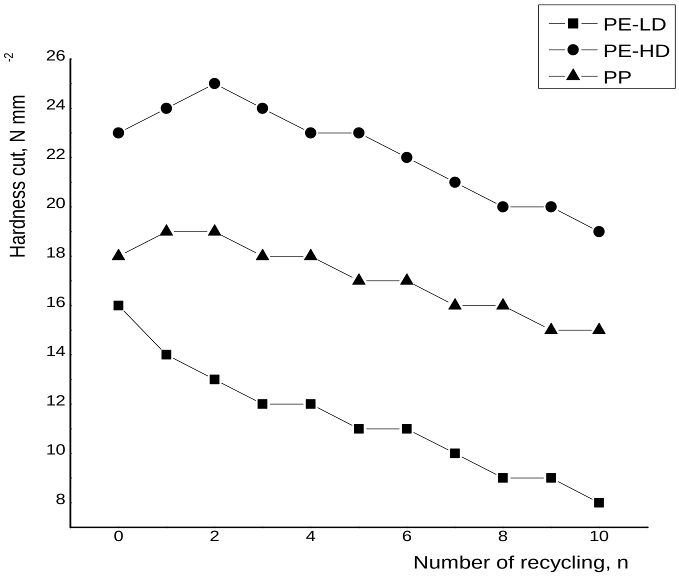

Figure 1. The influence of the multistep recycling of polyolefins on the hardness cut in case of PE-LD, PE-HD and PP

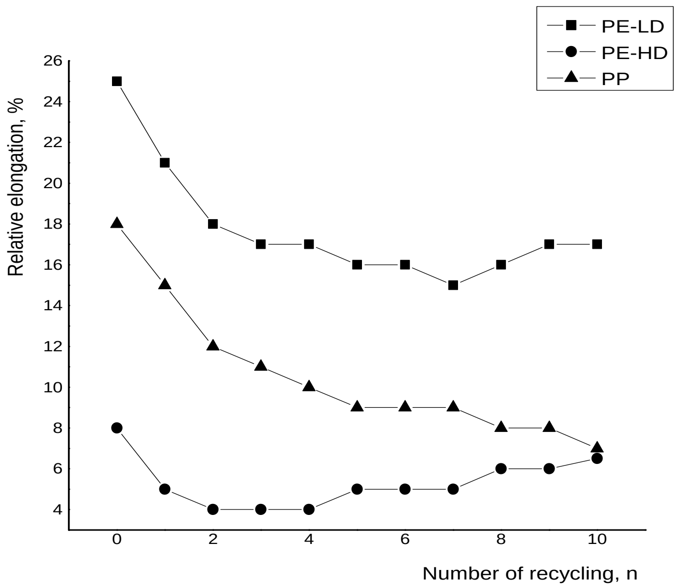

Figure 2. The influence of the multistep recycling of polyolefins on the relative elongation in case of PE-LD, PE-HD and PP

CONCLUSIONS

The results obtained indicated that there is a possibility of application of polyolefin waste. The use of recycled polyolefins leads to economic indicators that justify investing in the use of polyolefin waste. The use of polyolefin waste contributes to environmental protection.

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SOIL AND DEGRADATION OF SOIL

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ECOLOGICAL MONITORING OF SEWAGE SLUDGE AMENDMENT TO SOIL ON HEAVY METAL ACCUMULATION AND CONSEQUENT RESPONSES OF HELIANTHUS ANNUUS PLANT

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ABSTRACT

Microorganisms play key of geoactive roles in the biosphere, particularly in biotransformations and biogeochemical recycling, bioweathering, soil formation and bioremediation of heavy metal contaminated soil and wastewater. Soil is an important natural resource that needs to be preserved and its quality and productive capacity improved. Microbial activities are considered as early indicator of changes in soil properties resulting from soil amendment. Use of municipal sewage sludge (MWS) in agriculture is an alternative disposal technique of waste. The impacts of heavy metal containing MWS on the soil bioactivities were investigated in two agricultural soils of different textures at five different levels for eight weeks. In a pot experiment, high heavy metals content of MWS (Hódmezővásárhely, Hungary) at 0, 15, 30, 45 and 60% (w/w) was amended to two agricultural soils (clay loam brown forest soil; Gödöllő and chernozem meadow; Szeged) for eight weeks in greenhouse. Results indicated that microbial biomass carbon and nitrogen, CO_2-release and some enzymatic activities determined in fresh soil samples were affected by soil types and increased by organic matter (OM) application as well as the rate of heavy metals content in the MWS, also, the investigated parameters were higher in soil of Szeged than the soil originated from Gödöllő.

Key words: *Soil respiration, Soil microbial activity, Soil enzymes, wastewater sludge, sunflower plants.*

INTRODUCTION

The clean and safe environment is the fundamental requirement of human life. Today, due to constraint in availability municipal wastewater sludge (MWS) is being used in agricultural fields. Municipal WS has been recognized as one of the most cost effective and environmentally sound alternatives for organic wastes recycling from sewage water wastes have a potential to substitute inorganic fertilizers. Municipal WS can be a valuable resource if used as organic fertilizer and soil conditioner. Various studies (e.g., Palese et al., 2009) confirm that treated MWS can be useful as an additional organic matter (OM) resource for agriculture. The major benefits of MWS application are; increased supply of major plant nutrients; provision of some of the essential micronutrients (e.g., Zn, Cu, Mo, and Mn) and; improvement in the soil physicochemical properties, i.e. better soil structure, increased water holding capacity, and improved soil water transmission characteristics, etc. Toxic compounds such as heavy metals (HMs) could compromise the beneficial use of MWS. On the other hand, the MWS its use in agriculture is associated with health risks because of presence of pathogens (Toze, 2006), metallic contaminants like Cu, Ni, Cd, Cr, Zn, etc. and toxic organo-compounds. Soil analysis revealed that organic carbon (OC), phosphorus, calcium and magnesium content were high in sewage irrigated soils compared to tube well irrigated soils (Rana et al., 2010).

Health authorities in many parts of the world are becoming increasingly concerned about the effects of HMs on environmental and human health. Heavy metal contamination of agricultural soil is a worldwide problem. The immobilized HM may become plant-available with time through natural weathering process or through breakdown of high molecular weight organic-metal complexes. For example, Stacey et al. (2001) have observed that the rate of release of Cd and Zn from a range of biosolids during the decomposition of OM in the biosolids depends, to a large extent, on the chemical composition of the biosolids.

Heavy metal phytotoxicity in soil is determined by the fraction of the metal that is bioavailable. It is important to emphasise that there is a dynamic equilibrium amongst various fractions in soil and any depletion of the available pool due to immobilization, plant uptake, or leaching losses will result in the continuous release from other fractions to replenish the available pool. This is one of the main reasons why there is some reluctance towards using bioavailable pool in soils for regulatory purposes by environmental agencies in monitoring contaminated sites. In addition, the bioavailable pool is sensitive to edaphic and environmental conditions as solubilization of metals from sparingly soluble compounds responds to soil pH, redox potential, temperature, etc. (Stacey et al., 2001). Soils may become contaminated by the accumulation of toxic HMs and metalloids through emissions from rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, application of fertilizers and manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Khan et al. 2008, Zhang et al., 2010). The origin of HM contamination of soils may be anthropogenic as well as geogenic. Land filling and land application of the sludge are suggested as the most commonly recommended disposal techniques (Singh and Agrawal, 2010). However, land filling is not suitable method due to the fact that a large volume of soil is required to cover the waste in order to prevent the leaching of potentially toxic compounds (Chandra et al., 2008).

The mobilization of HMs in soil for plant uptake can be minimized through chemical and biological immobilization. Recently there has been increasing interest in the immobilization of HMs using a range of inorganic compounds and organic compounds. However, HMs do not biodegrade and can be concentrated due to the loss of carbon and water from the MWS due to microbial respiration. Thus, the application of MWS in agriculture may lead a risk for humans and the environment as a result of HMs and toxic organic compounds accumulation to high levels enough to cause damage, such as soil contamination, phytotoxicity, and the accumulation of HMs in the food supply. On the other hand, the application of MWS to flowering or ornamental plants in pots has several advantages such as: (i) these crops are non-edible therefore minimizes the direct human exposure; and (ii) plants are generally located in small pots. Thus, the more suitable recycling of sludge is its application on flowering and ornamental plants, which reduces the risks of potential toxins entering into the human food chain (Gao et al., 2008). Concentrations of HMs were higher with increase in MWS amendment rates. Ailincăi et al. (2007) found a similar trend of Cu, Ni and Cr in 40 and 60 t/ha sewage sludge amended soil.

The presence of toxic HMs in soil can inhibit the biodegradation of organic contaminants by microorganisms. Heavy metals are particularly important since high quantities of these metals can decrease crop production due to the risk of biomagnifications and bioaccumulation in the food chain and the accumulation of toxic HMs in crop plants is of great concern because it can enter the food chain. The uptake of toxic HMs by plants is often influenced by plant species, growth stage, soil type, metals and environmental factors. Toxic HM concentration in the soil solution plays a critical role in controlling metal availability to plants (Maimon et al., 2009). However, the availability of the toxic HM ions are influenced by various factors including soil pH, the physical and chemical properties of soil, the clay content and manganese oxide concentration. Phytoremediation is defined as the use of plants to remove pollutants from the environment, is a promising technology for the remediation of contaminated soils and perhaps for the removal of metals from contaminated soil (Dede et al., 2012). This technology can be applied to both organic and inorganic pollutants. Sunflower is able to secrete organic acids which acidify the rhizosphere and increases the solubility of toxic metals like Pb and Cu (Cunningham and Berti 2000).

Phytomanagement aims to combine the production of valuable biomass, such as bioenergy or stock fodder, with the gradual removal of the contaminants, and simultaneously mitigates risks by preventing the off-site movement of contaminants via leaching, runoff or erosion. Studies have shown that the accumulation of contaminants or nutrients by plants varies greatly among crops and cultivars and also differs between different parts of a plant (Fässler, et al., 2010).

Soil microbial content and activity have a variety of properties that can affect changes in metal speciation, toxicity and mobility, as well as mineral formation or dissolution or deterioration. Amendment of MWS led to significant increase in HMs e.g., Pb, Cr, Cd, Cu, Zn and Ni concentrations of soil (Singh and Agrawal, 2007). Soil microbial activity has a great potential as an early and sensitive indicator of stress in soil. Excessive accumulation of HMs in agricultural soil through wastewater irrigation may cause soil contamination and affect food quality and safety (Rahman et al., 2012). The bioavailable pool of metals, estimated as free ion activities, decreased with the increasing occurrence of metal-organic matter complexes (Hernandez-Soriano and Jimenez-Lopez, 2012; Hernandez-Soriano et al., 2013). It is suggested that the metals affected microbial biomass (MB) and activities by behaving synergistically or additively with each other. Although soils had higher MB and activities than the background soil, due to higher OM content, the ratios of microbial parameters/OC indicated that inhibition of microbial growth and activities had occurred due to metal stress (Bhattacharyya et al., 2008). Evolution of CO_2 is the major product of aerobic metabolism in the C cycle. Monitoring is needed to encourage the use of wastewater sludge in agriculture and to regulate its use to prevent harmful effects on soil, crop, animal and man (Bayoumi Hamuda and Ligetvári, 2011). The aim of the study was to investigate the effects of MWS of high HMs content on microbial, enzymatic activities in the rhizosphere of sunflower plants grown in two different soil types.

MATERIALS AND METHODS

The potential impact of the MWS-borne HMs (Pb, Cd, Zn and Cu) was monitored in the research when MWS was applied to two agricultural soils. Research was done in glasshouses with sunflower (*Helianthus annuus* L.) grown on two soil types at different application rates for 8 weeks.

Table 1 represent the pH, OM and nitrogen and HMs contents in used soils and MWS. Soils were taken from the plough layer at 0-20 cm depth. The experiment was carried out with pots of 2 kg capacity with clay loam brown forest soil (Gödöllő) and chernozem meadow soil (Szeged) treated with high HMs content MWS of Hódmezővásárhely, Hungary. Soil samples were treated with 0, 15, 30, 45 and 60% (w/w) in three replications. The moisture content of MWS amended soils was adjusted to 45% of water holding capacity and water losses were compensated by the addition of sterile distilled water during incubation. After eight weeks, Plants were collected and dry weights (g) were determined, fresh soil samples were used for determining the microbial and biochemical activities.

Table 1: Summary of some physicochemical properties of investigated soils and used wastewater sludge

Parameters	Soil samples		Wastewater sludge
	Soil 1 (Gödöllő)	Soil 2 (Szeged)	Hódmezővásárhely
$pH_{(KCl)}$	4.72	6.20	7.8
Humus/Organic content (%)	1.24	3.55	20.4
Total N, mg/kg	8.411	334.7	43311
Zn (mg/kg)	38.1	1.10	1068
Cu (mg/kg)	22.9	2.4	182.3
Cd (mg/kg)	0.18	1.02	4.168
Pb (mg/kg)	15.1	0.96	540.7

The MBC was determined by the chloroform-fumigation–extraction procedure in which C is extracted by 0.5 M K_2SO_4 before and after fumigation (Vance et al., 1987). Soil OC was determined according to Walkley and Black (1934) method. MBC was calculated as: MBC = E_C/k_{EC}, where E_C = (OC extracted from fumigated soils) − (OC extracted from non-fumigated soils) and k_{EC} = 0.45 (Wu et al., 1990). The total N was measured by the micro-Kjeldahl method (Bremner 1982) and MBN was calculated as: MBN = E_N/k_{EN}, where E_N = (total N extracted from fumigated soils) − (total N extracted from non-fumigated soils) and k_{EN} = 0.54 (He et al., 1997).

Basal respiration (CO_2-evolution) was measured by incubating fresh soil equivalent to 100 g dry weight at 28°C in 1000 ml air-tight jars for 28 days, adjusted to 45% of water holding capacity. In another beaker 50 ml of 1 M NaOH was placed inside the jar in order to trap the CO_2 evolved during the incubation period. 0.375 M $BaCl_2$ was added to NaOH to precipitate CO_2 as $BaCO_3$. The excess of NaOH that did not react with the CO_2 was determined by titration with 1 M HCl.

Hydrolysis of fluorescein diacetic acid (FDA) was evaluated according to the methods of Schnürer & Rosswall (1982) and expressed as µg fluorescein/g soil. The method of García et al. (1997) was used to determine the dehydrogenase activity (µg INTF/g soil/h). Urease (µg ammonium/g soil/h) was determined following the method of Nannipieri et al. (1980). Acid phosphatase and β-glucosidase activities were determined (µg p-nitrophenol/g soil/h) by spectrophotometry at 398 nm (Tabatabai and Bermned, 1969). Aryl-sulphatase activity was measured colorimetrically at 420 nm (µg p-nitrophenol/g soil/h) according to (Tabatabai and Bermned, 1970).

RESULTS AND DISCUSSION

Impact of MWS on microbial activity

Smith (2009) stated that the content, behaviour and significance of HMs in composted waste materials is important from two potentially conflicting aspects of environmental legislation in terms of defining end-of-waste criteria and increasing recycling of composted residuals on land and protecting soil quality by preventing contamination. All types of municipal solid waste compost contain more HMs than the background levels present in soil and their contents will increase in amended soil. There is general consensus in the scientific literature that aerobic composting processes increase the complexation of HMs in organic waste residuals, and that metals are strongly bound to the compost matrix and OM, limiting their solubility and bioavailability in soil (Smith, 2009).

The application of MWS has positively influenced the soil MB (Table 2). There was stimulation effect of MWS application on MBC (C_{mic}) and a ratio of MBC to total OC (C_{mic}/C_{org}) in both soils at the rates of 15 and 30%. The treatment of 60% caused a gradual reduction in the C_{mic} and C_{mic}/C_{org} ratio, compared with the control, suggesting low detrimental influence of total HMs of MWS on MB was there. Heavy metals caused a lesser incorporation of OC into microbial cells.

Table 2: Microbial biomass and respiration rate of the soil under various MWS treatment

Soil type	MWS doses (%)	C_{mic} (mg/kg)	N_{mic} (mg/kg)	C_{mic}/N_{mic} ratio	C_{mic}/C_{org} ratio	Respiration rate (CO_2–C mg/kg)
soil 1 (Gödöllő)	0	156.1	11.43	13.657	0.280	1.451
	15	230.6	12.11	19.042	0.362	2.183
	30	315.71	12.94	24.398	0.426	3.764
	45	469.45	14.59	32.176	0.564	5.975
	60	281.2	12.44	22.605	0.316	6.878
soil 2 (Szeged)	0	173.3	21.25	8.155	0.262	1.93
	15	287.5	25.74	11.169	0.414	3.135
	30	335.7	27.45	12.23	0.427	5.350
	45	484.6	29.73	16.30	0.559	7.624
	60	378.9	23.68	16.001	0.423	9.452

Similar to C_{mic}, MBN (N_{mic}) increased initially until the MWS treatment reached 30% and 45% then decreased gradually at 60% MWS applied dose. The results revealed that high HMs content of MWS treatment had a negative impact on soil MB at higher level (60%). Simultaneously, the MBC/MBN ratio showed the same tendency as C_{mic} and N_{mic}, indicating a change in the microbial content was affected by high application level of MWS. At the same time, the average of C_{mic}, N_{mic}, the C_{mic}/C_{org} ratio and the MBC/MBN ratio in soil 2 were all higher than those in soil 1, mainly because soil 2 has more SOM and clay minerals, which can enhance the ability of absorbing more HMs, accordingly, declining the bioavailability of HMs in MWS application, suggesting that the degree of influence on MB by HMs content was related to the clay and OM contents of the soils. Ultimately, it can be concluded that the level of HMs content in MWS treatments increased to 60% has an ecological risk existed in soil MB. Soil MB, which is considered to be an integral component of SOM and plays an important role in nutrient recycling and ecosystem sustainability, has been found to be sensitive to increased HMs content in soils. There is now a considerable amount of evidence documenting a decrease in the soil MBC and MBN as a result of eight weeks exposure to HM added to the soil by the application of MWS. This is expected that HMs content in MWS applied to soil had an inhibitory effect on soil MB at high concentration (60%).

The ratio of the BC to OC can be used as an indicator of soil quality and soil polluted with HMs. A decrease in the C_{mic}/C_{org} ratio with increasing concentrations of HMs in soils treated with MWS has been reported in many studies (e.g., Bardgett et al., 1994). Inconsistently, our results showed the MBC/MBN ratio increased initially at low applied dose (15-30%), then decreased with increasing MWS applied dose (60%), while, it was found that there was no systematic change in the MBC/MBN ratio, consequently, this parameter should be interpreted carefully as that a change in the microbial population is not always accompanied by a change of the MBC/MBN ratio (Yao et al., 2003). The application of MWS at lower level (15 and 30% or 45%) resulted in an increase in soil MB compared with the control. Fließbach et al. (1994) mentioned that generally, the low metal sludge had beneficial effects on C_{mic} and on the soil microbial activity.

The result indicated that C_{mic}/N_{mic} ratios were significantly correlated to HM stress. There was a significant decrease in the C_{mic}/N_{mic} ratio at 60% MWS applied dose. All the results showed that soil microbiological parameters could have great potential as sensitive, effective, and liable indicators of the stresses (Liao and Xie, 2007). The HMs availability in soil depends on the nature of the chemical association between a metal with the organic residual and soil matrix, pH, the concentration of the metal in the MWS and the soil, and the ability of the plant to regulate the uptake of a particular metal.

Effect of MWS on soil respiration

The results demonstrated in Table 2. indicate that the soil basal respiration in both soils increased by increasing the rate of the MWS applied to the soils. Meanwhile, on the average, the soil basal respiration in soil 2 were little higher than those in soil 1, indicating that the impact of HMs added by MWS on soil respiration varies with soil type. Mineralization of OC to CO_2 commonly known as “soil respiration” is a good index of total activity of microorganisms involved in OM decomposition (Anderson, 1982). Therefore, soil respiration has been the most studied parameter on the effects of HMs on microbial activities in soil (Bååth, 1989). The basal respiration is apart from reflecting the mineralization rate of soil OC, reflects the respiratory activity of its microbial contents, which biodegrade OM in the soil and is closely related to soil environmental quality (Yeates, 1994). In most cases, HM pollution according to the application of MWS had a little effect on soil basal respiration at low levels (15-30%), but with higher levels, the soil basal respiration increased significantly. Soil respiration was a better indicator in assessing the effect of Cu, Zn, Ni, Cd and Pb pollutants on soil microbial populations than was acid phosphatase activity in these mineral soils with different organic contents (Dumontet et al., 1993).

MWS affects enzyme activities

Enzyme activity is often related to C_{org} and C_{mic} as well as due to the higher rate of enzyme production by the microbial population. Our results showed that the activities of enzymes in soil 2 (originated from Szeged) were higher then the activities measured in soil 1 (originated from Gödöllő). Also, the results indicated that the enzymatic activities were sensitive to accumulated effect of HMs in MWS amended soils of 60% application rate. Fig. 1. shows increased activities of dehydrogenase and FDA up to 45% then declined at 60% MWS rate of received sludge. It was found that maximal activities of acid phosphatase and β-glucosidase were at 30% of rate of MWS application (Fig. 2.). The increase in acid phosphatase activity indicated high level of inorganic P present in soil. Also, there were no significance differences between the activities of aryl-sulphatase and urease in soil 2 (Fig. 3.).

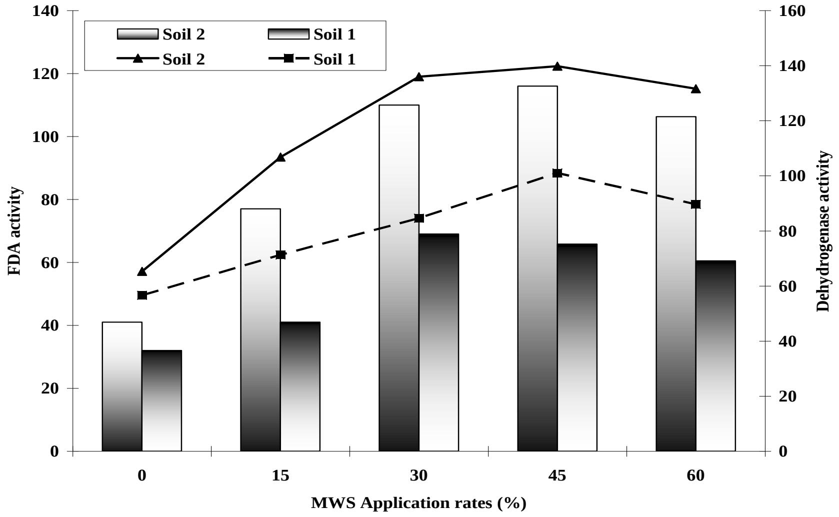

Figure 1. Impacts of MWS on FDA and dehydrogenase activities in various soil types

The results indicated close positive correlations between OC, microbial activities and enzymatic activities in both soils. This result is in agreement with Chander et al. (1995). Perucci (1992) reported a close relationship between FDA-hydrolysis kinetics and soil MB.

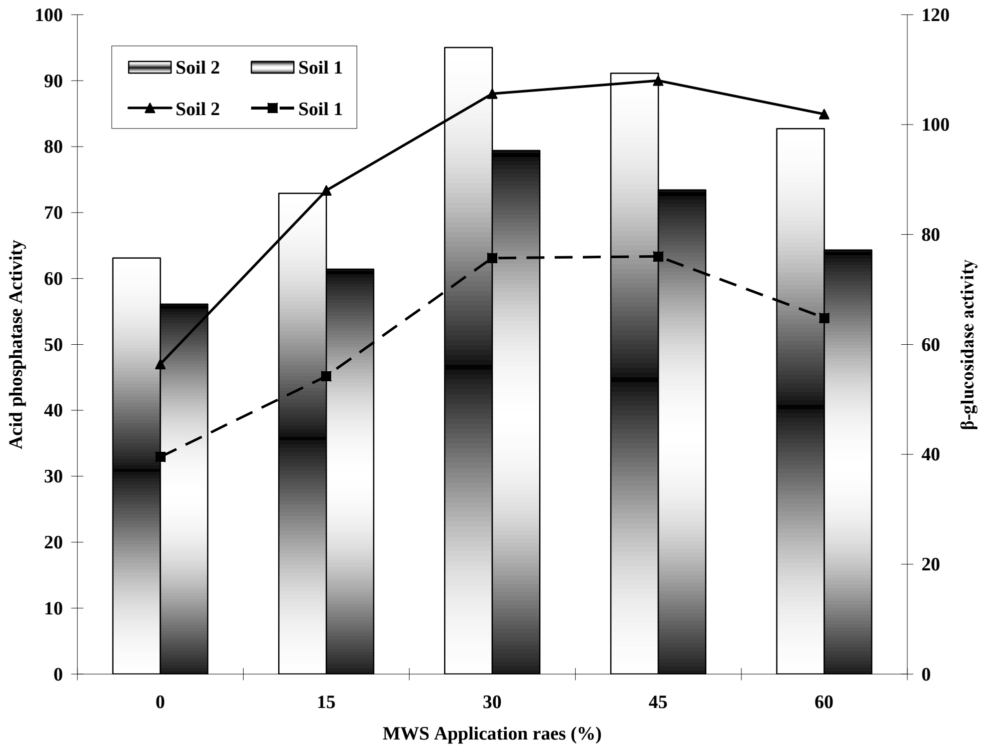

Figure 2. Impacts of MWS on acid phosphatase and β-glucosidase activities in various soil types

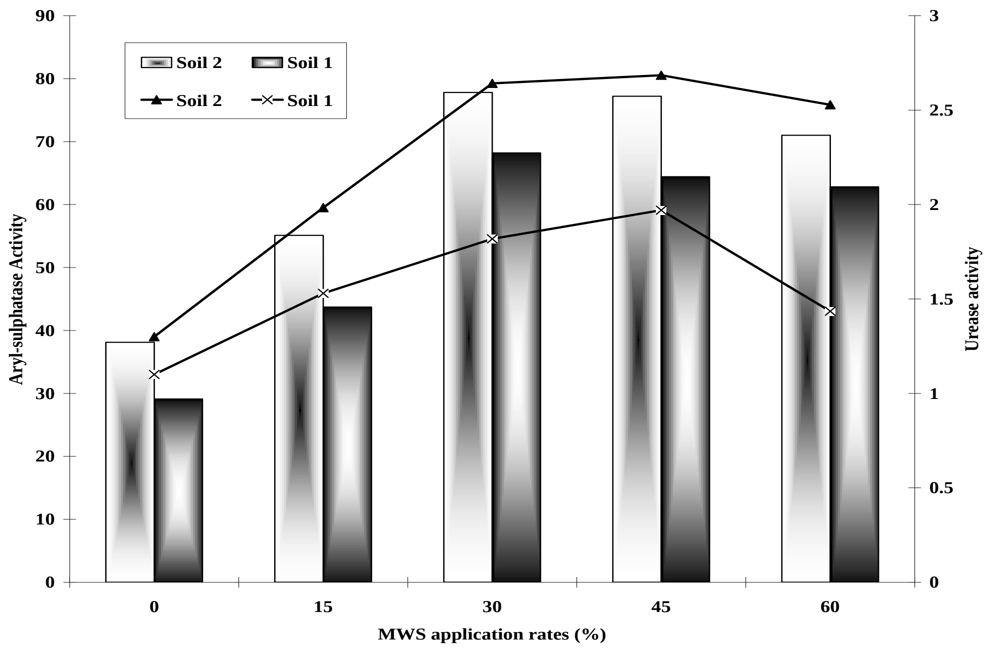

Figure 3. Impacts of MWS on aryl-sulphatase and urease activities in various soil types

The total plant dry biomass (TPDB) was affected significantly ($P < 0.05$) by application of rates of MWS (Fig. 4.). The TPDB in the sunflower plants varied depending on the quality of MWS regards to the toxic HMs content. Sunflower produced appreciably higher shoot, root and TPDB at high application rates. Higher TPDB accumulation was possibly due to the greater vegetative growth resulting from higher photosynthetic activities influenced by the addition of N fertilizer.

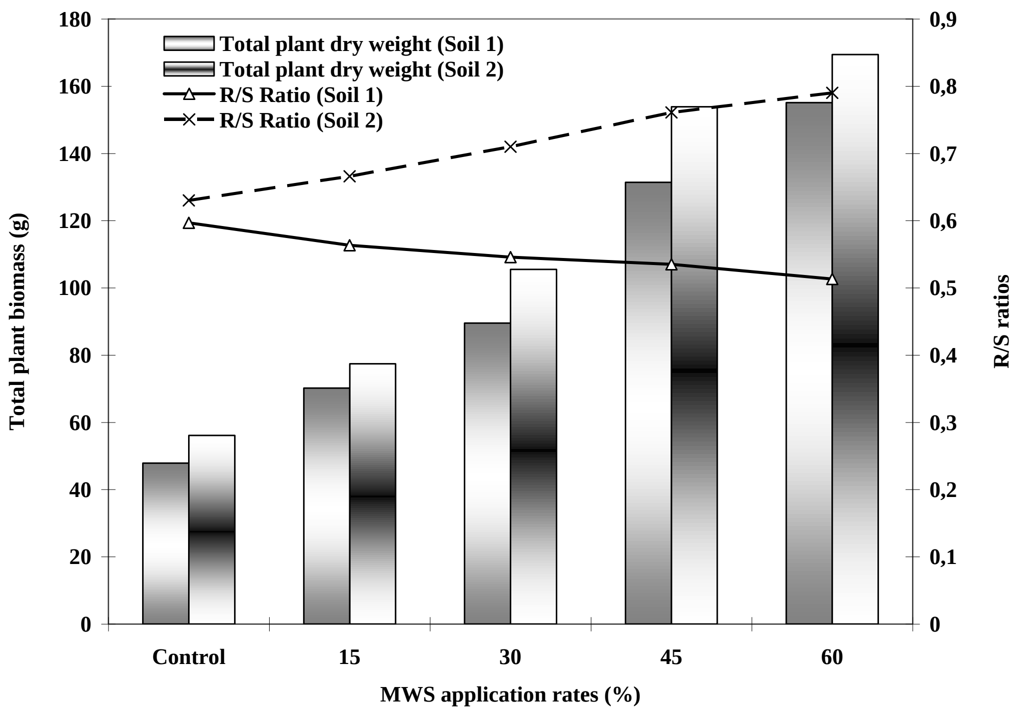

Figure 4. Impacts of MWS on plant biomass yield and R/S ratio

Sunflower responded well to varying levels of MWS in the present study. Sunflower plants grown MWS amended soil exhibited significantly higher TPDB yield probably due to its broader leaves which would intercept more sunlight and enable higher rates of photosynthesis and as a result incorporate more C into the plants (Martens et al., 2000) which support our results.

Lead and Cu concentration were positively correlated to the TPDB due to the increased plant tissue to accumulate more HMs. Furthermore the higher TPDB indicates that plants were bigger and probably possessed higher absorption rate so that more HMs uptake took place (Ho et al., 2008). Our results were in an agreement with Rahman et al. (2013) who mentioned that the Pb and Cu uptake ability of sunflower was appreciably greater than Indian mustard and amaranth. There was a positive relationship between N fertilizer application on plant growth and their ability to absorb Pb and Cu. The plant N content directly or indirectly affected the HM concentrations in the plants, by boosting the biomass of the plants and subsequently their ability to accumulate more HMs. This positive correlation suggests that inorganic or other types of fertilizers, such as organic fertilizers, can be used to increase the biomass of plants and their capacity to accumulate HMs from the soil.

CONCLUSION

The application of MWS of high HMs content at lower level (15-30%) resulted in an increase in soil MB and soil basal respiration compared with the control, but had an inhibitory influence at highest dose (60%). The degree of influence on soil microbial activities by MWS was related to the clay and OM contents of the soil types. Moderate (45%) soil amendment was no risk to soil microbial activity, while, at higher dose of MWS treatment increased to 60%, there was some ecological risk for soil microbial content in the soil-MWS-sunflower rhizospheric system. However, more research is needed to assess the environmental risk of application of high HMs content MWS under field conditions. Concerning the flow of C and energy the microbial activity and biomass, our results showed that it may depend on the soil type and soil components.

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EFFECTS OF NITRIFICATION INHIBITORS AND NITRATE SOURCES ON ROOT COLONIZATION OF FABA BEAN BY RHIZOBIUM LEGUMINOSARUM

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ABSTRACT

Little information concern the impacts of various nitrates at different concentrations known in the presence of nitrification inhibitors to inhibit the nodule formation and functioning on root colonization of legume plant by microsymbiont Rhizobium. Laboratory and greenhouse pot experimental studies were conducted to determine the effect of two nitrification inhibitors: nitrapyrin and ammonium thiosulfate on symbiotic N_2-fixation in faba bean nodules. Plant dry weight was used to assess the effect of the nitrification inhibitors on the Rhizobium - faba bean symbiosis. The results of pot experiment indicated that this study investigated the potential differences between two R. leguminosarum strains in the presence of two herbicides which functioning as nitrification inhibitors on root colonization of faba bean at different levels of various nitrate sources. Secondly, this study evaluated the effects of 20 and 50 mg N/kg soil on root colonization of faba bean by the rhizobial strains. The presence of low concentration of NO_3^--N increased the rhizobial population, the root length colonized and nodule number as well. The strain GH130 was more sensitive to the two nitrification inhibitors and inorganic N forms except calcium nitrate than Lóbab Z strain. Results demonstrate that the two herbicides decreased the concentration of nitrate in the soil.

Key words: *Nitrification inhibitors, nitrate sources, root colonization, Vicia faba, Rhizobium leguminosarum.*

INTRODUCTION

Nitrogen is the most limiting crop nutrient; thus biological N_2-fixation, particularly the development of productive associations of plant and N_2-fixing bacteria and possibly other free living N_2-fixers, has the potential to provide an endless and low cost source of N. So, N is amongst the most limiting nutrient for plant growth. It is a constituent of all proteins, nucleic acids and many other biomolecules and it is essential in all living organisms. The faba bean (*Vicia faba* L.) is a major vegetable legume grown and consumed in all over the World. Soil acidity may affect all stages of growth and specifically the legume-*Rhizobium* symbiosis, from strain survival in soil and on the seed, to root-hair infection, nodule initiation and N_2-fixation (Bayoumi Hamuda et al., 2009). The availability of this important nutrient in the soil is constrained by many biotic and abiotic factors. Leguminous plants such as *V. faba* in association with *Rhizobium* bacteria have the ability to convert nitrogen from the air into the soil and transform it into ammonium (NH_4^+), which can be used directly by the host plant. Nitrogen fixed by the rhizobial in the host plant may be released into the rhizosphere through the root exudation (Ndakidemi, 2006) and thus improving the N status of the soil.

Rhizobium is also known as biofertilizer as they may increase the availability of soil nutrients to the plants and in the rhizosphere through processes such as biological N_2-fixation. They may contribute to soil nutrition from their dead cells (McCulley, 2001) or making nutrients more available through solubilization of phosphate and other minerals bound in unavailable forms such as Fe. Studies have reported the solubilization of P in the rhizosphere by *R. leguminosarum* bv. *Phaseoli* (Chabot et al., 1998). Other mechanisms are related to siderophores production which helps facilitate the solubilization of certain nutrients such as Fe from unavailable to more available form (Dakora and Phillips, 2002).

Recent findings showed both more crop enhancing and biofertilizer attributes in cereal crops due to rhizobial inoculation. In addition, plant nutrients like P, K, Ca, Mg and even Fe accumulation were also observed. Therefore, further research in this area will be able to develop a sustainable biofertilizer technology for greater and environment friendly cereal production system (Mia and Shamsuddin 2010).

Biological oxidation of ammonia (NH_3) to nitrate (NO_3^-) is known as nitrification. Nitrate is also sensitive to denitrification, whereby N is converted and lost from the cropping system in the gaseous forms N_2, NO and NO_2. These gases are partially responsible for global warming. Inhibition of nitrification in agricultural systems would therefore be a considerable gain both economically and environmentally. Since NO_3^- is mobile and NH_3 is immobile in the soil, decreasing the time of nitrification and increasing the time of N availability for plant absorption should increase the efficiency of soil fertility as well as the biological N_2 fixation. Spyrou et al. (2009) stated that the effects of synthetic pesticides on the soil microbial community have been thoroughly investigated in the past mostly by culture-dependent methods and only few recent studies have used culture-independent approaches for this purpose. However, it should be noted that most of these studies have been conducted in microcosms where the soil microbial community is exposed to unrealistic concentrations of the pesticides, providing an unrealistic exposure scheme for soil microorganism.

Synthetic nitrification inhibitors are commercially available. Some plants, such as the tropical grass *Brachiaria humidicola*, were proposed to release compounds from their roots that suppress nitrification (Ishikawa et al., 2003). A highly sensitive bioassay was developed using a recombinant *Nitrosomonas europaea* that can detect nitrification inhibitors released from roots (e.g., Iizumi et al., 1998; SUBBARAO et al., 2006). The presence of ammonium (NH_4^+) is the stimulus for release of inhibitors from *B. humidicola* roots (Subbarao et al., 2007). Inter- and intra-specific differences among plant species in the capacity to release inhibitory compounds exist (Subbarao et al., 2009).

Ali et al. (2008) mentioned that increasing the nitrapyrin application rate to 8.32 mg kg^{-1} caused a 50% reduction in nitrification up to 4 weeks. It has been reported recently that nitrification inhibitor nitrapyrin increased NO, retention with NO, fertilization in a soil-peat-sand medium (Mills et al., 1976), a pine bark-sand medium (Mills and Pokorny, 1978), and a peat-vermiculite medium (Pill, 1981). Nitrapyrin was hypothesized to exert an inhibitory effect on biodenitrification as well as on nitrification (Mills et al., 1976). Calderon et al. (2005) established that excessive application of manure may lead to NO_3^- leaching to groundwater and fluxes of nitrogen oxides to the atmosphere. Nitrification inhibitors such as nitrapyrin (N-serve; 2-chloro-6-(trichloromethyl)pyridine) may help to conserve manure N in the root zone by limiting NO_3^- supply to denitrifiers. Also, the observed reductions in microbial biomass may affect N availability beyond the time frame of the experiment because less N will be available for remineralization. Inhibiting nitrification offers the availability of N in the reduced form and thus may prove to be a useful tool in maximizing soil bioproductivity and minimizing water pollution with oxidized N forms. The only possibility to reduce losses of the amount of N is to inhibit the first step of nitrification by nitrification inhibitors (Hauck, 1984).

The rate of respiration of soil microorganisms is usually restricted by low concentrations of available materials in the soil. Nitrapyrin (N-Serve) is specific inhibitor of the ammonium oxidation component of nitrification (Zacherl and Amberger, 1990). Roberts et al. (2003) found that 28 days of N transformation test was developed in the laboratory with a suitable soil which was amended with powdered plant meal as an organic N source. Soil samples of 1 kg treated with five concentrations of Nitrapyrin, in the range 1.0 and 100 mg kg^{-1} dry weight were incubated for 28 days at 20 ± 2°C. A dose response was produced and the N mineralization EC_{50} (95% C.I.) for nitrapyrin was 3.1 mg kg^{-1} dry soil. The determined EC_{50} was compared with literature figures for similar end points but using different methodology. Lack of O_2 limits nitrification in the soil; therefore an increase in NO_3^- production indicates good soil aeration. Also, pH is an important factor in the nitrification (Lång, 2003).

Influence of various chemicals such as nitrification inhibitors on the agrochemical and microbiological parameters of a soddy-podzolic soil was investigated by VAKKEROV-KOUZOVA (2010). It was found that the toxic effect of these compounds on the soil microbial content was higher with their increasing concentrations. Besides the availability of adequate information on the effects of *Rhizobium* inoculation on N economy of soils, very few studies have assessed their impact on the availability of other nutrient elements in the rhizosphere of legumes. This study examines the effects of i) *Rhizobium* inoculation, ii) herbicides which work as nitrification inhibitors supply, and iii) different sources of nitrate application on symbiotic relationship in the rhizosphere of *V.* faba.

The objective of these investigations was to measure the impacts of different forms of inorganic N and various N-transformation inhibitors on the symbiotic interaction between *Rhizobium – Vicia faba*.

MATERIALS AND METHODS

Random soil samples were taken from the surface layer (0–15 cm) after removing the first 2 cm of unfertilized sandy low organic matter (1.22) content of acidic (pH 5.2) brown forest soil in Gödöllő, Hungary.

The treatments consisted of thirty six combinations of three rates (0.5, 5, and 50 mg/kg soil) of the nitrapyrin (2-chloro-6-(trichloromethyl)-pyridine) and ammonium thiosulfate. Two rates (20 and 50 mg/kg soil) of three forms of inorganic N form (calcium nitrate, potassium nitrate and sodium nitrate). Two fast growing strains of *R. leguminosarum* (Lóbab Z and GH130) which form effective nodules on *Vicia faba* plant roots were used as bioinoculants for root nodulation in pots containing one of the above combinations. There was also a control treatment those soil sub-samples which not receive either N source, not inoculated with *Rhizobium* strains or both. The water holding capacity of the soil sub-samples approximately kept at constant (45%).

The experiment was carried out in the greenhouse at 25°C ± 3°C. Sensitivity of *R. leguminosarum* strains to nitrapyrin and thiosulfate and the respiratory activity of the *Rhizobium* cells in pure and nitrification inhibitors treated cultures using the microfermentor method and Warburg's respirometric technique respectively were carried out according to the methods described by Bayoumi Hamuda et al. (1996).

Root colonization of faba bean under each combination was examined after 2 weeks of sowing the seeds in 2 kg pots. Data presented in term of relative growth rate comparing with controls. Plants were harvested after 7 weeks, nodule number/plant, dry weight of plant and total N content/plant using micro-Kjeldahl method (Bremner, 1982) were determined. Means of three replicates per treatment were analyzed using ANOVA to determine statistical differences among treatments at P = 0.05.

RESULTS AND DISCUSSION

The effects of different nitrate sources and nitrification inhibitors (nitrapyrin and thiosulfate) on the relative growth rates and O_2 consumed per cell dry weight *R. leguminosarum* strains were studied. Table 1 illustrates the moderate effects of nitrapyrin on the growth of the strains. The strains were able to tolerate the lowest concentrations, while at 50 mg/l the strains were sensitive. The thiosulfate had relatively low effect. The relative O_2 consumption of the *Rhizobium* cells in nitrate sources or nitrification inhibitors treated cultures was measured.

Table 1: Effect of different concentrations of nitrate sources, Nitrapyrin and Thiosulfate on the relative growth rates and oxygen consumption of R. leguminosarum strains

Nitrate sources and N inhibitors	Level (mg/l)	*Rhizobium leguminosarum* strains			
		Lóbab Z		GH130	
		Relative growth	Relative O_2 consumption	Relative growth	Relative O_2 consumption
Calcium	20	125	116	108	104
	50	89	82	76	69
Potassium	20	113	109	104	101
	50	81	83	77	79
Sodium	20	110	106	101	101
	50	79	80	73	77
Nitrapyrin	0.5	96	113	89	104
	5	64	71	68	68
	50	53	49	49	44
Thiosulfate	0.5	101	107	94	102
	5	81	87	75	81
	50	69	73	59	65

It was found that at lowest concentration, the relative O_2 consumed per cell dry weight was higher than the control and by increasing the concentration, the relative O_2 consumption decreased especially in case of the strain GH130.

The influences of faba bean root colonization due to the inoculation by *R. leguminosarum* strains in soil treated with different combinations of various nitrate sources and N inhibitors at 21 days after plantation are given in Table 2. It was found that nitrapyrin more toxic regarding the root length than thiosulfate and Lóbab Z *Rhizobium* strain more tolerant to nitrapyrin than the strain GH130. The most toxic combination was found is the combination which contained $NaNO_3$ followed by KNO_3 and $Ca(NO_3)_2$.

Table 2: Effect of different combinations of nitrate sources, Nitrapyrin and Thiosulfate on root length (cm) due to the Rhizobium colonization after 21 days of plantation

Nitrification Inhibitors	Level (mg/kg)	*Rhizobium leguminosarum* strains											
		Lóbab Z						GH130					
		Concentrations (mg/kg soil) of nitrate sources applied to the soil samples											
		Ca		K		Na		Ca		K		Na	
		20	50	20	50	20	50	20	50	20	50	20	50
Control		11.9						10.3					
Nitrapyrin	0	12.5	11.3	12.2	11.3	11.9	11.6	11.4	11.1	10.8	10.5	10.2	9.8
	0.5	12.1	11.7	11.5	11.1	11.2	10.4	11.1	10.8	10.4	10.1	9.9	9.6
	5	11.8	11.2	10.9	10.6	10.7	10.1	10.7	10.4	10.1	9.7	9.6	9.3
	50	10.9	10.6	10.3	9.8	10.1	9.5	10.3	10.1	9.6	9.2	9.1	8.5
Thiosulfate	0	12.9	12.3	12.4	11.7	9.6	9.1	9.7	9.3	9.1	8.9	8.8	8.4
	0.5	12.6	12.1	11.8	11.1	9.2	8.7	9.2	8.8	8.8	8.3	8.2	7.8
	5	12.1	11.7	11.2	10.4	8.8	8.5	8.7	8.1	8.3	7.9	7.8	7.4
	50	11.4	11.1	10.6	10.1	8.4	8.1	8.2	7.6	7.9	7.4	7.2	6.8

Table 3 illustrates that nodule number and plant biomass were reduced at all concentrations of nitrapyrin in the presence of different concentrations of various nitrate sources in comparison with control.

Table 3: Effect of different combinations between nitrate sources and Nitrapyrin on nodule number per plant, plant dry weight and total nitrogen content

Nitrate source	Level (mg/kg)	Nitrapyrin Level (mg/kg)	*Rhizobium leguminosarum* strains: Lóbab Z			GH130		
			Nodule No./plant	Plant dry weight (g)	Total N Content (mg)	Nodule No./plant	Plant dry weight (g)	Total N Content (mg)
Ca^{2+}	20	0	83	6.9	461	71	6.3	408
		0.5	76	6.7	467	73	6.1	415
		5	53	5.9	475	50	5.5	424
		50	37	5.1	488	29	4.7	439
	50	0	42	6.3	493	38	5.8	475
		0.5	35	6.1	499	28	5.7	481
		5	22	5.7	512	19	5.5	493
		50	8	5.1	534	3	5.1	503
K^+	20	0	78	6.8	454	71	6.3	397
		0.5	68	6.3	467	62	5.8	407
		5	49	5.8	477	43	5.2	426
		50	33	4.7	481	28	5.1	445
	50	0	39	6.2	489	31	4.9	461
		0.5	31	5.4	499	27	4.7	477
		5	20	4.6	501	16	4.3	485
		50	7	4.1	517	5	4.1	491
Na^+	20	0	63	6.5	421	54	5.8	384
		0.5	52	5.9	434	41	5.6	393
		5	39	4.6	446	29	5.3	404
		50	28	4.4	452	16	4.9	419
	50	0	31	5.9	466	11	4.6	432
		0.5	27	5.4	478	7	4.3	448
		5	19	4.8	481	3	4.2	452
		50	3	4.2	493	0	3.9	460

The rate of reduction was increased by increasing the concentrations. Total N content was found to be increased by increasing the concentrations of nitrapyrin in presence of all various nitrate sources. Our results are not in agreement with Parkin et al. (2010) when the nitrification inhibitor, nitrapyrin has been shown to decrease soil N losses during the fall and spring, and maintain fertilizer-N availability to the crop. Additionally, nitrification inhibitors have shown promise in reducing soil N_2O emissions. This observation is not confirmed by the results in Table 3 which showed that the decreasing in nodule number as a result of reduction in rhizobial population will indirectly increase the N content in soil. Rice and Olsen (1988) found that nitrapyrin at 2 μg ml^{-1} increased nodule numbers on alfalfa plants grown in nutrient solution. High rates of the two compounds significantly reduced nodule numbers. They suggested that the nitrification inhibitors have the potential to affect N_2-fixation processes in soil and nodules, but that the effect is not likely to be of practical significance when the compounds are used at rates normally required to inhibit nitrification. Our results showed that all nitrapyrin concentrations reduced nodule numbers (Table 3) on faba bean roots in the presences of all concentrations of various nitrate sources.

Table 4 demonstrates that by increasing the concentrations of thiosulfate, the root-nodule number/plant increased in the presence of calcium nitrate, while it was decreased in all cases of nitrapyrin treatments. It is clear that nitrapyrin has a moderate influence on the nodule number. *R. leguminosarum* Lóbab Z strain was more tolerant to applied inhibitors than GH130 strain. Our results revealed that 0.5 and 5 mg/l are non-toxic, while 50 mg/l are highly toxic. We are in agreement with

Jenson and Sörensen (1952) who mentioned that thiosulfate has been classified earlier as very toxic for ammonia-oxidizing bacteria.

Table 4: Effect of different combinations between nitrate sources and Thiosulfate on nodule number per plant, plant dry weight and total nitrogen content

Nitrate source	Level (mg/kg)	Thiosulfate Level (mg/kg)	*Rhizobium leguminosarum* strains					
			Lóbab Z			GH130		
			Nodule No./plant	Plant dry weight (g)	Total N Content (mg)	Nodule No./plant	Plant dry weight (g)	Total N Content (mg)
Ca^{2+}	20	0	83	6.9	461	71	6.3	408
		0.5	79	6.8	469	77	6.1	419
		5	62	6.1	487	65	5.9	432
		50	54	5.7	498	37	4.8	443
	50	0	47	6.5	499	48	5.9	487
		0.5	37	6.3	509	37	5.8	489
		5	25	5.8	531	21	5.6	504
		50	11	5.2	554	7	5.4	524
K^+	20	0	78	6.8	454	71	6.3	397
		0.5	76	6.5	476	67	5.9	422
		5	53	5.9	491	46	5.4	446
		50	37	4.8	498	32	5.3	451
	50	0	43	6.3	493	38	5.1	469
		0.5	34	5.6	509	29	4.9	497
		5	26	4.9	521	19	4.6	498
		50	12	4.4	531	10	4.4	499
Na^+	20	0	63	6.5	421	54	5.8	384
		0.5	56	6.1	443	43	5.7	399
		5	43	4.7	456	32	5.4	423
		50	32	4.5	465	18	5.1	441
	50	0	39	6.1	478	17	4.7	453
		0.5	29	5.5	481	9	4.4	464
		5	21	4.9	487	5	4.3	469
		50	0	4.4	499	0	4.1	467

Regarding to the total N content per plant dry matter, the results indicate that the increase in nitrate form with or without N inhibitor the total N content per plant dry matter increased. At the same time the plant dry matter decreased when the high concentrations of various nitrate form were applied in the presence or absence of N inhibitors. Similarly, the root-nodule number was decreased by increasing the treatment doses. The *Rhizobium* population of the two strains was also, decreased when the more nitrate applied to the soil, and nitrapyrin was more toxic to *Rhizobium* population than thiosulfate (unpublished data). Our results are in an agreement with the conclusion of Saad et al. (1996) that thiosulfate slightly inhibits the nitrate without involving the formation of volatile sulphur compounds as potential nitrification inhibitors. Denitrification was not affected by the addition of thiosulfate. Dolen et al. (1980) found that plant dry weight, total N, and total Ca was increased at 0.1 and 1 ppm N-serve. The authors indicated that at greater 10 ppm the plants showed visual symptoms of a stunted growth, stem elongation, flowers and pods failed to form or were aborted, young leaves were curled, and roots were club shaped with many branches. These symptoms were increasingly evident with increasing N-serve application rates. Dry wt and total N in the plant was less than the control at the higher N-serve applications. Table 2 shows that the dry weight of plant was decreased in case of Nitrapyrin in case GH130 more than as in case of Lóbab Z and lower than when soil treated with thiosulfate.

The total N content in soil treatment with nitrapyrin or thiosulfate in the presence of sodium nitrate or potassium nitrate was lower than in the presence of calcium nitrate. Whereas the total N content higher in plant dry matter which grown in thiosulfate in the presence of calcium nitrate were higher in any other treatments. Kucharski (1993) found that there is a negative effect of CMP, N-serve and ATC on faba bean growth and development, N_2-fixation, and bioactivity of some *Rhizobium*. In our studies, we found that the negative effects were at higher concentrations of nitrapyrin and thiosulfate (at 5 mg/kg soil). Our observations indicate that high concentrations of nitrapyrin and thiosulfate were detrimental to both strains and these results were contradicted with the report of Zacherl and Amerger (1990), who showed reduction in growth of *R. leguminosarum*, was only 17% with 100 ppm nitrapyrin.

Similarly, negative effects were found e.g., in contrast the microbes targeted by DCD, the ammonium-oxidising bacteria, were significantly affected by DCD with reductions in population size and altered activity (O’Callaghan et al., 2010). Heightened concerns for pollution from N and its ecological effects, and a promising new nitrification inhibitor on the horizon most likely will renew interest in using nitrification inhibitors as a management tool, making their future the brightest ever. For further investigations, the rate of nitrate mobilization and ammonia formation will be measured under each combination according to the results obtained.

CONCLUSION

The addition of $NaNO_3$ or KNO_3 at 50 mg/kg soil in the presence of nitrapyrin or thiosulfate strongly inhibited the symbiotic relationship (nodule number, total N content and plant dry weight), while, $Ca(NO_3)_2$ at increased the rhizobial population, especially in the presence of low doses of thiosulfate (0.5 and 5 mg/kg) and the root length.

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MULTIELEMENT PROFILES OF CHILDREN IN URBAN ENVIRONMENTAL CONTEXT

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ABSTRACT

The maintaining of an optimal mineral balance is of great importance in the healthy functioning of human organism, in the prevention, mitigation, and treatment of numerous diseases. The human mineral status is characterized by the gender, age, individual metabolic activity and food habits specificity, and in addition depends substantially on the occupational exposure and environmental context of residence. The high prevalence of some essential elements deficiency and some toxic elements excess needs to address the concerns of the urban population. The results of mineral status estimation in children population (in the age of 11-13 years old) of different urban areas of Belarus are under consideration in this paper. The mineral element content of scalp hair samples was used as the biomarker for mineral status of the observed population. Mineral elements concentrations were determined by energy dispersive X-ray fluorescence (EDXRF) spectrometry method. The accuracy of the methodology was appraised through the analysis of NCS Certified Reference Material DC 73347 (Chinese National Analysis Center). The prevalence of mineral elements disturbances was revealed within examined groups. The findings define the critical points of mineral status and some guidelines for future preventive measures, such as nutrition interventions on regional level.

Key words: *mineral elements, children, urban areas.*

INTRODUCTION

The relevance of mineral elements in human health is obvious from the beginning of the life until the old age. More than one-third of all proteins need metal ions for functioning (Bertini et al., 2001; Regan, 1993) and more than one-quarter of all enzymes in the body require micronutritional elements in order to be activated and to function properly in metabolism (Higaki et al., 1992). The maintaining optimal mineral balance is crucial for the well functioning of the biological systems and is of great importance in the prevention, mitigation, and treatment of numerous diseases. Cells very efficiently exploit speciation in the metal-protein systems and reach a very strict control over the metal acquisition, distribution and regulation processes (Kozlowski et al., 2009). Meanwhile, the effects of environmental exposure to trace metals on human health have been discussed in the last decades, especially with respect to toxic metals originating in anthropogenic activities. Some metals are not considered essential and their presence, even at very low doses, may result in impairment of biological functions (Apostoli, 2002; Khalique et al., 2005; Kar et al., 2013). For instance, cadmium is carcinogenic and lead neurotoxic, and even in small amounts both may interact with calcium and replace it in the skeleton or zinc in the heme enzymes and metallothioneins (Goyer, 1997). Copper, zinc and iron are essential trace elements responsible for the function of many cellular enzymes and proteins; however, the same elements become toxic whenever excessive intracellular accumulation occurs. In fact, copper and iron may contribute to the production of free radicals and, therefore, are likely to play a relevant role in regulation and induction of apoptosis (Kozlowski et al., 2009).

Contamination through atmospheric particulates is a major concern especially in urban areas where it has adverse effects on human health.

Besides, recent data on nutrient and supplement intake indicates that the vast majority of people suffer from micronutrients malnutrition. Even in developed countries, many sections of the population do not receive the essential minerals needed from the diet (Huskisson et al., 2007; Shankar, 2013; Capita, 2006). People with a low intake of calories and/or with high requirements of micronutrients (e.g. in the so called demanding period of extensive exercise or emotional and/or physiological stress) as well as people with special food habits or inadequate food choice and/or handling are especially at risk (Eichholzer, 2003). It should be noted that the increased requirements may also occur during growth and due to demanding lifestyle of high occupational pressure for urban population.

Thus, the concern about the effects of inadequate micronutrient diet intake and environmental exposure to metals and metalloids on human health has driven the scientific community to find reliable tools and methods for assessing the levels of minerals in human body. It is recognized that human mineral status is characterized by the individual variability, gender specificity, age dependence, individual metabolic activity, occupational exposure, geological location and food habits. It is revealed that mineral homeostasis formed in different environmental locations defines by specific mineral distribution in human tissues. Thereby the improving general mineral balance strategy cannot provide enough trace elements when individual requirements within some groups of population for the same nutrients are increased in. That is why in the first place it is important to determine, with confidence, whether the selected group of subjects has a deficiencies of specific elements. The determination of the presence or absence of the deficiencies concerning one or more of the major and trace elements can be a complex problem.

The assessment of the mineral status and the identification of critical points, including the list of minerals with elevated risk of deficiency or excess and specific groups that are at elevated risk, should precede any interventions in the field of the mineral status improvement.

Formerly, we obtained data about essential elements profile of children from one of the biggest industrial centers of Belarus. The extensiveness of essential elements deficiency was revealed within examined group. The findings were indicative of the need for the preventive measures. To define the critical points of the mineral status and to develop some guidelines for future preventive measures, such as nutrition interventions on regional level, we have investigated mineral status in some groups of children living in other regions of Belarus. In this paper the results of examination in three groups differentiated by the residence criteria are considered.

METHODS

To obtain the multielement profiles of children in the urban environmental context, the subjects residing in various geographical areas of Belarus, represented by differing environmental conditions, were chosen. All examined individuals were in the age of 11-13 years old. This is so called “eco-sensitive” age population, which is characterized by the increased requirements in point of essential nutrients.

Three study groups were formed. The Group I consisted of 78 individuals (43 girls and 35 boys) living in the largest industrial city, located in central geographical region of Belarus. Some anthropogenic load from traffic and manufacturing industry attributes to population of this city. Group II was 129 representatives (71 girls and 58 boys) of the large industrial town population in the eastern geographical region of Belarus. This town is characterized by the prevalence of organic airborn pollution. Group III was the population (90 individuals – 46 girls and 44 boys) of north-eastern region of Belarus, living in small town with no existence of any industrial activity.

The study inclusion criteria were the permanent residence in the mentioned sites (for at least 5 years), the absence of any chronic disorders and diseases. All participants and their parents were fully informed about the study. To perform needed ethic procedures parents accepted the participation of their children by freely signing a written informed consent.

As an indicator for mineral status of children the hair mineral content was used. At present, the usefulness of human scalp hair as an indicator of major and trace element levels in human body to put information on the diet in nutritional studies, to diagnose disease conditions in medicine, to discover forms of poisoning due to abnormal doses of metals during forensic studies, to identify potential exposure of resident population to metals and to estimate occupational exposure in environmental practice have been distinctly demonstrated. Hair reflects the exposure of individuals to the metals, providing possible correlation with a number of factors related to genetic, nutritional and geographical origin (Wolowiec et al., 2013; Srogi, 2006; Frazao and Saiki, 2007; Choinacka et al., 2010; Bass et al., 2001). Hair is a biological specimen that is easily and noninvasively collected, with minimal cost, it is easily stored and transported to the laboratory for analysis. The content of the elements in hair tissue is considerably higher than in blood or urine, used for mentioned purposes. It is to be noted that hair element content gives information about long-term exposure as the concentration of elements in other tissues such as serum illustrates short-term exposures because the element concentrations in the blood are controlled by a homeostatic mechanism (Esteban and Castano, 2009; Dunicz-Sokolowska et al., 2006). These attributes make hair an attractive substrate for the purposes of biomonitoring.

For all groups, specimens 3-4 cm long were cut with stainless steel scissors from the part closest to the scalp in the suboccipital region of the head. To distinguish between endogenous, namely, absorbed into the blood and incorporated into the hair matrix minerals, and those are exogenous, namely, derived from external contamination, the hair sample preparation procedure included washing step. The washing method proposed by the International Atomic Energy Agency (IAEA, 1997) was used for this purpose.

Elements concentrations were determined by energy dispersive X-ray fluorescence (EDXRF) spectrometry method. The accuracy of the methodology was appraised through the analysis of NCS Certified Reference Material DC 73347 (Chinese National Analysis Center).

The data analysis was performed with the computer statistical analysis system STATISTICA 8.0, StatSoft. Inc. As the obtained element concentration values were not normally distributed (Shapiro-Wilk`s W test of normality was applied) nonparametric methods were used for sequent data analysis.

RESULTS AND DISCUSSION

The measured levels of mineral elements, such as calcium, zinc, potassium, cuprum, selenium, iron, chromium, lead, mercury, cadmium and bismuth (medians, 25th and 75th percentiles) in hair of children from Group I, II and III are shown in Table 1. For many elements the results were strongly scattered and differed between individuals, as shown by the coefficients of variation ranging from 42 % (zinc) to 238 % (bismuth). In view of the low uncertainties of the measurement precision the calculated coefficients of variations reflect the intrinsic biological variability due to gender, lifestyle, eating habits, environmental factors and individual metabolism.

The median elemental concentrations in hair were statistically compared using the Kruskal-Wallis test, with a level of significance set at $p<0,05$, taking geographical location and environmental context into account. The concentrations of all determined elements except zinc were high significantly altered between Groups I, II and III ($p<0,001$). Concerning zinc we found out the difference between Group II and III only for girls.

Table 1: Hair mineral content for the examined groups of children

Element	Group I			Group II			Group III			p-level
	Median, mg/kg	25th perc., mg/kg	75th perc., mg/kg	Median, mg/kg	25th perc., mg/kg	75th perc., mg/kg	Median, mg/kg	25th perc., mg/kg	75th perc., mg/kg	
Ca	326,66	182,02	575,89	1115,89	356,54	2117,56	356,50	226,57	794,55	<0,001 *
Zn	122,07	97,74	150,13	124,05	108,79	141,12	116,85	102,59	137,92	0,211
K	80,99	54,49	120,19	124,21	93,17	180,32	76,93	49,76	114,82	<0,001 *
Cu	7,21	5,79	8,85	9,91	6,96	15,77	5,66	5,23	6,52	<0,001 *
Se	0,72	0,44	1,01	0,53	0,35	0,66	0,47	0,35	0,59	<0,001 *
Fe	12,25	8,54	20,50	12,25	7,99	16,50	19,34	13,81	25,89	<0,001 *
Cr	1,70	1,14	2,19	1,10	0,77	1,37	1,28	1,00	1,62	<0,001 *
Pb	1,45	1,02	2,19	1,27	0,85	2,14	0,91	0,62	1,37	<0,001 *
Hg	0,23	0,19	0,43	0,13	0,07	0,25	0,21	0,13	0,28	<0,001 *
Cd	0,11	0,07	0,15	0,08	0,00	0,12	0,10	0,07	0,13	<0,001 *
Bi	0,53	0,25	0,76	0,24	0,13	0,35	0,33	0,23	0,41	<0,001 *

p-levels – significance of Kruslal-Wallis test; * - marked statistically significant values (p<0,05).

Different researchers state the need in hair analysis to differentiate data of girls from those of boys (G. Dongarra 2010), which was confirmed in our study: the high significant gender differences were revealed for the levels of calcium, zinc, cuprum and lead in hair (p<0,001); the concentrations of potassium, selenium, iron, chromium were demonstrated the low significant differences (p<0,05) and only for the concentrations of mercury, cadmium and bismuth had not any gender specification. To take into consideration the mentioned feature of the hair mineral content for the majority of determined elements, within the observed groups also the groups of girls and boys were distinguished. Table 2 shows the element levels in hair according to gender.

Table 2: Hair mineral content for the examined groups of children, according to gender

	Element	Group I	Group II	Group III	p-level
		Median, mg/kg			
Boys	Ca	202,99	347,66	239,18	I-II: <0,001; II-III: <0,001 *
	Zn	119,32	110,56	113,35	n/d
	K	80,68	149,71	87,84	I-II: <0,001; II-III: 0,006 *
	Cu	7,11	7,21	5,65	I-III: 0,0015; II-III: <0,001 *
	Se	0,87	0,60	0,51	I-II: 0,023; I-III: <0,001 *
	Fe	9,81	10,68	17,49	I-III: <0,001; II-III: <0,001
	Cr	1,63	1,17	1,40	I-II: 0,0038 *
	Pb	1,45	1,74	1,13	II-III: 0,0016 *
	Hg	0,30	0,13	0,20	I-II: <0,001; I-III: 0,017 *
	Cd	0,11	0,09	0,09	n/d
	Bi	0,50	0,24	0,25	I-II: <0,001; I-III: <0,001 *
Girls	Ca	506,76	1884,29	795,46	I-II: <0,001; II-III: <0,001 *
	Zn	125,78	136,67	118,52	II-III: 0,019 *
	K	81,52	110,94	64,63	I-II: <0,001; II-III: <0,001 *
	Cu	7,45	12,01	5,82	I-II: <0,001; I-III: <0,001; II-III: <0,001 *
	Se	0,68	0,49	0,46	I-II: 0,0012; I-III: 0,003 *
	Fe	15,74	12,92	23,06	II-III: <0,001; I-III: 0,015 *
	Cr	1,73	0,98	1,24	I-II: <0,001; I-III: 0,049 *
	Pb	1,46	0,97	0,78	I-II: 0,0085; I-III: <0,001 *
	Hg	0,22	0,13	0,23	I-II: p<0,001; II-III: 0,005 *
	Cd	0,10	0,07	0,10	I-II: 0,02; II-III: 0,013 *
	Bi	0,54	0,22	0,37	I-II: <0,001; II-III<0,001 *

p-levels – significance of multiply comparisons test after Bonferroni correction; * – marked statistically significant values (p<0,05); n/d – no differences.

When compared with the others, the Group II samples had the significantly highest median concentrations of calcium and potassium both for boys and girls. Samples from the Group III had the significantly highest concentrations of iron, as opposed to the lowest level of cuprum. The Group I medians of the next elements were statistically different from those found in hair of children from Group II and III: selenium (both genders); lead, mercury and bismuth (boys); chromium (girls). There were the highest medians of the above mentioned elements in Group I. The statistic summary with the medians, 25th and 75th percentiles, minimum and maximum values of the mineral elements concentrations from the assays of children scalp hair within the examined groups are presented in Figure 1 and 2.

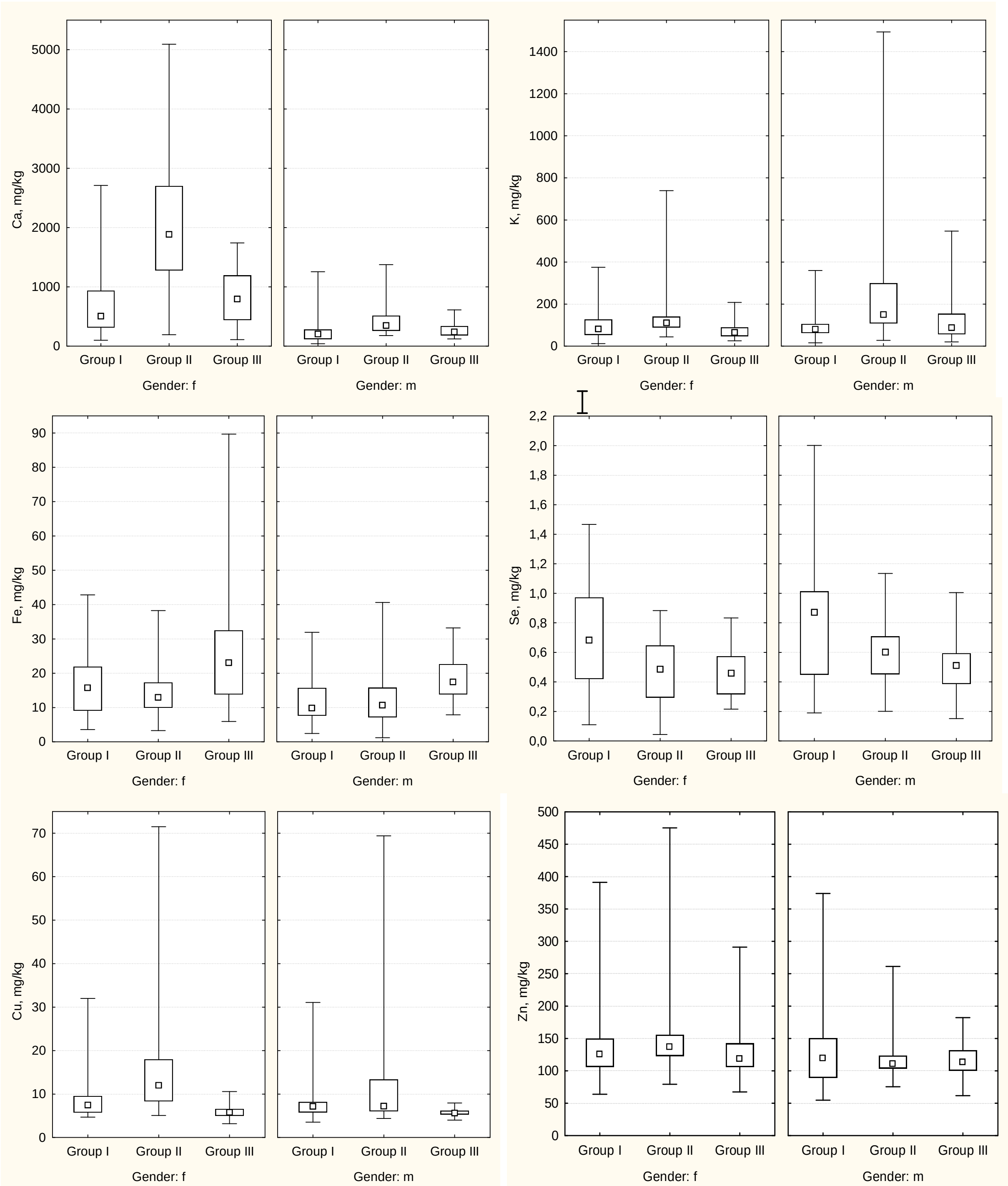
It is considered that hair of normal and healthy individuals generally contains each major – and trace element within a well-defined concentration range. Marked deviations from these values indicate physiological or environmental disorder. In this study as the reference element values we regard those proposed by Skalny (2003) and Skalnaya (2003), supplemented with the values by Bertram (1992). Comparing obtained concentrations with the appropriate reference values, we can see that median values of calcium exceed appreciably the upper limit of the reference values for Group II and III hair samples from girls and median concentrations of chromium are outside the upper limit of the reference values for all examined population. Meanwhile, the cuprum median levels (with the exception of girls from Group II) and selenium those (except Group I) were lower than the minimum reference value. However it should be mentioned that for purpose of deficient-excess condition estimation it is more reasonable to use the distribution of individual values, but not average values (see Table 3).

Table 3: Hair mineral elements distribution (percentage of individuals with mineral elements deficient, normal and excessive state) in Group I, II and III

	Element	Group I			Group II			Group III		
		Deficiency, %	Normal, %	Excess, %	Deficiency, %	Normal, %	Excess, %	Deficiency, %	Normal, %	Excess, %
Boys	Ca	68,6	20,0	11,4	22,4	56,9	20,7	53,3	44,4	2,2
	Zn	28,6	60,0	11,4	10,5	87,7	1,8	15,6	84,4	0,0
	K	24,2	75,8	0,0	5,2	86,2	8,6	22,2	77,8	0,0
	Cu	68,6	22,9	8,6	56,9	15,5	27,6	100,0	0,0	0,0
	Se	35,3	64,7	0,0	62,0	37,9	0,0	82,2	17,8	0,0
	Fe	71,4	20,0	8,6	64,9	29,8	5,3	20,0	68,9	11,1
	Cr	0,0	8,6	91,4	0,0	14,0	86,0	0,0	6,7	93,3
	Pb	-	71,4	14,3	-	77,6	22,4	-	77,8	22,2
	Hg	-	100,0	0,0	-	100,0	0,0	-	100,0	0,0
	Cd	-	100,0	0,0	-	100,0	0,0	-	100,0	0,0
	Bi	-	14,3	85,7	-	36,2	63,8	-	28,9	71,1
Girls	Ca	16,3	46,5	37,2	1,4	1,4	97,2	6,8	27,3	65,9
	Zn	13, 6	76,7	9,3	5,6	77,5	16,9	8,9	84,4	6,7
	K	23,3	76,7	0,0	1,4	97,2	1,4	33,3	66,7	0,0
	Cu	59,5	26,2	14,3	22,5	26,8	50,7	95,6	4,4	0,0
	Se	45,2	52,4	2,4	77,5	22,5	0,0	88,9	11,1	0,0
	Fe	41,9	46,5	11,6	51,4	40,0	8,6	20,0	46,7	33,3
	Cr	2,4	7,3	90,2	5,6	21,1	73,2	0,0	11,1	88,9
	Pb	-	75,0	15,0	-	93,0	7,0	-	97,8	2,2
	Hg	-	100,0	0,0	-	98,6	1,4	-	100,0	0,0
	Cd	-	100,0	0,0	-	100,0	0,0	-	100,0	0,0
	Bi	-	17,1	82,9	-	31,0	69,0	-	4,4	95,6

The calcium deficiency state has been well documented worldwide. This occurrence means a scarce presence of element, referred to insufficient diet, hindered diet uptake or increased urinary excretion (Watts, 1990; Suliburska, 2011; Peterlik et al., 2009). Nevertheless, to take into consideration the mentioned above reference ranges, it is apparent that excess hair calcium values are of a high prevalence in the groups of all tested subjects. 37,2% of girls and 11,4% of boys from Group I; 97,2% of girls and 20,7% of boys from Group II; 65,9% of girls and 2,2% of boys from Group III have calcium concentrations in hair which exceeded the upper reference level. It should be said that this fact have been described. Almost always, the increase in the body circulation up to the deposition into the hair of certain elements indicates a low bioavailability of the mineral, and therefore a reduction of its activity in biological reactions in which it is involved (Anke and Rish, 1997; Avino et al., 2013). According to those assumptions the high hair calcium content (especially for girls) is evidence of accelerated calcium excretion from an organism that precede the deficient state. In turn, with regard to the observed objects, this point reflects the process of calcium metabolism intensification during the period of pubertal growth spurt. But the higher excess calcium abundance was revealed in Group II. We explain the peculiarity of increased calcium loss in this group by more stressful conditions of location for examined persons.

Table 3 shows that a significant percentage of cases (73,2 – 93,3%) are of exceeded chromium concentrations in hair samples. Avino et al. (2013) reported mean value 0,183 mg/kg with minimum and maximum 0,045 and 1,47 mg/kg respectively (for young adult population of high school students, not exposed to specific contamination/ not occupationally exposed). Chromium exposure is usually associated with the industries using or manufacturing chromium, stationary fuel combustion (chromium can be released into the environment from the burning of natural gas, oil and coal), living near a hazardous waste facility that contains chromium. Other environment sources of chromium are emissions of chromium-based automotive converters and tobacco smoke. And the high chromium level of in all observed groups (irrespective of industrial activity) are probably due to vehicle traffic and smoke habits.



▫ - Median; ▭ - 25%-75%; Ｉ - Min-Max.

Figure 1. Box-whiskers plots of calcium, potassium, iron, selenium, cuprum and zinc concentrations distribution in hair samples from Group I, II and III, according to gender

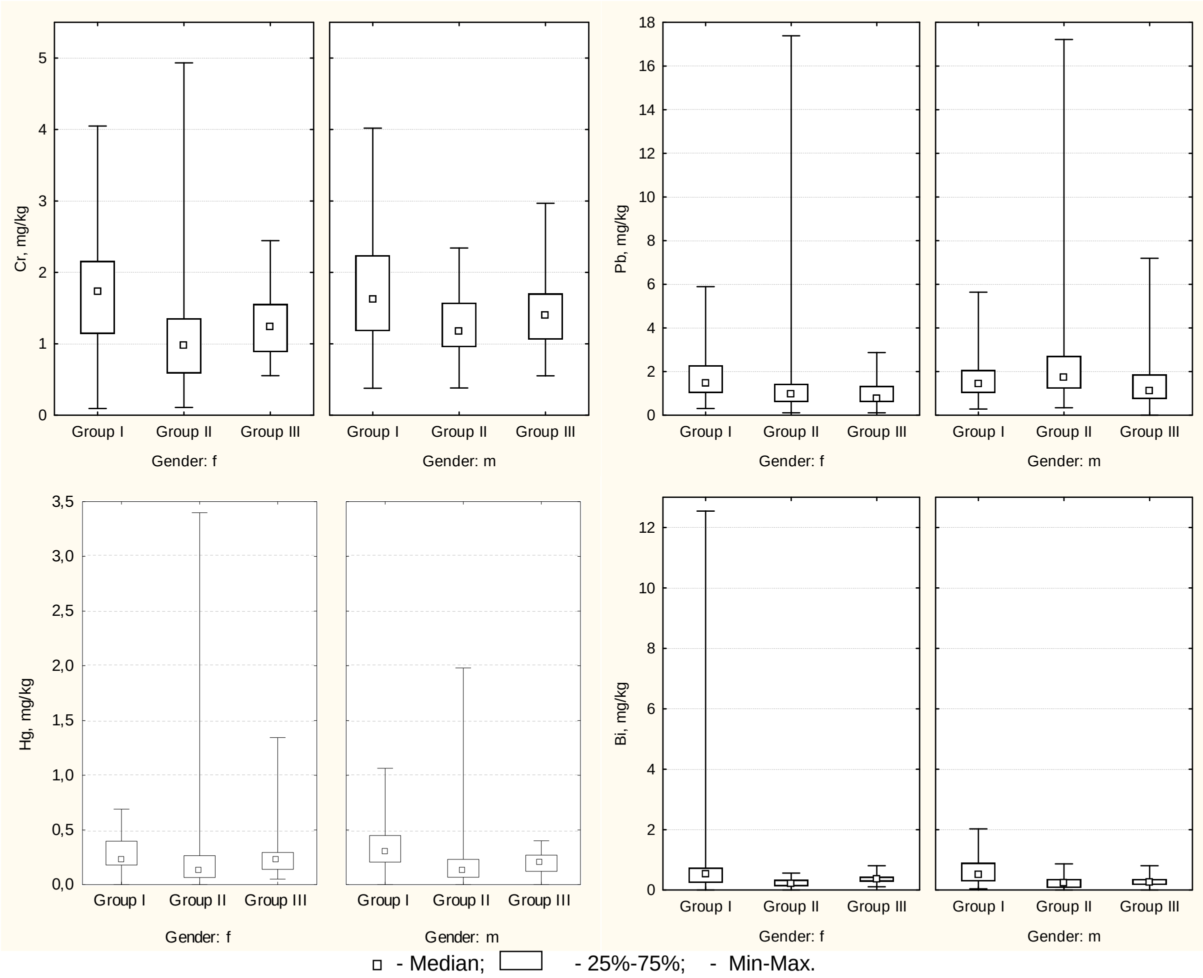


Figure 2. Box-whiskers plots of chromium, lead, mercury and bismuth concentrations distribution in hair samples from Group I, II and III, according to gender

According to the obtained data there is significantly high prevalence of decreased cuprum, iron, zinc and selenium hair concentrations within all tested groups of children. Though the mentioned concentrations are referred to the mild deficiency states, this occurrence does not deny the functional consequences. According to some methodological approaches, the risk of mineral deficiency is considered to be elevated and of public health concern when the prevalence or probability of inadequate mineral balance is greater than 25% (Benoist et al., 2007). In this case, an intervention to increase population mineral intake is required. Following this approaches, we can highlight the key point of mineral imbalance for each observed group. It should be said that there are evident and statistically significant differences between groups in regard to the occurrence of deficiency. At first, the concentrations of cuprum and iron within group III differ highly from those within Group I and II.
These elements represent the most considerable inter-regional variations. It should be noted that cuprum concentration values are quite homogenous in Group III. Taking into consideration their rather decreased levels for observed persons we can conclude that there is specific factor that lead to severe prevalence of the deficient state with respect to cuprum in this location. 100 % of boys and 95,6 % of girls from Group III have highly decreased hair cuprum concentrations (according to the reference levels) and otherwise 56,9 % of boys and 22,5 % of girls from Group II, 68,6 % of boys and 59,5 % of girls from Group I are of low cuprum concentrations. The “cuprum-iron” interrelationship could be the most apparent explanation of this fact, as at the same time the abnormally increased concentrations of iron are widespread in Group III. Thus, for the cuprum deficient factor identification the subsequent comprehensive investigations are needed.

As for the prevalence of selenium deficiency state the point is that Belarus is the endemic region in respect of selenium deficiency for different components of environment. Meanwhile, the representatives from Group I have significant lower occurrence of decreased selenium hair level than those from Groups II and III. The higher concentrations of selenium with respect to the other study areas may be a consequence of diet.

The obtained data state the very low levels of mercury and cadmium present in the hair samples of young people living in different urban contexts of Belarus: in particular, mercury and cadmium were at 0,23 mg/kg 0,13 mg/kg, 0,21 mg/kg and 0,11 mg/kg 0,08 mg/kg 0,10 mg/kg, respectively in Group I, II and III. But the presence of lead and bismuth exceeded concentration is noted.

CONCLUSIONS

In the present work, hair from the well-defined groups of generally non-exposed children living in urbanized and industrialized areas was studied in order to reveal the major – and trace metal profile of modern urban population of Belarus. The significant differences between boys and girls were found in hair mineral concentrations. The prevalence of deficiency states for the list of essential elements (calcium, zinc, cuprum, selenium, iron) was shown within the obtained data analysis. In regard to described, the supposed state of mineral undernutrition can result a slow height increment, lower peak bone mass, and delayed puberty in this crucial window of development. Some hair «toxic» metal concentrations have shown values outlying from reference. The increased concentrations of chromium, lead and bismuth were revealed, that reflected the presence of metal anthropogenic load within considered regions.

This study evidently has shown the good possibilities of evaluating the impact of the geochemical environment on major and trace metal contents in human scalp hair. The data reported the distinct mineral concentration dependence on location sites refer to the different urban areas of Belarus. The observed variations reflect the specific impact of the environmental conditions on the human mineral balance. This exemplifies the need to consider the problem of mineral imbalance in urban population on the regional level. The results of the mineral balance assessment for the children residents of three different locations can be considered as the background for the future nutrition interventions of mineral balance improvement.

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CHANNEL TYPE UV REACTOR FOR SUGAR SYRUP STERILIZATION

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ABSTRACT

In this paper we analyze UV radiation intensity distribution and overall dose in an open channel rectangular cross-section multi-lamp reactor, whose bottom partly reflect UV radiation. Sugar syrups for pharmaceutical or beverage industry are subjected to microbiological contamination, and it is traditionally sterilized by thermal treatment, that consumes lot of energy. By UV radiation sugar syrup sterilization is achieved in cold process and consumes 4-5 times less energy than thermal process. UV fluid radiation at 254 nm is physical treatment to achieve micro-organisms inactivation (i.e. disinfection-sterilization) in UV transparent fluid. Advantage of this physical method for disinfection-sterilization is that there is no over-dosage problem, and it does not change either organoleptic, physical or chemical fluid characteristics, as with chemical treatments. Fluid flowing through the open channel reactor could be waste-water, potable water or any UV transparent aqueous solution, and in our case it is sugar syrup. UV radiation intensity distribution is necessary to determine sucrose syrup radiation doze that flows through the reactor for the defined fluid transparency in UV spectrum at 254 nm. Fluid transparency, UV sources radiation power and defined radiation dose that must be achieved in UV reactor, under the worst conditions, determine the maximum fluid flow.

Key words: *Sugar syrup, UV radiation, Sterilization, UV intensity, UV doze.*

INTRODUCTION

It is well known that all bacteria, spores, viruses and protozoa (including Cryptosporidium and Giardia oocysts) can be inactivated by UV [1]. Concentrated Syrups, typically at 25 to 67 Brix, have a high osmotic pressure. This prevents micro-organisms growing and reproducing, however they will survive in spore form and will grow once the syrup is diluted into the food product or beverage. Microbial growth in foods and beverages can cause food discoloration, off flavors and shorten shelf life.

Earlier experiences

Gaddie et all. [2] in their paper gave their experimental results experience for thin film UV sugar syrup (further on SS) sterilization. They treated 1200 gallons sugar syrup (approximately 4500 liters) that had approximately 66 Brix concentration through an UV sterilizer that contains 4 germicidal lamps, with 20 gallons per minute high turbulence flow rate. From results it is seen that average doze was approximately 18 mJ/cm2. This in corresponding with measured result that the inactivation rate was 99.9%, for yeast, that have 90% inactivation for dose 6 mJ/cm2. Morselli and Whalen [3] treated sugar maple sap with in line UV sterilizer, and concluded that it is cost-effective method for sugar sterilization, that does not change neither organoleptic characteristic nor color of syrup, as thermal treatment, that heavily changes saps color to dark brown. They achieved result for bacteria reduction around 99% and yeast from 62% to 75%, depending on season.

UV Reactor Radiation Intensity Distribution and Doze Importance

UV radiation intensity in UV reactor (further UVR) distribution and doze at UVR exit, which isapplied to sugar syrup fluid is very important factor in UVR design, aimed to define number and UV lamps, and UVR geometry (UVR dimensions and lamp displacement) in it. In cylindrical UVR this type of analysis is much easier, particularly with one lamp UVR, due to geometrical compatibility of lamp, having cylindrical shape too, and UVR [4], [5]. UVR design and analysis becomes more complicated with many UV lamps in a cylindrical UVR vessel [6] [7], and especially in opened channel plan-parallel UVR [8], [9]. These types of reactors are used for high transparent potable water in large capacity systems (≥ 1 m^3/s) or for low transparent fluids, such as waste water or sugar syrup treatment. In this paper we will analyze open channel type UVR aimed sugar syrup UV sterilization for various sugar syrup concentration.

UV Reactor Types for sugar syrups

Because sugar syrups have high absorption (low transmission) that implies relatively lower fluid depths. Consequently UVR for UV sugar syrup sterilization could be roughly divided into two main categories:
(1) **Closed -** they work under pressure, and have radiation sources (lamps) immersed in the fluid, rarely over it, usually, but not necessarily, cylinder in shape.
(2) **Opened -** they work under ambient pressure, and lamps are placed over treated fluid (i.e. sugar syrup).
Closed UVR vessels are usually cylinder in shape, with one coaxial UV lamp for fluid depth, that is in advanced predefined by geometry, according to syrup concentration and quality (i.e. absorbance). Rarely, those are multi-lamp UVR. Mentioned type of UVR imperfection is predefined geometry, and consequently every change in quality, for predefined doze could be only corrected by fluid flow.
Opened UVR are mostly of plan-parallel type, with square or perpendicular cross section. Open channel UVR (further OCUVR) cross section is parallel to axis of lamps over it, and their axes are orthogonal to the UVR axis. Sugar syrup in an OCUVR has transversal flow direction according to the lamps axis. OCUVR have some advantages, compared to closed UVR. It is easily to change fluid depth and lamps position, change fluid velocity through an OCUVR, and manage supply power by switching on/off UV lamps, to obtain adequate (optimal) doze according to sugar syrup concentration. OCUVR disadvantage could be slightly higher energy consumption that could be overcome by ceiling reflection [8], lamps power management [10] and optimization for every sugar syrup quality and flow rate [11].

Various and the most frequently used types of UVR, for sugar syrup sterilization are given in Figures 1 to 3 [7], [9].

Figure 1. Cylindrical UV reactor with one centrally positioned UV lamp, for sugar syrup UV treatment, with predefined quality and concentration, low capacity

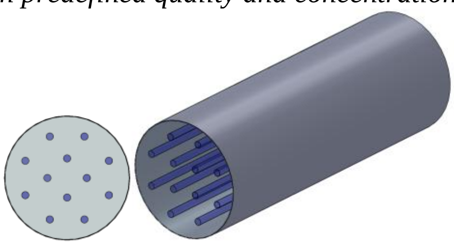

Figure 2. High capacity UV reactor for sugar syrup sterilization; fixed geometry and capacity; predefined quality and concentration only

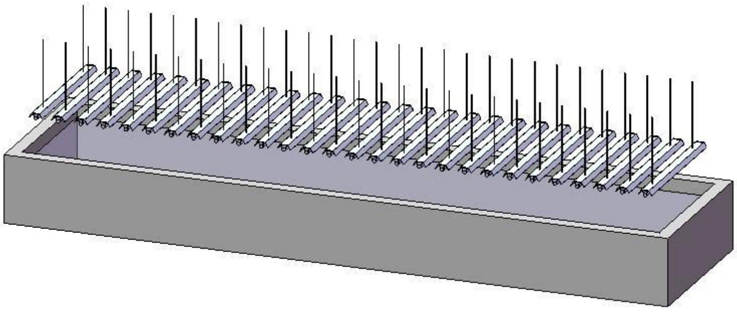

Figure 3. Open channel UV sterilizer for sugar syrup sterilization; variable geometry and according to consumption very high capacity; for variable concentration and quality sugar syrup

THEORY

For this model we take into account some assumptions:

1. Reflectance of other UVR sides and ceiling are not taken into account,
2. UVL are lined above the fluid around the UVR center, with minimum possible distance between lamps axis, for that was proved as optimal position above channel type UVR [10],
3. Finite length UVL are approximated as infinite sources [12], i.e. they have only radial radiation component,
4. Fluid flow is assumed to be laminar, as it is proved later from calculation; laminar flow is taken into account as the worst condition for doze near UVR bottom.

According to the results derived in [10], [8] и [7], UV intensity radiation on UVR bottom which reflection is ρ_0, in point k, that comes from all low-pressure UV lamps (further UVL), where each of them has irradiation power P_0, is defined by expression (Fig. 4):

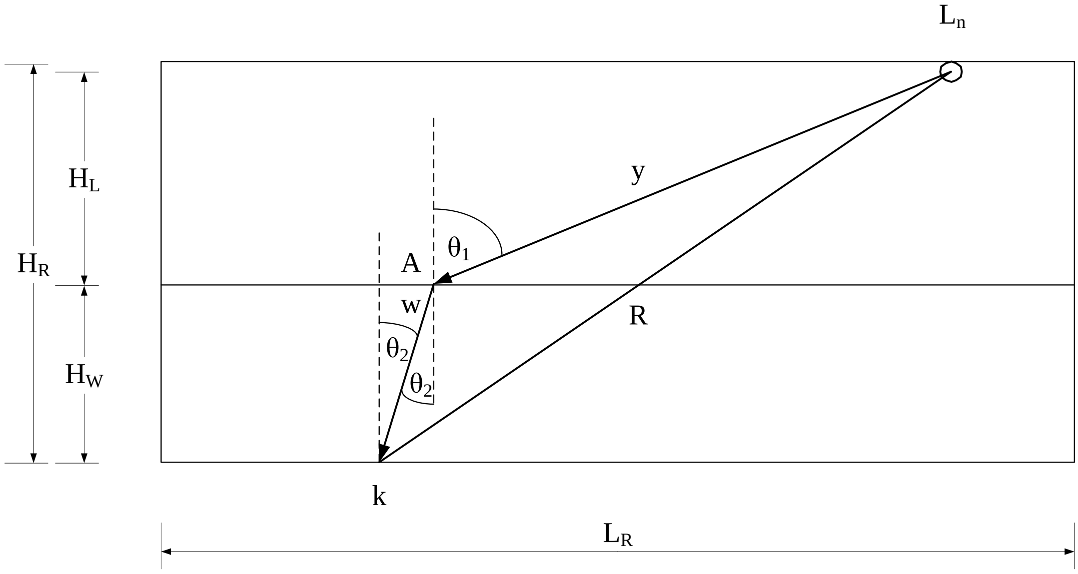

Figure 4. Longitudinal cross section of an open channel UV reactor with one lamp representing UVR geometry

$$\Psi_k = \frac{\eta \cdot P_0}{2 \cdot \pi \cdot L_e} \cdot \sum_{n=1}^{Nl} \frac{T_{n,k} \cdot T_{F\,n,k}}{r_{n,k}} \cdot\ 1 + \rho_0 \cdot \cos\gamma_{n,k} \quad , \tag{1}$$

$$T_{n,k} = \exp(-\alpha_F \cdot w_{n,k}) \,, \tag{2}$$

where (2) is expression for UV radiation transmission losses along path through water $w_{n,k}$, of an n^{th} UVL (one of Nl lamps) to point k on the bottom of the reactor, and α_F is fluid (syrup) absorbance;

$$T_{Fn,k} = 1 - R_{Fn,k}\ , \tag{3}$$

where (3) represents Fresnel transmission and reflection coefficients, respectively on the surface air-water [13];

$$\eta = \eta_T \cdot \eta_A \cdot \eta_V\ , \tag{4}$$

where in (4) is total UVL power coefficient, that depends on supply voltage η_V, UVL power depression coefficient (ageing) at the end of UVL life η_A, coefficient UVL power transmission η_T. Coefficient η_T depends on rate length to radius of the lamp l_R, as it is given in the following expression according to [12]:

$$\eta_T = \sqrt{1 - \frac{1}{l_R}} - \frac{1}{l_R}\ , \quad l_R = \frac{L_e}{r_L} \tag{5}$$

where: L_e is effective UVL length as well as UVR channel width W_R, while r_L is UVL radius, and L_R is UVR length. $\gamma_{n,k}$ is UV radiation incidence angle on the UVR bottom, that comes from n^{th} UVL and reaches UVR bottom point (axis) k [14]; $r_{n,k}$ is distance from n^{th} UVL axis to k^{th} parallel axis on the UVR bottom ; ρ_0 is bottom reflection for normal incidence.

Radiation doze is intensity and retention time product (1). In our case retention time is given for stationary flow, for flow rate changes in UVR are slow, and consequently retention time is given by expression:

$$t_R = \frac{V_F}{Q_F} = \frac{H_F \cdot W_R \cdot L_R}{Q_F}\ , \tag{6}$$

where: Q_F is fluid flow rate in m^3/s; V_F, H_F are: fluid volume and depth in UVR respectively, and W_R, L_R are UVR width and length, respectively.

$$D = t_R \cdot \overline{\Psi}_S\ , \tag{7}$$

where $\overline{\Psi}_S$ is average intensity on the UVR, given by:

$$\overline{\Psi}_S = \frac{1}{K} \cdot \sum_{k}^{K} \Psi_k\ , \tag{8}$$

and Ψ_k is given in (1).

In our case, minimum UV radiation doze in thin fluid film on the UVR bottom at UVR exit, for transversal and laminar water flow through the cannel type UVR is given by expression (Fig. 5.):

To determine required UVL number N_x, for variable SS flow rate Q_x and required minimum doze D_{Rq}, we are going to apply expression (9) derived from expressions (6)-(8):

$$N_x = \frac{D_{Rq} \cdot Nl}{\overline{\Psi}_S \cdot t_{Rx}} = \frac{D_{Rq} \cdot Nl \cdot Q_x}{\overline{\Psi}_S \cdot H_F \cdot W_R \cdot L_R}\ , \tag{9}$$

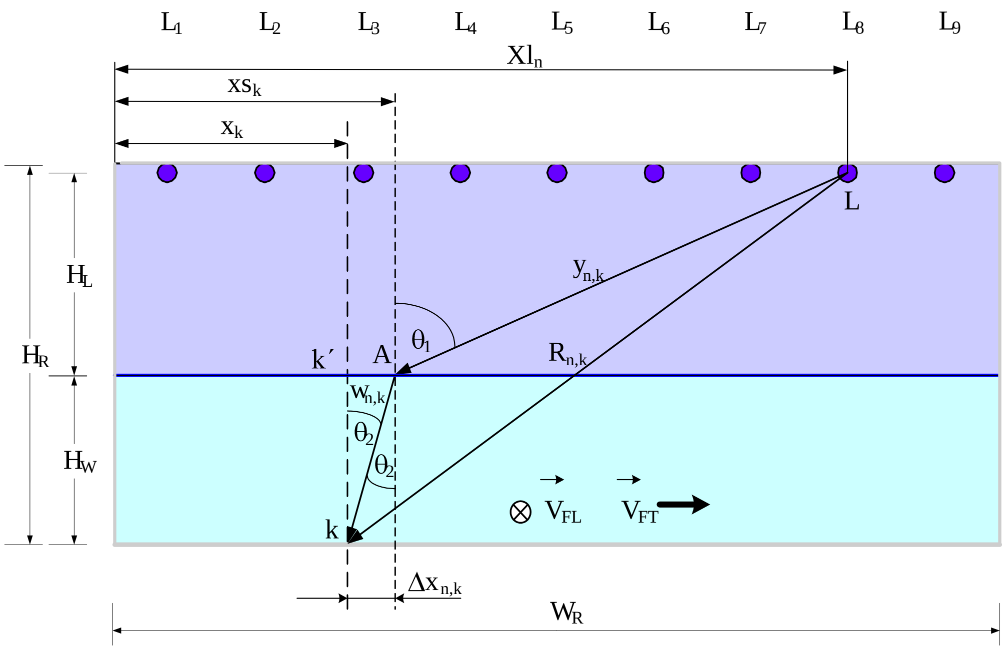

Figure 5. Geometry of central UVR segment with nine UV lamps; V_{FL} and V_{FT} represents velocity vectors for longitudinal and transversal fluid flow, respectively; $(H_W = H_F)$

where, retention time in UVR, for steady-state fluid flow is given by:

$$t_{Rx} = \frac{V_F}{Q_x} = \frac{H_F \cdot W_R \cdot L_R}{Q_x}; \qquad (10)$$

FINDINGS (RESULTS)

Input parameters for syrup fluid sterilization are:
(1) Lamps axis height (non optimized) over fluid surface is 2 cm;
(2) Axial distance between two lamps is 4 cm;
(3) Average required doze 60 mJ/cm^2 for inactivation of 90% molds that could be in syrup;
(4) Minimum doze required in thin fluid film on the UVR bottom 180 mJ/cm^2 for inactivation of 99.9% molds; with that doze yeast will be inactivated completely, for they have 10 times lower resistance to germicidal UV radiation, i.e. 6 mJ/cm^2,
(5) UVR length 1 m, width 1.1 m (the same as lamps effective length),
(6) Fluid absorbance is 0.5/cm, at 254 nm, and corresponds to concentration 10-11%,
(7) UVR bottom reflection 0.4 at 254nm, for orthogonal incidence,
(8) UVR has 10 lamps, with installed power 2.5 kW and maximum capacity for given SS quality of 2 m^3/h,

Mathematical modeling, for a priori UVR design, can be seen from the following graphs (Figures 6.1 & 6.2, 7.1 & 7.2 and 8). For given assumptions and parameters from Figs. 6 and 7, it is seen that intensity and doze profiles imply transversal fluid flow. Mean intensity, over UVR length, on the SS surface is 23 mW/cm^2, and on the bottom is 4.5 mW/cm^2, and the same ratio ≈5, for doze at UVR exit on the surface is 910 mJ/cm^2 and on the bottom 181 mJ/cm^2. For turbulence fluid flow, that means approximately 80% of perfect mix, we can obtain at least 400 mJ/cm^2, and this could increase either UVR capacity and/or inactivation efficiency, or both. High reflection ceiling could increase results [8] at least 20%, and dose-capacity UVR product for the same amount. From Fig. 8 it is seen that UVR capacity constant per lamp is 0.2m^3/h. It is seen linear relationship between number of active lamps and UVR capacity, too. Fliud velocity is 2.5 cm/s, for maximum capacity 2 m^3/h implies laminar flow;

retention time is approximately 40 s. For lamps that have radius 13 mm, and length approximately 1100 mm, rate $l_r=l/r\approx85$ and that justifies main assumption: application of infinte radiation source model.

It is advisable to add some UVL at both sides of existing lamps for two reasons: to replace automatically malfunctioned UVL during the process, or to enable UVR higher capacity if it is necessary [10], or to be applied for lower quality SS. According to previous, one can conclude, that it is better to have multi-lamp system instead of mono-lamp system for same UV radiation power.
Thermal process only for heating 2000 liters of SS (67 Brix), from ambient temperature to 100 degrees centigrade, without thermal losses and maintaining that temperature for some period of time, requires approximately 150 kWh. To sterilize the same amount of SS by UVR requires 2.5kWh, that means 1.7% of thermal process, or 98% energy savings.

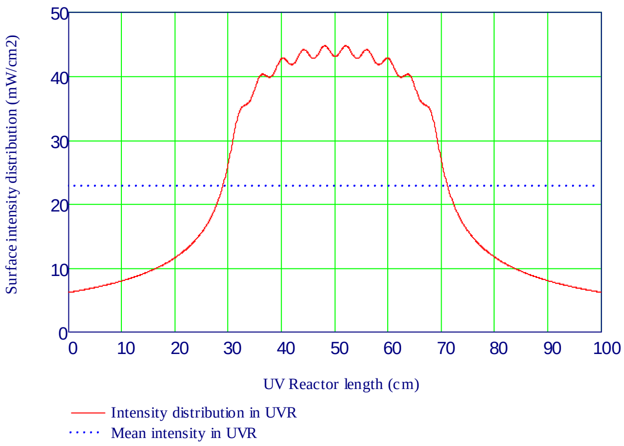

Figure 6.1. Surface intensity distribution; mean intensity 23 mW/cm^2;
Text for Figures 6.1. & 6.2.: Sugar syrup distribution over UVR length for laminar fluid flow and absorption 0.5/cm; fluid depth 2 cm; 10 lamps, distance between lamps 4 cm; lamps height over fluid 2 cm; UVR width 1.1 m, length 1 m; ceiling reflection not included in model.

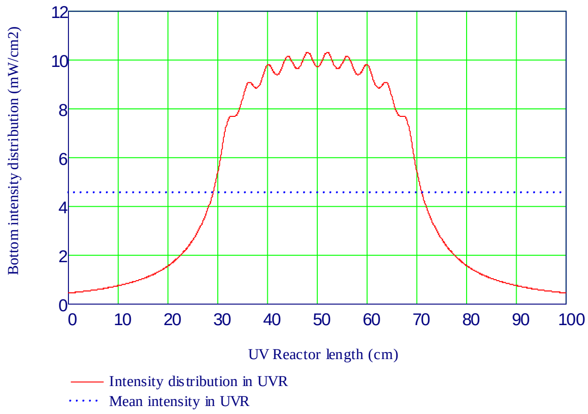

Figure 6.2. Bottom intensity distribution; mean intensity 4.5 mW/cm^2;

From the thermal energy standpoint the most efficient SS thermal sterilization is reached for the highest SS concentration (67 Brix). Reason is simple: water has much higher specific thermal capacity then crystal sugar. But for UV sterilization it is irrelevant, comparing to thermal sterilization, and it is possible to make system that would continually produce desired concentration sterile SS for production line, without storage tanks and other [11], for thermal treatment, required equipment.

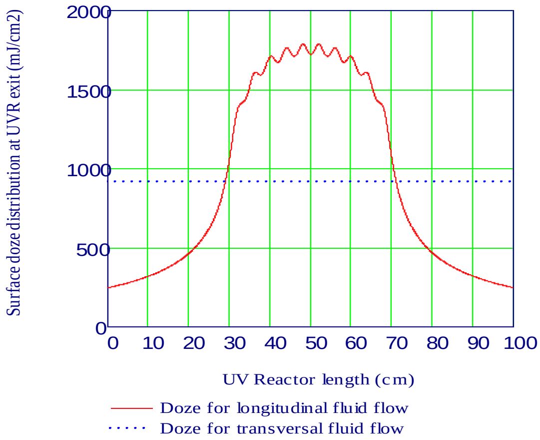

Figure 7.1. Surface doze distribution; mean doze, for transversal fluid flow 910mJ/cm^2;
Text for Figures 7.1. & 7.2.: Sugar syrup at UVR exit for laminar fluid flow and absorption 0.5/cm; fluid depth 2 cm; 10 lamps, distance between lamps 4 cm; lamps height over fluid 2 cm; UVR width 1.1 m, length 1 m; bottom reflection 0.4, for normal incidence; ceiling reflection not included in model.

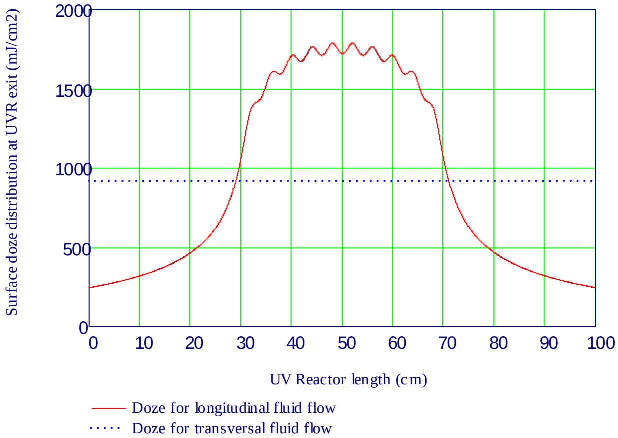

Figure 7.2. Bottom doze distribution; mean doze, for transversal fluid flow 180mJ/cm^2;

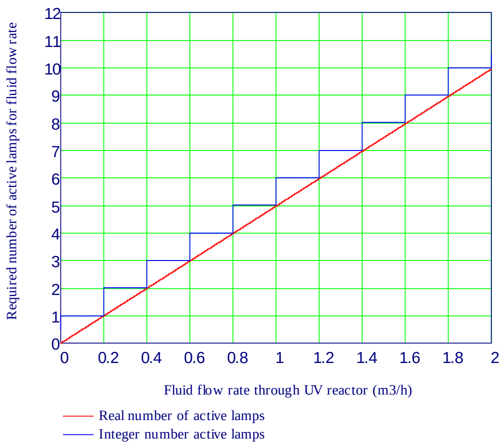

Figure 8. Required number of active UV lamps, according to defined fluid flow rate and predefined minimum doze in thin fluid film on the UV reactor bottom (180 mJ/ cm^2), for fluid absorbance 0.5/cm, and bottom reflection coefficient 0.4, for normal incidence.

CONCLUSIONS AND IMPLICATIONS

Closed UVR types have some disadvantages implied by its fixed geometry: For full (nominal) capacity user should have the same sugar syrup concentration and quality (color, i.e. transparency). Some small decrease in quality or concentration increase can be compensated by SS flow rate, but for higher decreases it is impossible. It is not possible to change capacity of this UVR, nor to reduce energy consumption for smaller flow rate, according to production requirement. That implies accumulation tank for SS and additional system with UV lamps over SS surface to prevent recontamination and maintaining SS sterility. UV sterilizer cleaning and washing is an additional waste of time money. All of mentioned is overcome by an open channel (variable geometry) in-line system that produces sterile wide concentration range (10% to 67%) syrup for variable SS quality (transparency) [11]. With this system it is possible to change SS flow according to the consumption and to adjust: energy consumption by adequate number of working UV lamps needed for SS sterilization, SS fluid depth, as well as lamp height over fluid surface per SS concentration and quality. Besides it is possible to adjust power and energy consumption by adequate number of active UV lamps needed for sterilization of given SS fluid quality, flow rate and concentration. Mentioned in-line system will decrease investments and energy consumption with high reflective ceiling [8] and UV lamps power management [10].

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NANOTECHNOLOGY IN ENVIRONMENTAL PROTECTION

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ENERGY IN NANOSCIENCE AND TECNOLOGY

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ABSTRACT

All the elementary steps of energy conversion such as charge transfer, molecular rearrangement, chemical reactions, etc. take place in nanoscience and nanotechnology. The development of new nanoscience materials, as well as the methods to characterize and manipulate them, creates an entirely new paradigm for developing new and revolutionary energy technologies. The table provides a list of the main opportunities in nanotechnology for producing new energy-generation systems for electronics and other items. Nanotechnology will help in the development of the following two energy conservation objectives: inventing future energy generation devices that perform in ways that current devices cannot, and finding new ways to to minimize energy input and waste output. Ideas for new uses of nanotechnology have developed faster than the actual methods. The electronics industry needs these advances in order to reduce energy demand in a society that is increasingly looking for ways to save energy. The thermodynamic and kinetic phonon properties of cylindrical quantum dots are analysed using a developed method. As a consequence of the applied new method the configurational dependence of diffusion coefficient and dots' density were included into calculations.

Key words: *nanotechnology, charge transfer, save energy, new nanoscience materials.*

INTRODUCTION

Nanotechnologies provide dramatic improvement of the possibilities of conventional energy sources (fossil fuels, nuclear fuels) and renewable energy sources (geothermal energy, solar, wind, water energy, etc.). They provide life optimization and efficiency of the system for energy use and costs reduction. Nanomaterials which are built into the systems are lighter, safer and more resistant to corrosion. Nanotechnologies play a very important role in obtaining solar energy through photovoltaic systems (solar cells). New types of solar cells with anti-reflective coating have been constructed, colored and polymer solar cells, which allow much greater efficiency. Polymer solar cells have proven effective for portable electronic devices because of the price and flexible design. It is believed that with the use of nanostructures such as quantum dots and wires, the efficiency of solar cells is increased up to 60% (www.hessen-nanotech.de). Conversion of energy from the primary sources into electricity, heat and kinetic energy requires great efficiency. If the requirements for efficiency have been met, especially in fossil fuels and steam power plants, significant quantities of carbon dioxide emission can be avoided. Improvements are possible through heat resistant nanomaterials, anti-corrosion protective layers of soft nanomaterials (e.g. titanium aluminates). There are nanomaterials, such as nanotubes, which have a good electrical conductivity, low losses and can be used for electric cables. In addition, there are nanotechnology approaches for optimizing superconductive materials to conduct electricity with virtually no losses. Nanotechnologies have proven to have good properties for storing electrical energy. The best properties were shown in lithium ion technologies.

ENERGY IN THE CASE OF NANOSTRUCTURES

A phonon is a quantum of energy of the linear oscillator. The phonon energy of an isolated oscillator is equal to the product of the Dirac's constant $\hbar=1.055\cdot10^{-34}$Js and the frequency of the oscillator, which depends on the elastic forces, under whose influence oscillation is done. If there is a set of oscillators that interact with each other, phonons are collective excitations of the system. The frequency of such a collective excitation depends on the interaction between the atoms which oscillate and the reciprocal wavelength of mechanical oscillation waves, which extends through a set of interacting atoms.

The dependence on the reciprocal wavelength, i.e. the wave vector $k=\frac{2\pi}{\lambda}$, is called a phonon dispersion law. In crystals with a simple lattice and in the area of small wave vectors, phonons have the linear dispersion law $\omega(k)\sim k$. These phonons are acoustic phonons. Depending on the polarization, acoustic phonons have three branches: one longitudinal and two transverse. For longitudinal phonons, the polarization vector is directed in the direction of wave propagation and in the two transverse branches the polarization vectors are perpendicular to the direction of wave propagation. In a complex crystal lattice consisting of σ sublattices 3 σ phonon branches appear, of which three branches are acoustic phonons (their energy equals zero for k=0), and 3 σ -3 branches of optical phonons. For optical phonons, the frequency is different from zero for k=0. This means that for the excitation of optical phonons it is necessary to input energy. This excitation energy is called the threshold energy of optical phonons (gap).

Hamiltonian of the collective mechanical oscillations in a crystal (crystal phonons) is obtained by expanding the potential energy of crystals in small atomic displacements from the equilibrium position $\vec{u}_{\vec{n}}$. Here $\vec{n}$ is a lattice vector, which through the vector of the crystal unit cell $\vec{a}_x$,$\vec{a}_y$ and $\vec{a}_z$ is given with $\vec{n}=n_x\vec{a}_x+n_y\vec{a}_y+n_z\vec{a}_z$, where n_x,n_y and n_z are integers. Since all atoms, before they begin to oscillate, are in equilibrium positions, which correspond to the minimum interatomic interaction energy, during the expansion of potential energy in the series according to the displacements partial derivatives $\left(\frac{\partial V_{\vec{l}}}{\partial u_{\vec{l}}^{s}}\right)_{u_{\vec{l}}^{s}=0}$; $s=x,y,z$; $\vec{l}=\vec{n}-\vec{m}$ are equal to zero, so in the expansion, as the first different from zero, terms which include other derivatives of interatomic interaction energy according to projections $\left(\frac{\partial^2 V_{\vec{l}}}{\partial u_{\vec{l}}^{s} u_{\vec{l}}^{s'}}\right)_{u_{\vec{l}}^{s}=0;u_{\vec{l}}^{s'}=0}$; $s,s'\in(x,y,z)$; $\vec{l}=\vec{n}-\vec{m}$. These terms are called Hooke's constants (Abdul J. J., 1996; Agarwal R. P., 2000). Further terms of the expansion are discarded because they are proportional to the product of three or more small atomic displacements.

The potential energy of the system of mechanical oscillations is the second term of the expansion:

$$W=\frac{1}{2}\sum_{\vec{n},\vec{m}}V_{\vec{n}-\vec{m}}+(u_{\vec{n}}-u_{\vec{m}})=$$

$$=\frac{1}{2}\sum_{\vec{n},\vec{m}}V_{\vec{n}-\vec{m}}+\frac{1}{4}\sum_{s,s'}\left[\frac{\partial^2 V}{\partial u_{\vec{n}-\vec{m}}^{s}\partial u_{\vec{n}-\vec{m}}^{s'}}\right]_{\substack{u_{\vec{n}-\vec{m}}^{s}=0\\ u_{\vec{n}-\vec{m}}^{s'}=0}} u_{\vec{n}-\vec{m}}^{s}u_{\vec{n}-\vec{m}}^{s'} \tag{1}$$

The diagonal second derivatives in this term are Hooke's elastic constants, while the mixed derivatives, i.e. Hooke's torsion constants, are much smaller than Hooke's elastic constants, and are usually discarded in theory. Kinetic energy is added to the potential energy of mechanical oscillations

$$T = \sum_{\vec{n}} \frac{p_{\vec{n}}^2}{2M}, \qquad (2)$$

where M is the mass of atoms and p impulse given with $p_{\vec{n}} = M\dot{u}_{\vec{n}}$. Since phonons are quantum objects, the values $u_{\vec{n}}$ and $p_{\vec{n}}$ are the operators, where $u_{\vec{n}}$ is the multiplication operator, and $p_{\vec{n}}$ the differential operator. These operators satisfy the commutation relations (D. Popov at all 2003)

$$\left[u_{\vec{n}}^{s}, p_{\vec{m}}^{s'}\right] = i\hbar\delta_{\vec{n},\vec{m}}\delta_{s,s'} \qquad (3)$$

Phonons are excitations of the boson type, and the operators u_n^s and p_n^s expand on the plane waves, where the coefficients of the expansion are Bose creation and annihilation operators $b_{\vec{k}}^{+}$ i $b_{\vec{k}}$. These expansions were given by

$$u_{\vec{n}} = \sum_{\vec{k},j} \vec{l}_j\left(\vec{k}\right)\sqrt{\frac{\hbar}{2MN\omega_j\left(\vec{k}\right)}}\left(b_j\left(\vec{k}\right)e^{i\vec{k}\vec{n}-it\omega_j\left(\vec{k}\right)} + b_j^{+}\left(\vec{k}\right)e^{-i\vec{k}\vec{n}+it\omega_j\left(\vec{k}\right)}\right), \qquad (4)$$

$$p_{\vec{n}} = \frac{1}{i}\sum_{\vec{k},j} \vec{l}_j\left(\vec{k}\right)\sqrt{\frac{\hbar}{2MN\omega_j\left(\vec{k}\right)}}\left(b_j\left(\vec{k}\right)e^{i\vec{k}\vec{n}-it\omega_j\left(\vec{k}\right)} - b_j^{+}\left(\vec{k}\right)e^{-i\vec{k}\vec{n}+it\omega_j\left(\vec{k}\right)}\right). \qquad (5)$$

Substituting (4) and (5) in the Hamiltonian of mechanical oscillations, we obtain the Hamiltonian in diagonal form according to the operators of the number of phonons $\hat{n}_j\left(\vec{k}\right) = b_j^{+}\left(\vec{k}\right)b_j\left(\vec{k}\right)$. This formula has the following form:

$$\hat{H} = \sum_{\vec{k},j} \hbar\omega_j\left(\vec{k}\right)\left(n_j\left(\vec{k}\right) + \frac{1}{2}\right) \qquad (6)$$

The second term of the formula does not depend on the number of phonons and is called the energy of zero oscillations, i.e. the oscillations of atoms performed at the absolute zero. In the Debye's theory (H. Ibach, H Lüth, 2003; G. Strobl, 2004) the second term of the equation (6) is rejected. Hamiltonian with no second term shows that the internal energy of the phonon system at low temperatures is proportional to the fourth degree of absolute temperature, whereas at high temperatures it is proportional to the first degree of the absolute temperature.

Heat capacity of the phonon system, which is a derivative of internal energy according to the temperature is proportionate, at low temperatures, to the third degree of the absolute temperature, whereas at high temperatures it is constant and amounts to 3*R*, where *R* is the universal gas constant. This last result is called the Dulong–Petit law (H. Ibach, H Lüth, 2003; G. Strobl, 2004).

In the Debye's theory, the concept of the Debye's frequency is introduced, which is determined by the maximum value of the wave vector in the first Brillouin zone (C. Kittel, 1986). The value of the wave vector is given by $k_D = \frac{\pi\sqrt{3}}{a}$ for the crystal with simple cubic symmetry with the lattice constant *a*. The Debye's constant $\omega_D = ck_D$ corresponds to this maximum value of the wave vector, where *c* is the speed of sound in the crystal. Through the Debye's frequency the Debye's temperature is introduced, based on the relation $k_B T_D = \hbar\omega_D$, where $k_B = 1.38 \cdot 10^{-23}\ \frac{\mathrm{J}}{\mathrm{K}}$ - the Boltzmann constant. This is where $T_D = \frac{\hbar\omega_D}{k_B} = \frac{\hbar c k_D}{k_B} = \frac{\pi\sqrt{3}\hbar c}{a k_B}$, which is of the $10^2\ \mathrm{K}$ order.

To conclude this brief overview, we emphasize that the phonons are the elementary excitations which are present in all systems which are at temperatures different from the absolute zero, and as such influence the behavior of all other elementary excitations, which together with phonons, can occur in these systems.

THERMODYNAMIC AND KINETIC PROPERTIES OF PHONON SUBSYSTEMS IN THIN FILMS

Thin films are structures with broken symmetry. Here we will analyze a thin film that is infinite (translationally invariant with respect to the *x,y* planes), while its thickness in the direction of the *z* axis is nanometric. Therefore, in this direction there is a broken symmetry. The main consequence of the broken symmetry is the spatial dependence of the physical properties of the system. In the observed thin film, the physical values will be dependent on the index $n_z = 0,1,...,N_z$, which is used for numbering film layers along the *z* direction. The spatial dependence is determined by the boundary conditions. Here we will take the simplest boundary conditions, coming from the fact that the layers with indices $n_z = -1$ and $n_z = N_z + 1$ (Wesselinowa J.M., 2001; Wesselinowa J.M.,2002) do not exist. Analysis of the physical properties of the film will be performed based on the Green's functions (B.S. Tošić, at all,1992; V.Sajfert at all, 2003). Green’s functions of the type displacement-displacement and Green’s function of the impulse-impulse type will be calculated. Their spectral intensities will be used to determine some of the thermodynamic and kinetic properties of the film.
The first characteristic to be analyzed is the phonon dispersion law. It is given by:

$$E_{k_x,k_y,\mu} = 2\hbar\Omega\sqrt{\sin^2(n_z+1)\frac{a_x k_x}{2} + \sin^2\frac{a_y k_y}{2} + \sin^2(n_z+1)\frac{\pi\mu}{2(N_z+2)}} \tag{7}$$

where the minimum value of the index μ is not equal to zero but is equal to one. This fact, compared to the previously existing belief, provides important, qualitatively new difference between the thin film and the corresponding bulk structure. In the bulk structure with a simple lattice minimal phonon energy is equal to zero, while in the film, based on (7), this minimum energy is different from zero, and for $k_x = k_y = 0$ and $\mu = 1$ it is:

$$min\, E_{k_x,k_y,\mu} = E_{0,0,1} = 2\hbar\Omega\sin^2(n_z+1)\frac{\pi}{2(N_z+2)} \tag{8}$$

Minimum energy values are given in Table 1 for the films containing 3, 6 and 11 layers.

Table 1:

N	$E_{min}[k_B T]$	E_{min}[eV]
2	153.073	0.0132026
5	89.0084	0.00767697
10	52.2105	0.00450315

$\hbar\Omega = 200\ k_B$

In the table it was taken that the Debye’s energy is $200\ k_B$. From the table it can be concluded that phonon energy threshold decreases with the increasing number of layers. It is to be expected that the energy thresholds for the excitation of phonons in thin films make them appropriate elements for the achievement of high temperature superconductivity. In the three-layer film, there are only zero oscillations up to the temperature of about 150K. This means that, in relation to the movement of electrons, such a thin film up to 150K behaves as bulk structure at the absolute zero, at which electrons move without resistance. Based on this, in the three-layer thin film, the electrons move with no resistance at all temperatures below 150K.

Diffusion in a thin film was determined by the correlation function. In W.Jones, N.H.March, 1985 a formula for calculating the diffusion tensor is given:

$$D_{\vec{n}\vec{m}} = \left| lim_{\varepsilon \to 0} \int_0^\infty dt e^{-\varepsilon t} \frac{< p_{\vec{m}}(0) p_{\vec{n}}(t) >}{M^2} \right| \tag{9}$$

Substituting the correlation function in (9) we obtained the following expression for the diffusion tensor:

$$D_{n_x,n_y,n_z;m_x,m_y,m_z} = \frac{\hbar}{2M} \delta_{n_x,m_x} \delta_{n_y,m_y} \delta_{n_z,m_z} \tag{10}$$

It can be seen that the phonon diffusion tensor is diagonal and all its elements on the diagonal are equal. Therefore, in this case, the diffusion tensor can be treated as diffusion coefficient whose value is $\frac{\hbar}{2M}$. It should be noted that the phonon diffusion coefficient is independent of temperature. The same result was obtained in the reference (L.D. Landau. E.M. Lifshitz, 1980) but in a completely different way.

The next value which was examined was the kinetic energy per atom in different layers of the film. The mean value of kinetic energy per atom is given by:

$$< \mathsf{T}_{\vec{n}} > = \frac{1}{2M} < p_{\vec{n}}^2 > \tag{11}$$

If the value $< p_{\vec{n}}^2 >$ is replaced in (11), after the transition from the sums by k_x and k_y to the integrals, in the approximation of small wave vectors we obtain:

$$< T_{\vec{n}} > = \frac{\hbar\Omega}{4\pi} \frac{1}{N_z + 2} \sum_{\mu=1}^{N_z+2} \sin^2 \frac{\pi\mu}{N_z + 2} \cdot$$

$$\cdot \int_0^{\pi\sqrt{2}} dq\, q \sqrt{q^2 + 4\sin^2 \frac{\pi\mu}{2(N_z + 2)}} \coth \frac{\hbar\Omega}{2\Theta} \sqrt{q^2 + 4\sin^2 \frac{\pi\mu}{2(N_z + 2)}} \tag{12}$$

The values $< T_n >$ are numerically calculated for the three-layer film at temperatures 0K, 100K, and 200K, at which it is taken that the Debye’s temperature is $\Theta_D = \hbar\Omega = 200\, k_B$. The results of the numeric calculation are given in the Table 2.

Table 2:

n ↓	T[K] →	0	100	200
0		3.59968·10-21[J]	3.62816·10-21[J]	3.93043·10-21[J]
1		3.59256·10-21[J]	3.62381·10-21[J]	3.92888·10-21[J]
2		3.599968·10-21[J]	3.62816·10-21[J]	3.93043·10-21[J]

It should be emphasized that the calculation of the kinetic energy by using the formula (12) in the kinetic energy includes the energy of zero oscillations, i.e. oscillations, which on the basis of Heisenberg's principle, are at the temperature T=0K. In the Debye's phonon theory, the energy of zero oscillations is not taken into account (G. Strobl, 2004; H. Ibach, H Lüth, 2003). The table shows that the kinetic energy per atom depends on a spatial index of the layer in which the atom is located. It is also evident that the kinetic energy increases very slowly with temperature.

The potential energy per atom is given by:

$$W_{\vec{n}} = \frac{C}{2}\left[\left(u_{\vec{n}} - u_{\vec{n}-\vec{a}_x}\right)^2 + \left(u_{\vec{n}} - u_{\vec{n}-\vec{a}_y}\right)^2 + \left(u_{\vec{n}} - u_{\vec{n}-\vec{a}_z}\right)^2\right] \tag{13}$$

Since in the x,y planes the film is translationally invariant, we can write:

$$\left.\begin{aligned} \left(u_{\vec{n}+\vec{a}_x} - u_{\vec{n}}\right)^2 &= \left(1-e^{-iak_x}\right)^2 u_{\vec{n}}^2 \\ \left(u_{\vec{n}+\vec{a}_y} - u_{\vec{n}}\right)^2 &= \left(1-e^{-iak_y}\right)^2 u_{\vec{n}}^2 \end{aligned}\right\} \tag{14}$$

Taking into account the fact that the wave vectors kx and ky are moving in symmetrical borders, as well as the fact that the phonons dispersion law is a symmetric function, the mean value of the potential energy per atom can be expressed as follows:

$$< W_{\vec{n}} > \frac{C}{2}\left\{\left(4\sin^2\frac{ak_x}{2} + 4\sin^2\frac{ak_y}{2}\right) < u_{\vec{n}}^2 > + < u^2_{n_x,n_y,n_z} > + < u^2_{n_x,n_y,n_z-1} > - \right.$$
$$\left. - 2 < u_{n_x,n_y,n_z} u_{n_x,n_y,n_z-1} > \right\} \tag{15}$$

Using the formula (15) and the approximation of small wave vectors we obtain the formula for mean potential energy per atom:

$$< W_{\vec{n}} >= \frac{\hbar\Omega}{4\pi}\left\{\frac{1}{N_z+2}\sum_{\mu=1}^{N_z+1} J_3(\mu)\sin^2(b_z+1)\frac{\pi\mu}{N_z+2} + \right.$$
$$+ \frac{1}{N_z+2}\sum_{\mu=1}^{N_z+1} J_1(\mu)\sin^2(b_z+1)\frac{\pi\mu}{N_z+2} + \frac{1}{N_z+2}\sum_{\mu=1}^{N_z+1} J_1(\mu)\sin^2 n_z\frac{\pi\mu}{N_z+2} -$$
$$- \frac{2}{N_z+2}\sum_{\mu=1}^{N_z+1} J_1(\mu)\sin(n_z+1)\frac{\pi\mu}{N_z+2}\sin n_z\frac{\pi\mu}{N_z+2} \tag{16}$$

where

$$J_s(\mu) = \int_0^{\pi\sqrt{2}} dq\, q^s \frac{\coth\left(\frac{\hbar\Omega}{2\Theta}\sqrt{q^2 + 4\sin^2\frac{\pi\mu}{2(N_z+2)}}\right)}{\sqrt{q^2 + 4\sin^2\frac{\pi\mu}{2(N_z+2)}}} \tag{17}$$

The values of the potential energy per atom are numerically calculated for the three-layer film at temperatures T = 0K, T = 100K, T = 200K and T = 300K, and the results are given in the Table 3.

Table 3:

N=2

n ↓	T[K] →	0	100	200	300
0		3.26743·10-21[J]	3.29368·10-21[J]	3.56096·10-21[J]	4.11126·10-21[J]
1		3.58678·10-21[J]	3.61400·10-21[J]	3.90993·10-21[J]	4.51909·10-21[J]
2		3.57521·10-21[J]	3.59925·10-21[J]	3.88409·10-21[J]	4.48070·10-21[J]

The table shows that the potential energies per atom depend on the layer index. By comparing tables 2 and 3 we can conclude that the kinetic energy is the highest in the boundary layers, and the lowest is in the middle layer, while the potential energy is biggest in the middle layer and has lower values in the boundary layers. This is physically completely justified, because the atoms in the boundary layers are partially free, and have more kinetic energy than the atoms in the middle layer. Since the atoms in the middle layer are more tightly bound than the atoms in the boundary layers, it is completely understandable that they have a higher potential energy.

Mean values of energy per atom, i.e. the sum of potential and kinetic energies, were calculated for three different films containing 3, 6 and 11 layers. Energies were calculated at temperatures 0K, 100K, 200K and 300K. The results are given in the Table 4.

Table 4:

N=2

n ↓	T[K] →	0	100	200	300
0		6.86711·10-21[J]	6.92184·10-21[J]	7.49139·10-21[J]	8.65937·10-21[J]
1		7.17934·10-21[J]	7.23781·10-21[J]	7.83880·10-21[J]	9.06656·10-21[J]
2		7.17489·10-21[J]	7.22741·10-21[J]	7.81452·10-21[J]	9.02881·10-21[J]

N=5

n ↓	T[K] →	0	100	200	300
0		6.86736·10-21[J]	6.92293·10-21[J]	7.49357·10-21[J]	8.66263·10-21[J]
1		7.18011·10-21[J]	7.24064·10-21[J]	7.84448·10-21[J]	9.07507·10-21[J]
2		7.18339·10-21[J]	7.24569·10-21[J]	7.85399·10-21[J]	9.08931·10-21[J]
3		7.18361·10-21[J]	7.24611·10-21[J]	7.85483·10-21[J]	9.09056·10-21[J]
4		7.18314·10-21[J]	7.24450·10-21[J]	7.85159·10-21[J]	9.08570·10-21[J]
5		7.17540·10-21[J]	7.22901·10-21[J]	7.81771·10-21[J]	9.03360·10-21[J]

N=10

n ↓	T[K] →	0	100	200	300
0		6.86738·10-21[J]	6.92309·10-21[J]	7.49390·10-21[J]	8.66314·10-21[J]
1		7.18014·10-21[J]	7.24087·10-21[J]	7.84493·10-21[J]	9.07576·10-21[J]
2		7.18345·10-21[J]	7.24608·10-21[J]	7.85477·10-21[J]	9.09047·10-21[J]
3		7.18377·10-21[J]	7.24696·10-21[J]	7.85653·10-21[J]	9.09311·10-21[J]
4		7.18384·10-21[J]	7.24722·10-21[J]	7.85705·10-21[J]	9.09389·10-21[J]
5		7.18385·10-21[J]	7.24730·10-21[J]	7.85720·10-21[J]	9.09412·10-21[J]
6		7.18385·10-21[J]	7.24727·10-21[J]	7.85715·10-21[J]	9.09405·10-21[J]
7		7.18383·10-21[J]	7.24713·10-21[J]	7.85686·10-21[J]	9.09361·10-21[J]
8		7.18373·10-21[J]	7.24667·10-21[J]	7.85594·10-21[J]	9.09222·10-21[J]
9		7.18319·10-21[J]	7.24479·10-21[J]	7.85217·10-21[J]	9.08657·10-21[J]
10		7.17543·10-21[J]	7.22919·10-21[J]	7.81809·10-21[J]	9.03417·10-21[J]

Based on the table we conclude that the total energy of the atom depends on the index of the nz layer. It can also be concluded that the energy differences in layers are biggest at the thinnest films and that they decrease with the increase in film thickness. This is completely understandable since the thicker film is closer to the ideal structure, in which the energies in all layers are the same.

The internal energy is a very important property of the system. The internal energy of the film is the sum of internal energies in all layers of the film. If the energy of a single atom in the layer labeled with nz index at temperature T is indicated by Enz(T), then the internal energy of the film is given with:

$$U_f(T) = N_x N_y \sum_{n_z=0}^{N_z} E_{n_z}(T) \tag{18}$$

The internal energy of an ideal three-dimensional structure is given by:

$$U_n = \frac{9\pi^2}{16}\hbar\Omega + \frac{3\cdot 1.08232}{\pi^2}\frac{\Theta^4}{(\hbar\Omega)^3} \tag{19}$$

Since NxNyNz is of the 1024 order while NxNy is of the 1016 order, the comparison of the values (18) and (19) is interesting. Much better information about the difference between a film and the ideal structure can be obtained by comparing their specific heats.
Specific heat of the ideal structure is given in the formula:

$$C_V^{(id)} = \frac{1}{M}\frac{\partial U}{\partial T}, \tag{20}$$

where M= NxNyNzM. This formula combined with (19) gives the following expression for the specific heat of the ideal structure:

$$C_V^{(id)} = \frac{12\cdot 1.08232}{\pi^2}\frac{k_B}{M}\frac{\Theta^3}{(\hbar\Omega)^3}. \tag{21}$$

The formula for the internal energy of the film (18) is not suitable for differentiation according to temperature and therefore the average value C_V^f will be used, which is given by:

$$C_{n_z}(T_2) = \frac{E_{n_z}(T_2) - E_{n_z}(T_1)}{M(T_2 - T_1)} \tag{22}$$

It is important to note here that the specific heat of the film can be determined only for each of the layers. Since, because of this, the specific heat of the film does not exist as such, we will introduce the convention that the arithmetic mean value (22) represents the specific heat of the film.

Specific heats of the three-layer film, calculated by the formula:

$$\overline{C}(T_2) = \sum_{n_z=0}^{N_z} \frac{E_{n_z}(T_2) - E_{n_z}(T_1)}{(N_z+1)M(T_2 - T_1)} \tag{23}$$

and specific heats of the ideal structure, calculated by the formula (23) are given in the Table 5.

Table 5:

T	100	200	300
$C_V^{(id)}$ [$\frac{\mathrm{J}}{\mathrm{kgK}}$]	112.72	467.887	708.75
C_V^f [$\frac{\mathrm{J}}{\mathrm{kgK}}$]	113.27	906.16	3058.29

The table shows that at these relatively high temperatures, specific heats of the film are slightly lower than the specific heats of the ideal structure. This difference increases with increasing temperature. The specific heats of three-layer films in the temperature interval (2K, 10K) are given in the Table 6.

Table 6:

nz	T	2K	3K	4K	5K	6K	7K	8K	9K	10K
0		0	0	0	0	1.20·10-9	5.08·10-9	8.71·10-9	7.86·10-9	0
1		0	0	0	-7.52·10-9	1.05·10-9	4.70·10-9	8.14·10-9	7.43·10-9	0
2		0	0	0	-7.52·10-9	6.02·10-9	2.60·10-9	4.50·10-9	4.11·10-9	0

For the purpose of the comparison with the ideal structure we will take the specific heat of the ideal structure on 10K, which is 0.1135J/kgK. Based on this result it can be concluded that:

$$\frac{C_V^{(id)}(10)}{C_V^{(f)}(10)} = 3031.274203 \qquad (24)$$

This means that at low temperatures the specific heats of the film are about 3000 times lower than the specific heats of the ideal structure.

Further numerical analyses of specific heats show that up to the temperatures of 80K the specific heats of the film are lower than the specific heats of the ideal structure. In the temperature interval [80K, 97K] specific heats of the film become higher than the specific heats of the ideal structure. At temperatures above 97K films again have lower specific heats than the ideal structure. The described behavior of specific heats is presented in Figure 1 and it should be noted that a similar result was obtained in the reference (C. Kittel, 1986).

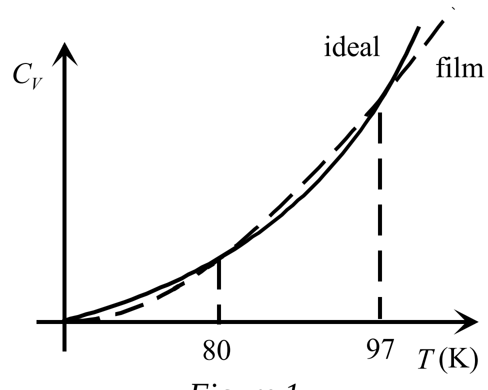

Figure 1.

The analysis of the physical properties of the phonon subsystem in the thin film will be finished with the calculation of the thermal conductivity. Thermal conductivity is an important kinetic property of the system and is calculated using the formula ([16] K. Stowe,2007).

$$\lambda = D \cdot C_V \cdot \rho \qquad (25)$$

We have already seen that the density and specific heat of a thin film can be calculated only for the layers of the film. We have introduced the convention that for the density and specific heat of the film as a whole, the arithmetic mean of density of the layers and the specific heat in layers are taken. Therefore the coefficient of thermal conductivity of the film as a whole will be taken as the product of

the diffusion coefficient, mean density and mean specific heat. For the three-layer film all of these features were previously calculated at temperatures of 100K, 200K and 300K.
At much lower temperatures than 100K, the thermal conductivity coefficient of the film is much lower than the coefficient of thermal conductivity of the ideal structure because the specific heats of the film at these temperatures are about 3·103 times lower than the specific heats of the ideal structure. Numerical calculations can show that at the temperature T=76.5K the coefficients of the thermal conductivity of the film and the ideal structure become equal. Up to a temperature T=101.5K thermal conductivity of the film is higher than the thermal conductivity of the ideal structure, and at temperatures higher than 101.5K film again it has a lower thermal conductivity. The described behavior of thermal conductivity of the film and the ideal structure is given in the Figure 2.

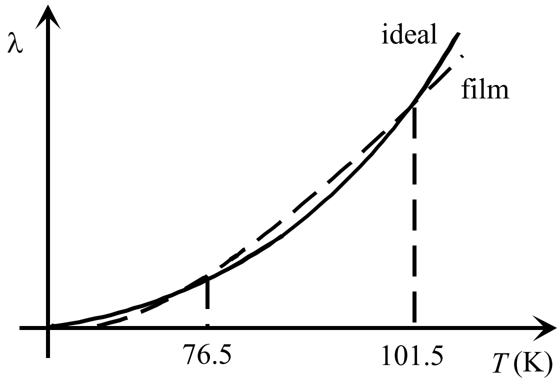

Figure 2.

CONCLUSION

The results of the analysis of the thermodynamic and kinetic properties of thin films showed that all of these features, apart from the diffusion coefficient, depend on the spatial coordinate in the direction of the broken symmetry (from the index nz which numerates layers of the film). It was also shown that the density of the film, its specific heat and thermal conductivity can be determined only for the layers of the film, not the film as a whole. For this reason, we were forced to apply the convention that the arithmetic mean of these properties in layers of the film is the property of the film as a whole. By comparing thus introduced values of the film with the corresponding values in the ideal structure, it was concluded that the films have a significantly lower specific heat and significantly lower thermal conductivity than the ideal structure. From a practical point of view, this conclusion is very important because it points to the fact that the films are much better thermal insulators than the corresponding bulk structures. Previously ascertained fact that the excitation of phonons in the film required excitation energy, which is different from zero (in the film there are no acoustic phonons) also has a technological importance, because it provides evidence that the films are better acoustic insulators than the corresponding bulk structures.

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NANOSCIENCE, NANOTECHNOLOGY AND ECOLOGY

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ABSTRACT

The domain of nanotechnology is defined in terms of a length scale - from one nanometer up to 100 nanometers, called the nanoscale, and by the appearance at these scales of novel physical properties. These derive from the importance at these scales of physical phenomena that are less obvious for larger objects, such as quantum mechanics. The industrial revolution of the late 19th and early 20th century led to unprecedented economic growth in Europe and the United States. However, it also produced unprecedented environmental pollution. In those simpler, more naive times, contamination of the environment was largely ignored. Advances in information technologies, science of materials, biotechnology, energy engineering, and many other disciplines, including environmental engineering, are converging at the quantum and molecular scales. The economic benefits of increased industrial production outweighed the emerging environmental problems, allowed this industrial contamination to dissipate to levels that made it relatively easy to ignore.

Key words: *nanotechnology, quantum mechanics, environmental pollution, contamination.*

INTRODUCTION

Nanoscience, i.e. nanotechnology as applied nanoscience, studies materials and phenomena in the fields of nanometers up to 100 nm. Materials and structures in this area show completely different properties from those of the bulk structure.

Research of structures with broken symmetry has a relatively long history. Progress in nanostructured technologies results in the production of purposely made deformed structures. Planned nanostructures are thin films, nanocylinders, nanorods etc. Today three-layer nanofilms are produced without any problems. In researches of this type researchers started from the very complex problems moving to less complex problems which resulted in the slow development of the theory of broken structures. Although it is well known that a similar problem in classical mechanics is solved by Boltzmann’s statistics, it took a long time to have Boltzmann’s ideas applied to the problem of chaotic structures with broken symmetry. Naturally, the statistical approach gave only the most likely solutions - not the correct solutions. Albert Einstein insisted that the complete theory must give exact solutions (he was also an opponent of quantum mechanics). However, Boltzmann’s ideas received wide field of application. It turned out that Boltzmann’s ideas contribute much more to the development of physics than Einstein's .

In our opinion, the probabilistic approach is a unique way of analyzing deformed chaotic systems. Probabilistic nature of statistical analysis approach gives the possibility to obtain the probability of the results of randomly deformed structures and allows the prediction of some fundamental effects.

Theoretical analysis of the planned (in the geometric sense) nanostructures is less complicated than in the case of accidentally distributed structures. In the basis of these analyzes is the Heisenberg’s uncertainty principle. There is an energy gap with configurational dependence of important physical properties. Equidistance of energy levels that occurs in the ideal structures was rejected. The mentioned properties compelled some authors to state that the nanostructures compared to the ideal structures behave as quantum mechanical laws compared to the laws of classical mechanics (M.L. Bellac,2006). Mathematical difficulties are primarily associated to the geometry of the structures. The most suitable for the analysis are the systems of difference equations obtained for a simple cubic symmetry. This gave rise to a new idea: whenever possible, one must determine the geometrical and statistical equivalence of a simple structure (cubic) with complicated geometries (triclinic, monoclinic, etc.) (V. Sajfert at all, 2007). Non-isomorphism of the transition configuration space – impulse space (autoreduction) is a very common feature of nanostructures and this also requires further research (V. Sajfert at all 2006). Analysis of the anharmonic (nonlinear) effects in nanostructures is mathematically more complicated. This is the reason why the Tjablikov's approximations are commonly used in the analysis of nanostructures (S.V. Tyablikov, 1967).

THE ADVANCE OF NANOTECHNOLOGIES

The general opinion is that the first steps in nanorevoultion in the nano world were made in the 1980s when scanning microscopes were found. They enable production of layered structures with layer thickness of the nanometer order. On the other hand, in the colloid chemistry Langmuir-Blodgett films with very large periodicity were made (see L. J. Blum, 1997; T. E. Edmonds (ed.),1987; T. Seiyama et al.,1983; B. E. Jones (ed.), 1987; N. V. Kirianaki et al., 2002; J. R. Carstens, 1993).

A relevant role in the development of nanotechnology is associated with the development of the speed of computers. Quantum phenomena are beginning to play an important role in the material properties with dimensions less than 10 nm. The energy structure of the low-dimensional systems in solid state physics, e.g. two-dimensional (thin films), one-dimensional (quantum wires) and zero-dimensional (quantum dots), changes significantly compared to the three-dimensional materials. On the other hand, quantum phenomena can have positive effects on the progress of microelectronics.

BRIEF OVERVIEW OF THE EXPERIMENTAL RESULTS

The rapid development of nanotechnology is followed by intense testing of the physical properties and practical consequences to nanomaterials. Materials of semiconductor nanocrystals are widely used and their application is in biology and medicine.

In recent years a significant number of papers and books on the synthesis of such materials, properties of nanomaterials depending on the shape and size and electron-phonon interaction has been published. Furthermore, intensive analyses are carried out of electrical, optical and mechanical properties of GaAs semiconductor nanocrystals. The application shall include: (a) quantum dots in p-type InAs/GaAs, (b) photodetectors based on InAs, (c) field-effect transistors of InAs nanocrystals and (d) InGaAs/GaAs lasers based on quantum dots (A. Ekimov, 1996; Y. Ohfuti, K. Cho, 1996; O.I. Micic and A. J. Nozik, 1996; T. Takagahara, 1996; M.A. Stroscio, M. Dutta, 2003).

In recent years nanorods are made of silver, gold, platinum, copper, and semiconductors. It was found that these materials have very different properties from bulk materials (N.R. Jana at all, 2001; V.M. Cepak, C.R. Martin, 1998; Z.L. Wang at all, 2000; M. Bianca at all 1997; Y.Y. Yu at all, 1997; N.R. Jana at all,2001; T. Kyotani at all,1997; A. Henglein, J. Giersig, 2000; M.E. Toimil Molares at all, 2001; S. Wang, S. Yang, 2000; C.C. Chen at all, 2000; J.G. Korvink at all, 2002.

Carbon atoms form coal and diamond with different molecular arrangements. It is now known that carbon molecules form nano-cylindrical tubes - nanotubes, which are much harder than steel and conduct electricity. Carbon nanotubes are expected to be the key for breakthroughs in medicine and electronics. Also, nanotechnology may enable a breakthrough in the industry. An electric current produced by solar cells or batteries allows the flow of electrons from one surface to another and improve battery performance. We get the cleaner, cheaper and safer electricity.

There are very recent experiments with superfluid magnetic YIG films and polarons (V.E. Demidov at all, 2008; V.M. Agranovich, B.S. Toshich, 1959). It turned out that a large gap in the spectrum of magnetic and polaron excitations leads to a short time statistical equilibrium when magnons and polarons have superfluid properties.

WHAT IS EXPECTED OF THE NANOSCIENCE RESEARCH?

The main reason for the intensive development of nanotechnology and nanoscience is the fact that nature does not produce all the materials needed for civilization, and therefore science deals with the problem of creating artificial materials.

Nanotechnology keeps the promise of the progress made in recent decades in computers, mobile phones and biotechnology. The application of these results led to the extremely fast computers, light materials for aircraft, finding cancerous tumors invisible under an optical microscope, or making large amounts of energy from the very efficient solar cells.

Another important aspect of nanotechnology is that it involves many different disciplines in which researchers are working, including chemistry, biology, science of materials, physics, and computer science. Communication and research between scientific disciplines and researchers is very important for the advancement of nanotechnology.

CHAIN WITH RANDOM INTERMOLECULAR DISTANCES

We will study stochastically two types of one-dimensional chains. The first type is the chain of identical atoms (molecules) with different distances between neighboring atoms. Practically, it is a chain with vacancies (cavities). The second type is the chain that is identical to the distances between atoms, but the atoms have different masses. It is a system with impurities. Whenever it is possible, the results of these chains will be generalized for tridimensional structures.

The results for the spatial distribution of defects (chain with vacancies) and the distribution of mass will be generalized using the convolution distribution (R. Baeza-Yates at all, 2005).

We shall consider a chain in which the distances between N_{1D} atoms a_1, and the distances between N_{2D} atoms a_2, etc. It is assumed that there are *n* different distances between atoms. The total number of atoms is constant, i.e. (R.K. Pathria, 2001).

$$N_D = \sum_{s=1}^{n} N_{sD} = \text{const},$$

also the length of the chain

$$L = \sum_{s=1}^{n} a_s N_{sD} = \text{const}$$

is constant.
The statistical probability of the described system is given by:

$$P = \frac{N_D!}{\prod_{s=1}^{n} N_{sD}!} \approx \frac{{N_D}^{N_D}}{\prod_{s=1}^{n} {N_{sD}}^{N_{sD}}} \tag{1}$$

Analogous to the standard Boltzmann approach (K. Stowe, 2007) the most likely distribution of atoms in the distances is obtained by equating the variation function

$$\Phi = \ln P - \alpha_D N_D - \beta L =$$

$$= N_D \ln N_D - \sum_{s=1}^{n} \left(N_{sD} \ln N_{sD} + \alpha_D N_{sD} + \beta a_s N_{sD} \right) \quad (2)$$

with zero. Undetermined Lagrangian coefficients (S. Abe, Y. Okamoto(eds.), 2001) are marked with α and β.

Since $\delta\Phi = -\sum_{s=1}^{n} \left(\ln N_{sD} + 1 + \alpha_D + \beta a_s \right) \delta N_{sD}$, the equation which determines the most likely distribution is:

$$\ln N_{sD} + 1 + \alpha + \beta a_s = 0, \quad (3)$$

wherefrom it follows

$$N_{sD} = e^{-\left(\alpha_D + 1\right)} e^{-\beta a_s}. \quad (4)$$

By substituting (4) in $\sum_{s=1}^{n} N_{sD} = N_D$, we get:

$$e^{-\left(\alpha_D + 1\right)} = \frac{N_D}{\sum_{s=1}^{n} e^{-\beta a_s}}. \quad (5)$$

Combining (4) and (5) we find the probability that the distance between N_{sD} neighboring atoms a_s is:

$$W_s = \frac{N_{sD}}{N_D} = \frac{e^{-\beta a_s}}{\sum_{s=1}^{n} e^{-\beta a_s}}. \quad (6)$$

Probability W_s given in the formula (6) is not suitable for further chain analysis because neither a_s nor β are known. Therefore, let us introduce an approximation:

$$a_s = s a_0 \quad (7)$$

where a_0 is the minimum distance between neighboring atoms (it is clear from (7) that $a_1 = a_0$). In the case of vacancies approximation (7) is relatively close to the real situation, but in the case of random impurities this approximation is approximate. Since the real distances are $\left(s + \rho\right) a_0$, the approximations are:

$$\left(s + \rho\right) a_0 \approx \left(s + 1\right) a_0 \text{ if } 0.5 < \rho < 1$$

and

$$\left(s + \rho\right) a_0 \approx s a_0$$

if $0 < \rho < 0.5$.

Putting (7) into (6) we obtain the approximate expression for the probability:

$$W_s = \frac{N_{sD}}{N_D} = \frac{e^{-\beta a_0 s}}{\sum_{s=1}^{n} e^{-\beta a_0 s}} \quad (8)$$

This formula will be basis for further analysis.

The first necessary step in the analysis is the determination of the Lagrange factor β. It can be determined by combining (8) and the conservation law:

$$L = \sum_{s=1}^{n} s a_0 N_{sD} \tag{9}$$

By including N_{sD} from (8) into (9) we obtain:

$$\frac{L}{N_D a_0} = \frac{\sum_{s=1}^{n} s e^{-\beta a_0 s}}{\sum_{s=1}^{n} e^{-\beta a_0 s}} = -\frac{\mathrm{d}}{\mathrm{d}(\beta a_0)} \ln \sum_{s=1}^{n} e^{-\beta a_0 s} =$$

$$= -\frac{\mathrm{d}}{\mathrm{d}(\beta a_0)} \ln\left(e^{-\beta a_0} \frac{1 - e^{-\beta a_0 n}}{1 - e^{-\beta a_0}} \right) \tag{10}$$

In order to simplify the equation (9) we will take the approximation: $e^{-\beta a_0 n} \approx 0$. After this (9) becomes:

$$\frac{L}{N_D a_0} = \frac{\mathrm{d}}{\mathrm{d}(\beta a_0)} \ln\left(e^{\beta a_0} - 1\right) = \frac{1}{1 - e^{-\beta a_0}} \tag{11}$$

From (11) it follows

$$e^{-\beta a_0} = 1 - \frac{N_D a_0}{L} \tag{12}$$

and further

$$-\beta a_0 = \ln\left(1 - \frac{N_D a_0}{L}\right) \tag{13}$$

The next approximation is $\ln\left(1 - \frac{N_D a_0}{L}\right) \approx -\frac{N_D a_0}{L}$ and it gives evaluation for β:

$$\beta = \frac{N_D}{L} \tag{14}$$

The described method is used to estimate the Lagrange factor β over the fundamental chain properties, i.e. through the number of atoms and its length. Of course it must be borne in mind that the term for β is approximate.

It is important to find the mean value for the distance a_s as the mean value is the constant of the lattice of the equivalent chain with identical distances between atoms. This mean value is given by:

$$< a_s > = \sum_{s=1}^{n} a_s W_s = \frac{\sum_{s=1}^{n} a_0 s e^{-\beta s a_0}}{\sum_{s=1}^{n} e^{-\beta a_0 s}} = -\frac{\mathrm{d}}{\mathrm{d}\beta} \ln \sum_{s=1}^{n} e^{-\beta a_0 s} = -\frac{\mathrm{d}}{\mathrm{d}\beta} \ln \frac{1 - e^{-n\beta a_0}}{e^{-\beta a_0} - 1} \tag{15}$$

wherefrom it follows

$$< a_s > = a_{eq} = a_0 \left(\frac{e^{\frac{\beta a_0}{2}}}{2\sinh \frac{\beta a_0}{2}} - \frac{n}{e^{n\beta a_0} - 1} \right); \quad \beta = \frac{N_D}{L} \tag{16}$$

The generalization of the presented approach in the three-dimensional structure gives the result:

$$W_{TOT} = \frac{e^{-\beta_x a_0 s - \beta_y b_0 s - \beta_z c_0 s}}{\sum_{s=1}^{n_x} e^{-\beta_x a_0 s} \sum_{s=1}^{n_x} e^{-\beta_y a_0 s} \sum_{s=1}^{n_x} e^{-\beta_z a_0 s}} \tag{17}$$

where $\beta_x = \frac{N_{xD}}{L_x}$, $\beta_y = \frac{N_{yD}}{L_y}$, $\beta_z = \frac{N_{zD}}{L_z}$ and a_0, b_0 and c_0 are minimal distances between the neighbors in *x*, *y* i *z* directions, respectively.

LINEAR CHAIN WITH A RANDOM DISTRIBUTION OF MASSES

We shall now consider a chain with N_M equidistant atoms which have different masses m_1, m_2, ... m_m. We assume that the mass m_1 has N_{1M} of atoms, the mass m_2 has N_{2M} of atoms etc. In this case, the number of atoms *N* and the mass *M* of the chain are conserved (J.D. Walecka, 2000; C. Lim, J. Nebus, 2007). This means that the conservation laws are:

$$\sum_{s=1}^{m} N_{sM} = N_M . \tag{18}$$

and

$$\sum_{s=1}^{m} m_s N_{sM} = M . \tag{19}$$

The statistical probability is given by:

$$P = \frac{N_M!}{\prod_{s=1}^{m} N_{sM}!} = \frac{{N_M}^{N_M}}{\prod_{s=1}^{m} {N_{sM}}^{N_{sM}}} . \tag{20}$$

As in the previous case, the most probable distribution is obtained by equating the variation function

$$\Psi = \ln P - \alpha_M N_M - \gamma M = N_M \ln N_M - \sum_{s=1}^{m} \left(N_{sM} \ln N_{sM} + \alpha_M N_{sM} + \gamma m_s N_{sM} \right) . \tag{21}$$

with zero.

We will not repeat the procedure set out in the paragraph 5 as it is practically the same.
The probability that N_s of the atom has a mass m_s is given by:

$$\Omega_s = \frac{e^{-\gamma m_s}}{\sum_{s=1}^{m} e^{-\gamma m_s}} \tag{22}$$

Taking an approximation for the masses:

$$m_s = s m_0 \tag{23}$$

where m_0 is the minimal mass, we obtain the approximate expression for the probability Ω_s:

$$\Omega_s = \frac{N_{sM}}{N_M} = \frac{e^{-\gamma m_0 s}}{\sum_{s=1}^{m} e^{-\gamma m_0 s}} \tag{24}$$

Combining (19) and (24) and using the same approximations as in the paragraph 5 we get the Lagrange factor γ:

$$\gamma = \frac{N_M}{M} \tag{25}$$

The mean value of the mass, which represents the mass of the equivalent chain (identical masses), is given by:

$$< m_s >= m_{eq} = m_0 \left(\frac{e^{\frac{\gamma m_0}{2}}}{2\sinh \frac{\gamma m_0}{2}} - \frac{m}{e^{m\gamma m_0} - 1} \right); \quad \gamma = \frac{N_M}{M} \tag{26}$$

The expression for the three-dimensional structure with different masses is given by:

$$\Omega_{TOT} = \frac{e^{-\gamma_x m_{x0} s - \gamma_y m_{y0} s - \gamma_z m_{z0} s}}{\sum_{s=1}^{m_x} e^{-\gamma_x m_{x0} s} \sum_{s=1}^{m_y} e^{-\gamma_y m_{y0} s} \sum_{s=1}^{m_z} e^{-\gamma_z m_{z0} s}} \tag{27}$$

where $\gamma_x = \frac{N_{xM}}{M_x}$, $\gamma_y = \frac{N_{yM}}{M_y}$, $\gamma_z = \frac{N_{zM}}{M_z}$ and m_{x0} , m_{y0} and m_{z0} are minimal masses in x, y and *z* directions, respectively.

NANOTECHNOLOGY AND ENVIRONMENTAL PROTECTION

Advancement in information technology, science of materials, biotechnology, energy engineering, including environmental protection engineering is associated with quantum and molecular dimensions. Engineers and environmental scientists have a new role, in cooperation with scientists of the science of materials, molecular biologists, chemists, to solve the problem of energy and materials in accordance with the responsibilities for environmental protection. One should always keep in mind what the impact of new materials on human health and the environment is. Although various studies offer some analyses of the toxicity of nanomaterials (Shahriar Sharifi at all, 2012) and their hazards to human health (H. L. Karlsson,2009; M. Mahmoudi at all 2011; A. Nchimi at all, 2010) at this level such an impact is not fully explained.

CONCLUSION

The results obtained in paragraphs 5 and 6, in particular formulas (8), (24), (33) and (35) give the opportunity to find which ideal structure can present a corresponding deformed structure. This presentation is not able to fully reproduce the behavior of the deformed structure. It gives the expectation of the deformed structure behavior. The obtained probabilities are of the exponential type and standard deviations for this type of distribution are the order of the expected average values. The stochastic method presented here is unique for obtaining even a remotely realistic picture of the physical processes in the deformed structure. It should be noted that nanostructures cut from an ideal bulk structure can be analyzed in this way. It gives the probability to evaluate appropriate behavior of nanostructures.

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ELECTRO AND ELECTRO-MAGNETIC POLLUTION IN URBAN AREAS

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RADIATION OF ELECTROMAGNETIC FIELDS AT RADIO FREQUENCIES

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ABSTRACT

The sources of radio frequency radiation (radio and TV transmitters, radars, microwave ovens, portable radio transciever equipment) are presented first. Then, the impacts of RF (Radio Frequency) and MW (Micro Wave) radiations on humans are presented. The absorption factors of radio frequency and microwave emissions by human body are also presented.

Key words: *Radio Frequency Radiation, Absorption factors.*

INTRODUCTION

Electromagnetic radiation consists of waves of electric and magnetic energy moving together (that is, radiating) through space at the speed of light (Figure 1).

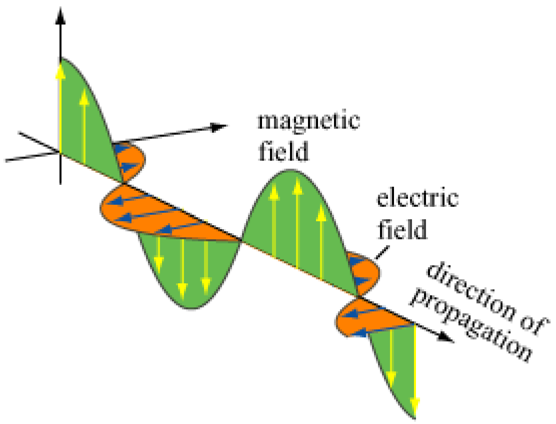

Figure 1. An electro-magnetic wave consists of an electric field and a magnetic field changing together in time and space.(https://www.google.rs/search?q=electromagnetic+wave+figure&tbm)

Taken together, all forms of electromagnetic energy are referred to as the electromagnetic spectrum (Figure 2). Radio waves and microwaves emitted by transmitting antennas are one form of electromagnetic energy. Often the term electromagnetic field or radiofrequency (RF) field may be used to indicate the presence of electromagnetic or RF energy.

An RF field has both an electric and a magnetic component (electric field and magnetic field), and it is often convenient to express the intensity of the RF environment at a given location in terms of units specific for each component(V.Šinik , S. Janković, Z. Despotović-2011). For example, the unit "volts per meter" (V/m) is used to measure the strength of the electric field and the unit "amperes per meter" (A/m) is used to express the strength of the magnetic field.

RF waves can be characterized by a wavelength and a frequency. The number of cycles per second is known as the frequency, which is measured in Hertz (Hz).

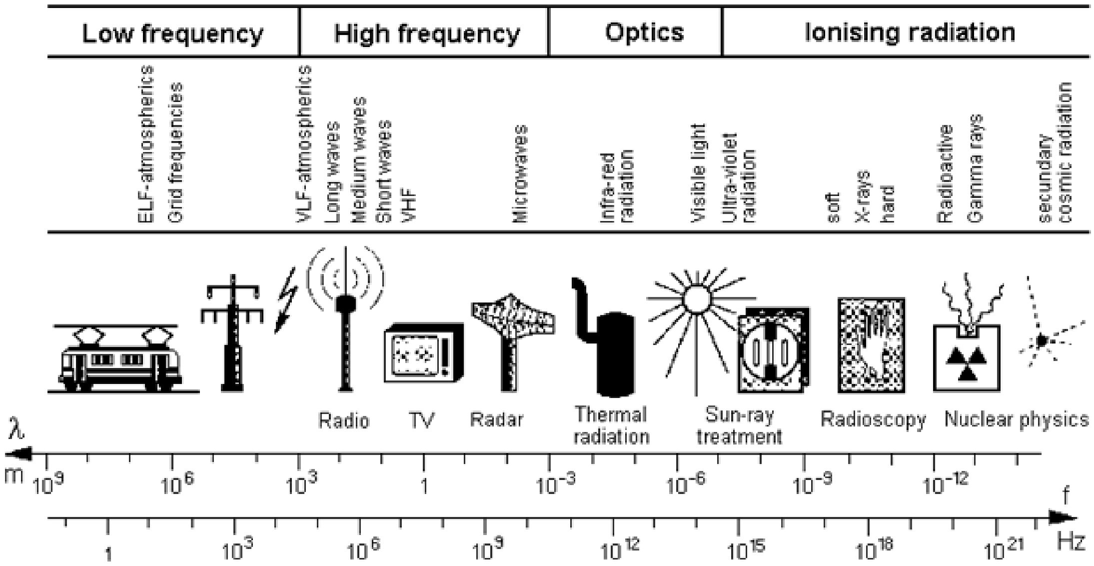

Figure 2. Electromagnetic Spectrum: (https://www.google.rs/search?q=electromagnetic+wave+figure&tbm)

The wavelength is the distance covered by one complete cycle of the electromagnetic wave, while the frequency is the number of electromagnetic waves passing a given point in one second. Different forms of electromagnetic energy are categorized by their wavelengths and frequencies. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum where electromagnetic waves have frequencies in the range of about 3 kilohertz (3 kHz) to 300 gigahertz (300 GHz).

THE SOURCES OF RADIOFREQUENCY RADIATION

Radiofrequency (or RF) Radiation refers to electromagnetic fields with frequencies between300 kHz and 300 MHz, while " Microwave (or MW) Radiation " (Figure 3) covers fields from 300 MHz to 300 GHz. Since they have similar characteristics, RF and MW radiation are usually treated together. As well, the lower-frequency boundary of RF radiation is often extended to 10 kHz, or even to 3 kHz, in order to include emissions from commonly used devices.

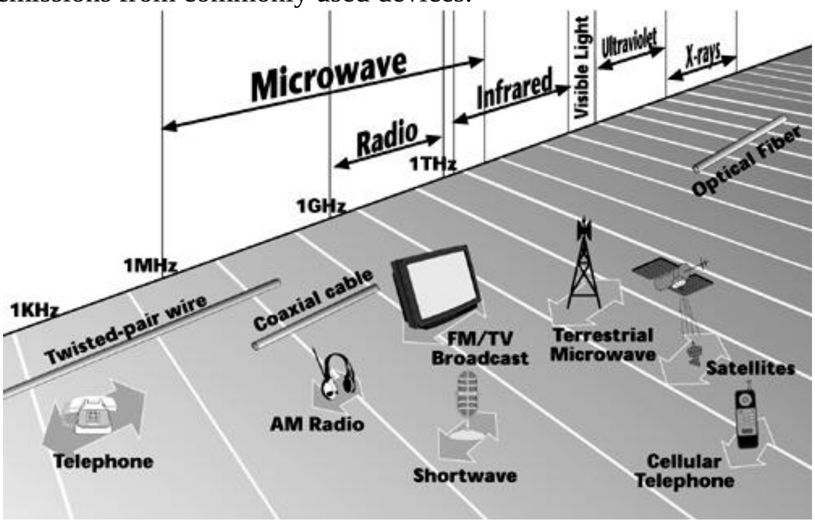

Figure 3. Microwave devices and the electromagnetic spectrum(https://www.google.rs/search?q=electromagnetic+wave+figure&tbm)

Radio and TV transmitters

A radio and TV transmitter (Figure 4) is usually part of a communication system which uses electromagnetic waves to transport information over a distance.

Figure 4. Big television and radio tower with several parabolic antenna on high quote (mountain) - Roncola (Italy)(http://www.123rf.com/photo_10872365_big-television-and-radio-tower-with-several-parabolic-antenna-on-high-quote-mountain--roncola-italy.html)

In electronics and telecommunications a transmitter or radio transmitter is an electronic device which, with the aid of an antenna, produces radio waves. Transfer of information (speech, music, image, computer data etc.) by radio can be presented in its simplest form with block - diagram as on Figure 5.

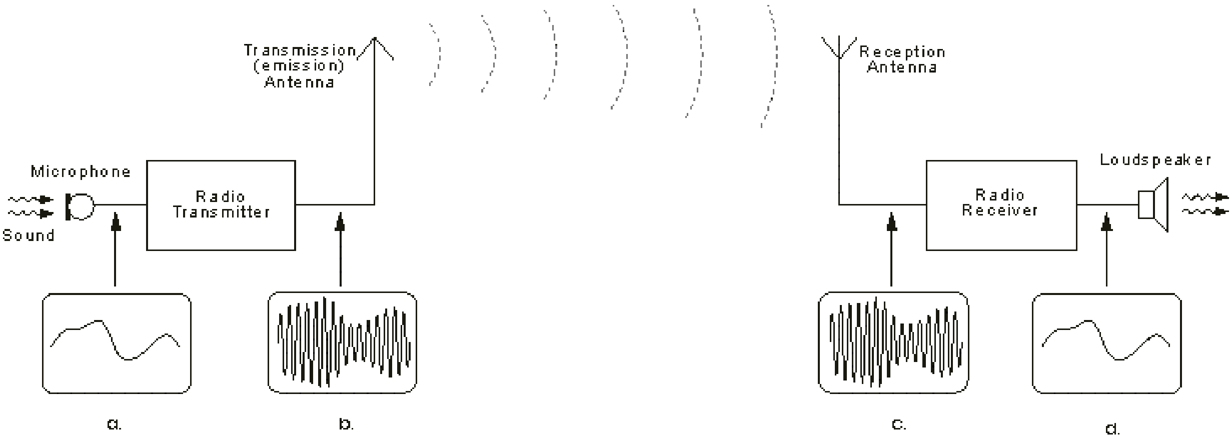

Figure 5. Radio transmission. Block diagram (https://www.google.rs/search?q=Radio+and+TV+transmitters+fig&sa=N&tbm=isch&tbo=u&source=univ&ei=XV0sUuSsOsHrswbj54DICw&ved=0CFAQsAQ4Cg&biw=1332&bih=576)

When antennas are located on tall columns, access by the general population to the base of the columns may be permitted if the exposure is less than the permitted levels. Small antennas of local television and radio stations are frequently located on the tops of tall buildings (skyscrapers), and in such cases the supervision of roof access is required.

Radar (***RA**dio **D**etection **A**nd **R**anging)*(Figure.6) is an object detection system which uses radio waves to determine the range, altitude, direction, or speed of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain. The radar dish or antenna transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter (http://en.wikipedia.org/wiki/Radar).

The modern uses of radar are highly diverse, including air traffic control, radar astronomy, air-defense systems, antimissile systems; marine radars to locate landmarks and other ships; aircraft anti-collision systems; ocean surveillance systems, outer space surveillance and rendezvous systems; meteorological precipitation monitoring; altimetry and flight control systems; guided missile target locating systems; and ground-penetrating radar for geological observations. High tech radar systems are associated with digital signal processing and are capable of extracting useful information from very high noise levels.

Figure 6. Some of the types of radar systems(http://en.wikipedia.org/wiki/Radar)

Radars usually operate at radio frequencies (RF) between 300 MHz and 15 GHz. They generate EMFs that are called RF fields. RF fields within this part of the electromagnetic spectrum are known to interact differently with human body.

RF fields below 10 GHz (to 1 MHz) penetrate exposed tissues and produce heating due to energy absorption. The depth of penetration depends on the frequency of the field and is greater for lower frequencies. Absorption of RF fields in tissues is measured as a Specific Absorption Rate (SAR) within a given tissue mass. The unit of SAR is watts per kilogram (W/kg). SAR is the quantity used to measure the "dose" of RF fields between about 1 MHz and 10 GHz. An SAR of at least 4 W/kg is needed to produce known adverse health effects in people exposed to RF fields in this frequency range (http://www.who.int/peh-emf/publications/facts/fs226/en/).

RF fields above 10 GHz are absorbed at the skin surface, with very little of the energy penetrating into the underlying tissues. The basic dosimetric quantity for RF fields above 10 GHz is the intensity of the field measured as power density in watts per square metre (W/m2) or for weak fields in milliwatts per square metre (mW/m2) or microwatts per square metre (µW/m2). Exposure to RF fields above 10 GHz at power densities over 1000 W/m2 are known to produce adverse health effects, such as eye cataracts and skin burns.

Microwave oven

A microwave oven(Figure.7) works by passing non-ionizing microwave radiation through the food. Microwave radiation is between common radio and infrared frequencies, being usually at 2.45 GHz of or, in large industrial/commercial ovens, at 915 MHz.

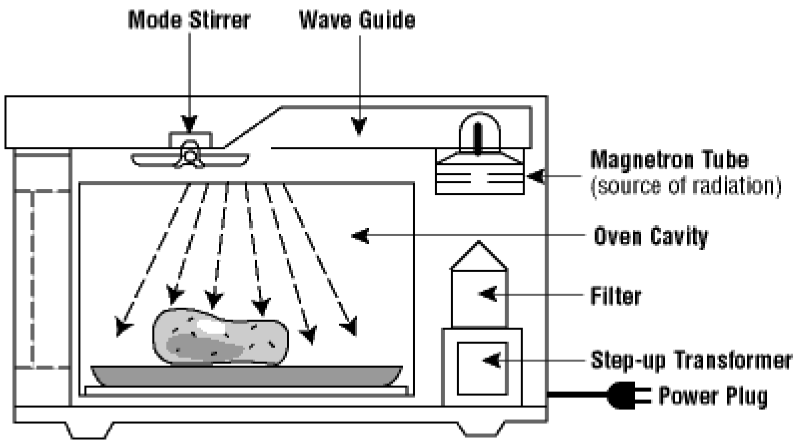

Figure 7. Microwave oven
(http://ccinfoweb.com/oshanswers/phys_agents/microwave_ovens.html)

A microwave oven consists of: a high voltage power source, a high voltage capacitor (connected to the magnetron, transformer and via a diode to the case),a cavity magnetron (which converts high-voltage electric energy to microwave radiation), a magnetron control circuit (usually with a microcontroller), a waveguide (to control the direction of the microwaves), a cooking chamber

Water, fat, and other substances in the food absorb energy from the microwaves in a process called dielectric heating. Many molecules are electric dipoles, meaning that they have a partial positive charge at one end and a partial negative charge at the other, and therefore rotate as they try to align themselves with the alternating electric field of the microwaves. Rotating molecules hit other molecules and put them into motion, thus dispersing energy.

A microwave oven converts only part of its electrical input into microwave energy. Additional power is used to operate the lamps, AC power transformer, magnetron cooling fan, food turntable motor and the control circuits. Such wasted heat, along with heat from the product being microwaved, is exhausted as warm air through cooling vents.

Portable radio transciever

A walkie-talkie (more formally known as a handheld transceiver) is a hand-held, portable, two-way radio transceiver. Walkie-talkies are widely used in any setting where portable radio communications are necessary, including business, public safety, military, outdoor recreation, and the like, and devices are available at numerous price points from inexpensive analog units sold as toys up to ruggedized (i.e. waterproof or intrinsically safe) analog and digital units for use on boats or in heavy industry. Most countries allow the sale of walkie-talkies for, at least, business, marine communications, and some limited personal uses such as CB radio, as well as for amateur radio designs. Walkie-talkies, thanks to increasing use of miniaturized electronics, can be made very small, with some personal two-way UHF radio models being smaller than a deck of cards (though VHF and HF units can be substantially larger due to the need for larger antennas and battery packs).

Figure 8. Portable radio transciever(http://en.wikipedia.org/wiki/Walkie-talkie)

HEALTH EFFECTS FROM RADIOFREQUENCY ELECTROMAGNETIC FIELD

At the international level are given guidelines Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz) by the International Body for the Protection of Non-Ionizing Radiation Protection (ICNIRP, International Commission on Non-Ionizing Radiation Protection) which are defined limits on the amount of time-varying electric and magnetic fields in open space, especially for general and working population.

The basics of EM interaction with materials were elucidated over a century ago and stated as the well-known Maxwell’s equations. The application of these basics to biological systems, however, is very difficult because of the extreme complexity and multiple levels of organization in living organisms, in addition to the wide range of electrical properties of biological tissues.

There are many factors to be taken in determining how the RF / MT energy absorbed in the body, such as:
- Dielectric compositions
- The size of the body,
- The shape and orientation of the body and polarization fields,
- The complexity (similar to zones) RF / MT field

Interaction of electromagnetic field (EMF) with environment and with tissue of human beings is still under discussion and many research teams are investigating it. Biological tissues are modeled by their permittivity and conductivity. The complex permittivity (ε) of a biological tissue is given by:

$$\underline{\varepsilon} = \varepsilon_r \cdot \varepsilon_0 + j\frac{\sigma}{2\pi f}$$

where, σ (S/m) is the conductivity of tissue in siemens per meter and ε_0 = 8:854x10^{-12} F/m.
Electrical conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the applied field.

Table 1: Electrical conductivity of body tissue

Tissue type	Conductivity (S/m) 150 MHz	450 MHz	900 MHz	1,800 MHz
Muscle	0.73	0.81	0.94	1.3
Skin (wet)	0.56	0.69	0.85	1.2
Blood	1.2	1.4	1.5	2.0
Grey brain matter	0.60	0.76	0.94	1.4
White brain matter	0.35	0.46	0.59	0.92
Fat	0.07	0.083	0.11	0.19
Bone	0.070	0.096	0.14	0.28
Liver	0.53	0.68	0.86	1.3

Each object, whether it is a case or a living being, when found in the RF / MW field, can under certain conditions, to enter into resonance with the source of such a field. If the object is a person, its resonant frequency is primarily dependent on the height of the body.

Three different cases:
- when the body is less than the size of the wavelength,
- when they are approximately equal in their size and
- when the body is much larger than the size of the wavelength.

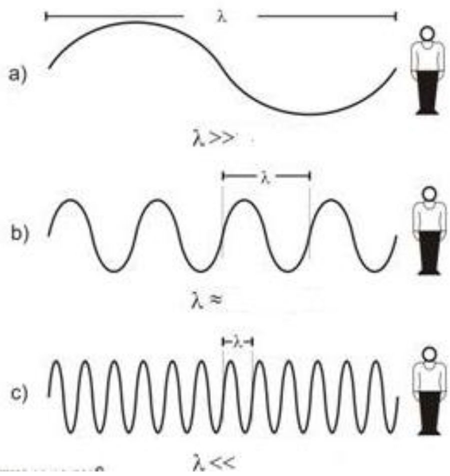

Figure 9. Size of the human body in relation to the wavelength of the electromagnetic wave

In cases where a body size smaller than the wavelength (Figure 9-a), there is little absorption.

When the wavelength is approximately equal to the size of the body (Figure 9-b), it appears the greatest absorption of the unequal distribution of power. Therefore, it may appear " hot spots" in certain parts of the body.

When the wavelength is smaller than the size of the body (Figure 9-b), the absorption is smaller, while the heating is limited to the irradiated surface.

At RF and microwave frequencies, electromagnetic fields penetrate into human body. These fields interact with biological tissue in several ways. The most important interaction can be explained in terms of energy transfer from the electromagnetic field to the tissue material. One measure of this macroscopic effect is the time-averaged absorbed power.

Specific absorption rate (SAR) is a measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency (RF) electromagnetic field; although, it can also refer to absorption of other forms of energy by tissue.

A quantity usually used is known as SAR and has dimension W/kg. SAR can be defined as:

$$SAR = \frac{1}{2} \cdot \frac{\omega \varepsilon_0 \varepsilon_r}{\rho} |E|^2$$

with ω the angular frequency , ε_0 the permittivity of free space, ε_r the imaginary part of the relative complex permittivity, ρ the tissue density in kg/m3 and E is the peak value of the total field inside the tissue material(Savroulacks, P-2003).

We can see that the SAR depends on dielectric parameters therefore the materials of phantoms have to have similar dielectric parameters as human tissues. The human head consists of several tissues, which have different electrical characteristics and form complex-shaped boundaries. The electrical characteristics of human tissues are very different from the normal propagation medium (air), but not so different between each other. For values of SAR are recommended maximum values by committee INCRIP, this value is 2 W/kg in EU(SSI'S Independent Expert Group on Electromagnetic Fields).

CONCLUSION

The most important use for RF energy is in providing telecommunications services. Radio and television broadcasting, cellular telephones, radio communications for police and fire departments, amateur radio, microwave point-to-point links, and satellite communications are just a few of the many telecommunications applications. Microwave ovens are a good example of a noncommunication use of RF energy. Other important noncommunication uses of RF energy are radar and for industrial heating and sealing. Radar is a valuable tool used in many applications from traffic enforcement to air traffic control and military applications. Industrial heaters and sealers generate RF radiation that rapidly heats the material being processed in the same way that a microwave oven cooks food. These devices have many uses in industry, including molding plastic materials, gluing wood products, sealing items such as shoes and pocketbooks, and processing food products.

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MEASURING THE ELECTROMAGNETIC FIELD IN URBAN AREAS

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ABSTRACT

Exposure to electromagnetic fields of extremely low frequencies (50 Hz) is the most common manner of exposure in urban areas. Human is surrounded by an abundance of electrical devices which inevitably create EMF which presents pollution of his living space. The human organism does not possess senses which could register these fields and because of this it is very important to study the effects of this field on the human organism considering that it is constantly exposed to the effects of these fields in the contemporary working and living surroundings. This paper derscribes the method which our students use to measure the magnetic field in an industrial environment of HC Zorka, located in the suburbs of the city of Sabac. The obtained values have shown that the magnetic fields are well below the limit values set by the national rulebook for EM fields ELF.

Key words: *Electromagnetic field, ELF, High voltage lines,Substations, Electric aparatures.*

INTRODUCTION

Aside from the continuous natural Earth electric and magnetic field, there are artificially generated changeable fields. In order to ensure a technical electrical field an artificially generated difference of potential has to exist, and to ensure the technical magnetic field electrical power is needed. The intensities of these fields depend on the voltage, i.e. strength of the power source, as well as on the distance of the source. The greater the distance, the less is the intensity.

Since the natural electrical and magnetic field of the Earth exist constantly, it is of great importance the possibility to measure the intensity of artificial fields exclusively. Although the electrical and magnetic fields of very low frequencies (ELF) are present at the same time mostly only the magnetic fields are measured. The reason for this is that the magnetic fields easily penetrate through buildings and people, while electrical fields have very small capability of penetration (Sever, 2007; Malfait, 2005).

DIFFERENT MEASURING SITUATIONS

Magnetic fields measured in this work:

- High voltage power line,
- Transformer station and
- Electrical appliances.

For measuring the magnetic fields, in all three cases, the magnetic field meter PCE-G28 was used, which contains a three-dimensional measuring sonde. The device measures with three axes automatically, therefore it is suitable for measuring in an industrial surrounding, as well as in a laboratory. The measurements of electrical appliances' magnetic fields were carried out in the facilities of the School, and the measurements on the power pole $110/10\ kV$ and transformer station HC Zorka, were carried out in the vicinity of the School.

Overhead High Voltage Lines

The transfer and distribution of electrical energy is carried out through high voltage power lines which consist of several parallel wires. The electromagnetic field of these wires is intense, and is usually closed between them. The magnetic field of the power lines is determined by the intensity of the current passing through it, the vicinity of the wires, the height of the power line above the ground surface and the space between the power lines. Magnetic induction of the high voltage lines varies during the day depending on the consumption of electrical energy and the temperature of the surroundings. The biggest fields are under the portable lines, and by increasing from them they quickly drop (Sever, 2007; Jeremic, 2009).

Magnetic fields were measured along a line situated in the middle of the distance between the two power lines, which is perpendicular to the line connecting these poles. At this place the distance from the ground to the power line is minimal and gives maximal field values. First the field which is directly beneath the power line is measured. The following measurements are carried out on greater distances, with a rate of $2m$ symmetrically to the line which connects the power lines. Usually ten measurements are done both on the left and right side. On Figure 1. the measuring points on the power line are presented.

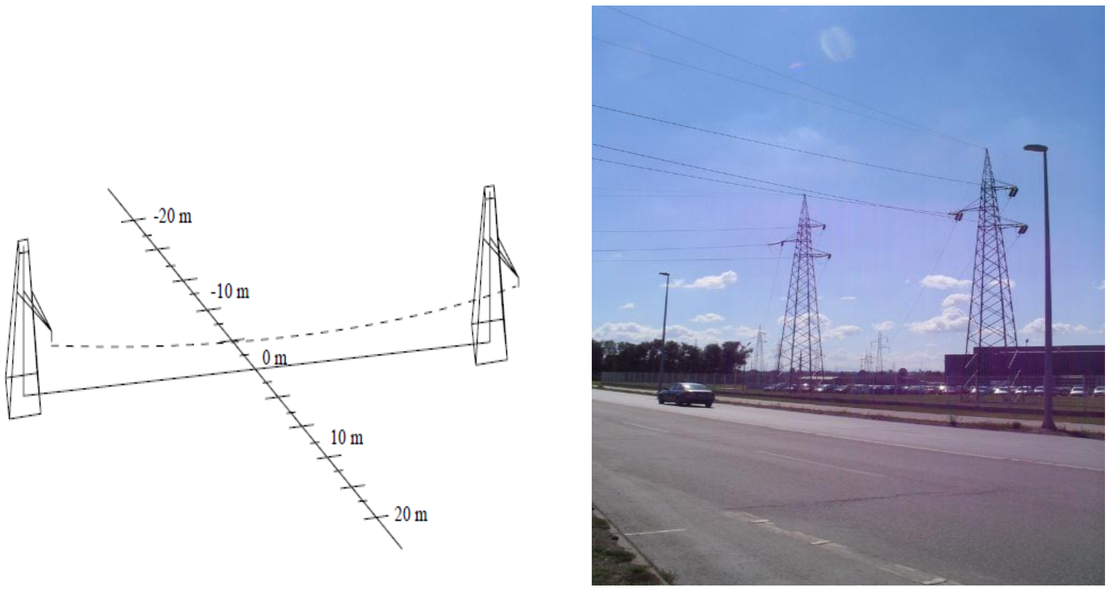

Figure 1. Measuring points of the high voltage overhead lines

Field meter should be placed successively in each of the measuring points. The measurements have to be done at the height of $1m$ above ground. It is sufficient to measure only two components of the field which are perpendicular to the line connecting the power lines, because the component which parallel to the line connecting the power lines is negligible. According to the measured values of the magnetic induction components B_x, B_y and B_z, the intensity of the magnetic field is calculated:

$$B = \sqrt{B_x^2 + B_y^2 + B_z^2} \tag{1}$$

The obtained results for the magnetic induction intensity at these points are shown in the function of distance from two parallel overhead lines, Figure 2.

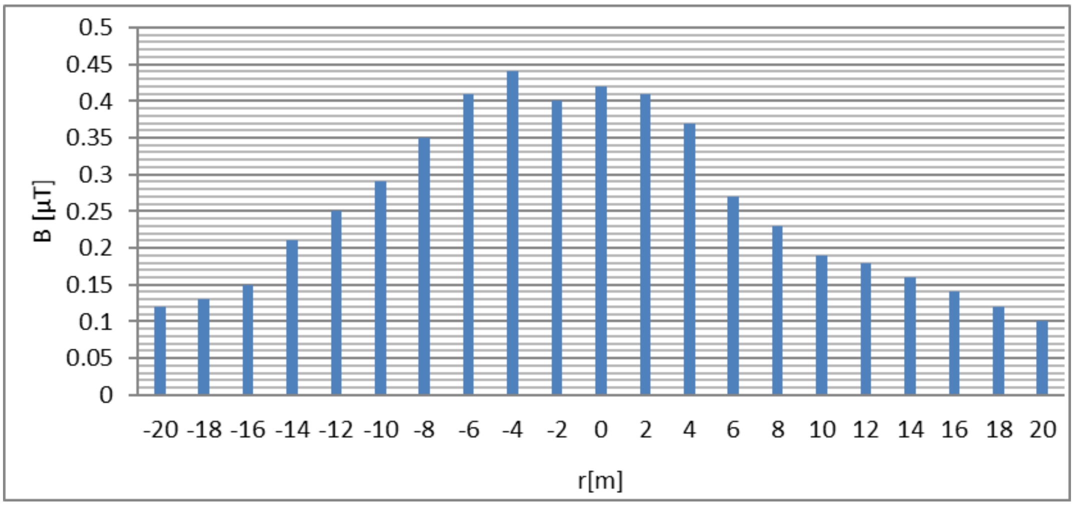

Figure 2. Magnetic field of two parallel overhead lines

Substation

Aside from the high voltage power lines, electrical substations can represent a source of a magnetic field of high intensity. Transformer substations and transformers represent very important parts of the electro-energetic system which serve for the alteration of the voltage level. Transformers are sources of strong magnetic fields, because their method of work is based on the changeable weather magnetic fields. Beside that, due to the lowering of the energetic lines which go in and out of the transformer station, the magnetic fields in their vicinity are even stronger.

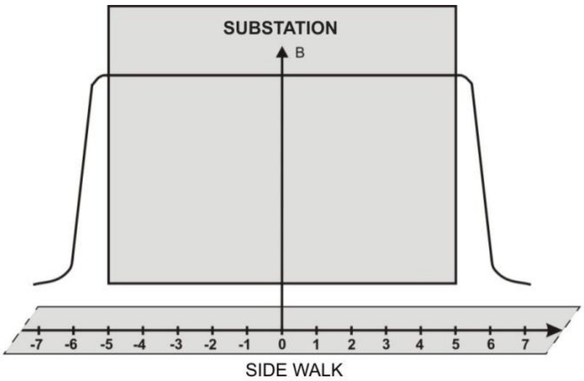

Figure 3. Measuring points of the substation

The magnetic fields were measured along the sidewalk which is located in the vicinity of one of the transformer stations of the HC Zorka in the city of Sabac. In Figure 3. a sketch of this station with the sidewalk is shown. Measurements should be carried out on every 5m of the sidewalk according to the markings on the sketch. The results acquired for the magnetic field in these points are shown on a separate diagram, Figure 4. From the diagram it can be seen to what an EM field the pedestrians are exposed.

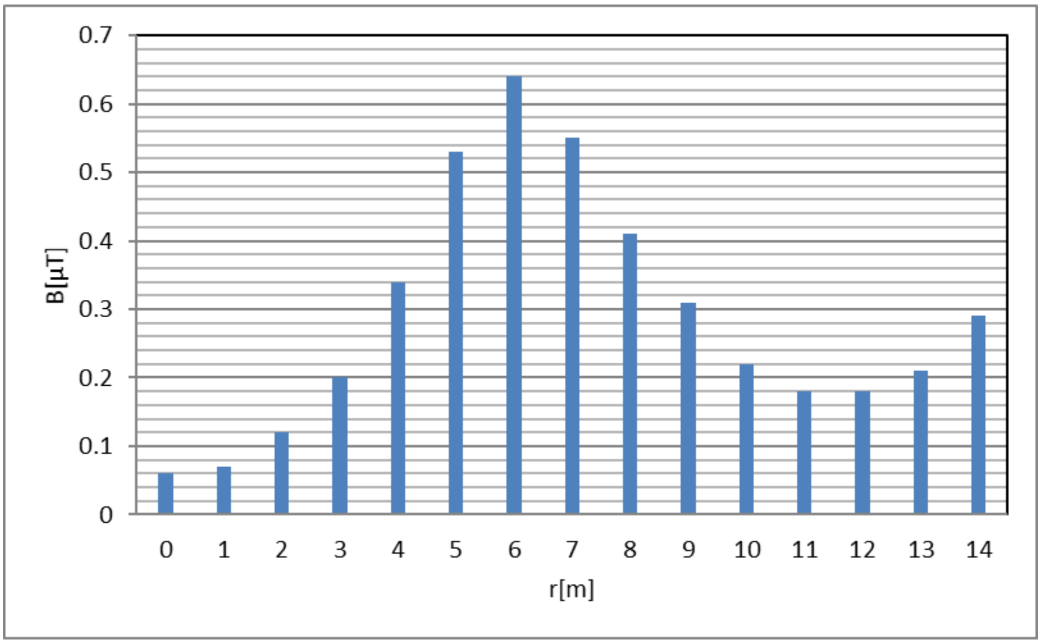

Figure 4. Magnetic field of the substation

Electric appliances

All electrical appliances, which are used in the household or in the office, create a magnetic field only during their work. Such fields very quickly decrease with the distance (usually reverse proportional to the third degree of distance), so that they are significant only on very small distances from the appliances (Sever, 2007; Krawczyk, 2008).

The measurement of the magnetic field of several appliances is measured, table 1, on the distance of $20\ \mathrm{cm}$ from them. Based on the measured values of magnetic induction components B_x, B_y and B_z, the intensity of the magnetic induction B. is calculated. The obtained values should be compared with the referent values for the magnetic flux.

According to ICNIRP standard (Jeremic, 2009) the limit values for magnetic fields of extremely low frequencies are:

- Increased sensitivity $B = 1\ mT$ and
- Professional exposure $B = 5\ mT$.

These values can be less, which is regulated by the national rulebooks about the limits of exposure to non-ionizing radiation in the Republic of Serbia, which was passed in 2009., after the Law on the protection from non-ionizing radiation was adopted. According to this rulebook (table 2 of rulebook) for frequencies $(0.025 - 0.8)kHz$, the reference value is $B[\mu T] = 2/f$, which for the frequency $f = 50\ Hz$, amounts to $B = 40\ \mu T$.

Table1: Measurement Results

Electric appliance	$B_x[\mu T]$	$B_y[\mu T]$	$B_z[\mu T]$	B$[\mu T]$
Fax	0.09	0.80	0.21	0.83
TV	1.56	2.75	0.14	3.16
Monitor	2.02	0.63	0.36	2.15
Dryer	0.21	0.02	0.02	0.21
Copy machine	1.50	0.35	0.28	1.56
Refrigerator	0.26	0.01	0.01	0.26

CONCLUSIONS

Based on the acquired results it can be concluded that in all three cases, the values of the magnetic field are of the same range, which are lower than the value of the Earth`s magnetic field.

Also it can be stated that the values of the magnetic fields, to which people are exposed to in the urban surroundings are under the limit values recommended by the ICNIRP and those regulated by the national rulebook.

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RADIOFREQUENCY RADIATION OF GSM NETWORKS

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ABSTRACT

The basic structure and operating principles of GSM equipment (mobile stations, system of basic stations, network and communication systems) are presented first. The interaction between mobile phone and human tissue, i.e. absorption of radio frequency energy emitted by mobile phone is described. Advices for safer usage of mobile phones are given.

Key words: *GSM equipment, Absorption factors.*

INTRODUCTION

The effect of mobile phone radiation on human health is the subject of recent interest and study, as a result of the enormous increase in mobile phone usage throughout the world (as of November 2011, there were more than 6 billion subscriptions worldwide) (GSM Association.-2009). Mobile phones use electromagnetic radiation in the microwave range. Other digital wireless systems, such as data communication networks, produce similar radiation.

In 2011, International Agency for Research on Cancer (IARC) has classified mobile phone radiation on the IARC scale into Group 2B - possibly carcinogenic. That means that there "could be some risk" of carcinogenicity, so additional research into the long-term, heavy use of mobile phones needs to be conducted(International Agency for Research on Cancer- 2011).

Many scientific studies have investigated possible health symptoms of mobile phone radiation. These studies are occasionally reviewed by some scientific committees to assess overall risks. A 2007 assessment published by the European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) concludes that the three lines of evidence, *viz.* animal, *in vitro*, and epidemiological studies, indicate that "exposure to RF fields is unlikely to lead to an increase in cancer in humans"(European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)-2008).

GSM NETVORK ARCHITECTURE ELEMENTS

On June, 1946 in Saint Louis, Missouri, AT&T and South-western Bell introduced the first American commercial mobile radio-telephone service to private customers(Figure 1.).(Peterson, A.C.)

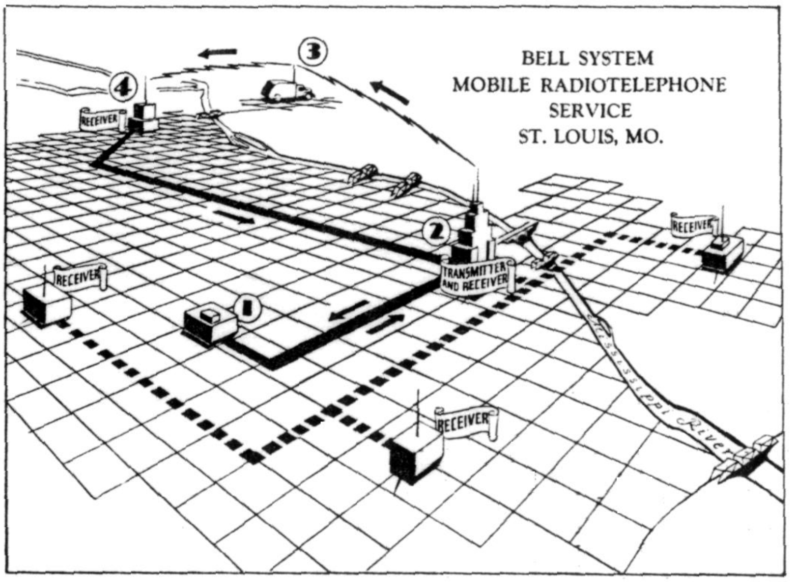

Figure 1. The first commercial American radio-telephone service(http://www.privateline.com/PCS/images/SaintLouis2.gif)

The GSM network architecture as defined in the GSM specifications can be grouped into four main areas:

- Mobile station (MS)
- Base-station subsystem (BSS)
- Network and Switching Subsystem (NSS)
- Operation and Support Subsystem (OSS)

The architecture of the GSM network is presented in Figure 2.

Mobile station

There are a number of elements to the cell phone, although the two main elements are the main hardware and the SIM(Figure 3).The hardware itself contains the main elements of the mobile phone including the display, case, battery, and the electronics used to generate the signal, and process the data receiver and to be transmitted (http://www.cs.ucl.ac.uk/staff/t.pagtzis/wireless/gsm/arch.html).

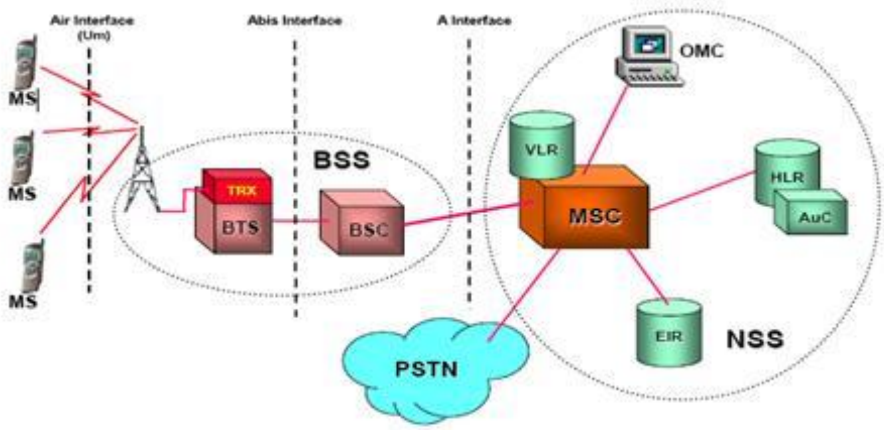

Figure 2. Architecture of the GSM network(http://tutorials.telecomseva.com/index.php/2012/02/what-is-gsm/)

The SIM or Subscriber Identity Module contains the information that provides the identity of the user to the network. It contains are variety of information including a number known as the International Mobile Subscriber Identity (IMSI).

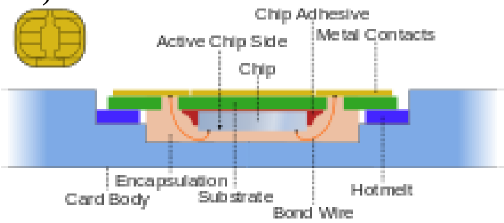

Figure 3. SIM chip structure and packaging(http://en.wikipedia.org)

The block diagram in Figure 4 provides a simplified description of the mobile station. A microphone captures the sound, which is sampled in a numerical format, compressed, coded, and modulated. A high-frequency oscillator translates the modulated signal to a valid transmission frequency. The received signal (less than 1mV) is amplified before down-conversion to a low-frequency, demodulation, decoding, and sound reconstruction.

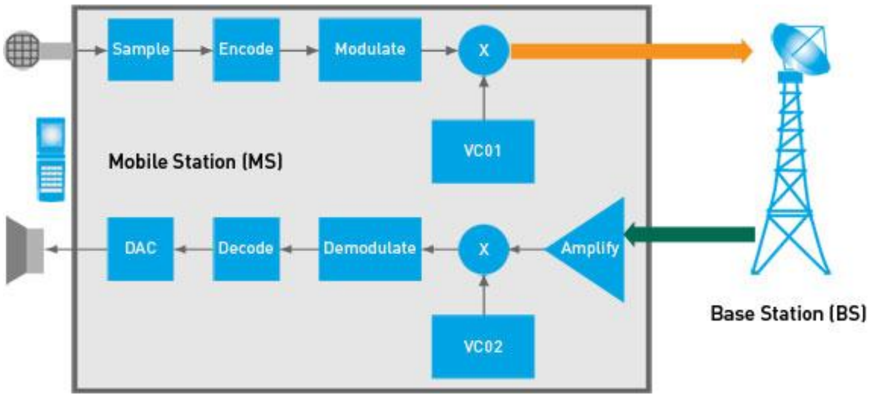

Figure 4. Block diagram of a mobile station(http://en.wikipedia.org)

Base Station Subsystem (BSS)

The Base Station Subsystem (BSS) section of the GSM network architecture that is fundamentally associated with communicating with the mobiles on the network. It consists of two elements:

Base Transceiver Station (BTS): The BTS used in a GSM network comprises the radio transmitter receivers, and their associated antennas that transmit and receive to directly communicate with the mobiles. The BTS is the defining element for each cell. The BTS communicates with the mobiles and the interface between the two is known as the Um interface with its associated protocols.

Base Station Controller (BSC): The BSC forms the next stage back into the GSM network. It controls a group of BTSs, and is often co-located with one of the BTSs in its group. It manages the radio resources and controls items such as handover within the group of BTSs, allocates channels and the like (http://www.radio-electronics.com)

Network Switching Subsystem (NSS)

Its main role is to manage the communications between the mobile users and other users, such as mobile users, ISDN users, fixed telephony users, etc. It also includes data bases needed in order to store information about the subscribers and to manage their mobility.

Mobile Switching services Centre (MSC): the central component of the NSS. The MSC performs the switching functions of the network. It also provides connection to other networks.

Home Location Register (HLR): The HLR stores information of the subscribers belonging to the coverage area of a MSC; it also stores the current location of these subscribers and the services to which they have access.

Visitor Location Register **(**VLR): contains information from a subscriber's HLR necessary to provide the subscribed services to visiting users.

Authentication Center (AUC): It serves security purposes; it provides the parameters needed for authentication and encryption functions. These parameters allow verification of the subscriber's identity.

Equipment Identity Register (EIR): EIR stores security-sensitive information about the mobile equipments. It maintains a list of all valid terminals as identified by their International Mobile Equipment Identity (IMEI). The EIR allows them to forbid calls from stolen or unauthorized terminals (e.g, a terminal which does not respect the specifications concerning the output RF power) (http://www.radio-electronics.com).

Operation and Support Subsystem (OSS)

The OSS or operation support subsystem is an element within the overall GSM network architecture that is connected to components of the NSS and the BSC. It is used to control and monitor the overall GSM network and it is also used to control the traffic load of the BSS. It must be noted that as the number of BS increases with the scaling of the subscriber population some of the maintenance tasks are transferred to the BTS, allowing savings in the cost of ownership of the system (http://www.radio-electronics.com).

HEALTH EFFECTS

In the past few years, very rapid development in mobile cellular communication has drawn attention to possible health risks of the electromagnetic energy (EM) emitted from the transmitters of hand-held phones (Selcuk Paker, Levent Sevgi-1998). The interaction between a human head and a hand-held phone under various conditions should be quantitatively evaluated in order to establish the safety in cellular mobile communication systems (L. Sevgi and S. Paker-1998). These evaluated values should be within the safety limits given in ANSI/IEEE C95.1-1992 RF Safety Guideless (ANSI/IEEE C95.1-1992.).

The basics of EM interaction with materials were elucidated over a century ago and stated as the well-known Maxwell’s equations. The application of these basics to biological systems, however, is very difficult because of the extreme complexity and multiple levels of organization in living organisms, in addition to the wide range of electrical properties of biological tissues.

Interaction of electromagnetic field (EMF) with environment and with tissue of human beings is still under discussion and many research teams are investigating it. Biological tissues are modeled by their permittivity and conductivity.

Electrical conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the applied field.

Each object, whether it is a case or a living being, when found in the RF / MW field, can under certain conditions, to enter into resonance with the source of such a field. If the object is a person, its resonant frequency is primarily dependent on the height of the body.

Beside public biological concerns in cellular mobile communication system, there is also a great demand to know the deterioration of the antenna performance because of the existance of human head. This is an important feedback for antenna designers to develop better structures. Analyzing possible range of variations of the induced field strengths in various tissues requires an extensive efford, since local field strengths strongly depend on various parameters (Selcuk Paker, Levent Sevgi-1997). Among the others : operational frequency and antenna power, mutual positions of the between device and head, design of the device, size and the shape of human head, distribution of tissues within the head and electrical properties of the tissues can be listed as important parameters which strongly affect the SAR distribution. Since some of the listed parameters are different for various individuals and can even change with time, analytical formulations (even the approximate ones) in SAR distribution calculations are extremely difficult.

The SAR distributions in a human head exposed to EM fields from hand-held cellular phones have been estimated through experimental (Q. Balzano O. Garay, F. R. Steel and K. H. Joyner V. Anderson-1978), and numerical calculations (P. J. Dimbylow and Y. Rahmat-Samii M. A. Jensen - 1993). The models used in these studies are quite different where from simple to enhanced geometries and from a few to many different tissue types are taken into account with different electrical properties. Morover, quite different values have been used in some of these studies (P. Gandhi G. Lazzi, C.M. Furse-1996) parallel to more accurate measurements of human tissues (P. J. Dimbylow and S. M. Mann-1993). For example, there are more than hundred percent differences in some of the tissue parameters in (O.P. Gandhi G. Lazzi, C.M. Furse-1996). Within the limits of the used models, these studies have presented the dependence of both local and global SAR distributions in a human head to the distance of the mobile cellular phone, as well as to its position. Also, it has been shown in these studies that SAR distributions within human neck and body casued by EM radiation above 300MHz are almost negligible. It is, therefore, quite acceptable to use isolated head and hand-held culluler phone during SAR distribution calculations.

TIPS FOR SAFER USE OF MOBILE PFONES

If thre is an increased risk of certain types of brain cancer caused by cell phone radiation, it likely very small. But in order to minimize your potential risk, here are some simple steps that you can take:

-Don't put your cell phone right next to your body (http://news.cnet.com/). Moving a cell phone even an inch from the body can greatly reduce radiation exposure. Signal strength falls off as the square of the distance to the source. This means that if you double the distance to the source, which is the cell phone to your head, the signal strength would be four times less, since two squared is four.

- Keep conversations short**.** The less you talk on your cell phone, the less exposure to radiation you will have. So by keeping voice conversations short, you're limiting your exposure (news.cnet.com*)*.

- Use a headset. Experts recommend using either a wired headset or a Bluetooth headset. While you may still be exposed to some radiation using either type of headset, it's still a lot less than holding the phone to your ear. If you do use a Bluetooth headset, I'd recommend taking it out of your ear when you're not using it.(http://www.telcogreen.com.au)

There's no need to continue to expose yourself to low levels of electromagnetic radiation when you don't need to, since we still don't know the long-term effects of radiation exposure at these low levels.

-Use the speaker phone function of the cell phone (www.consumercellular.com)**.** For the same reason you'd use a headset, using a speaker phone is another good option. It keeps the cell phone away from your body, and you don't have to worry about using a headset. Of course, the downside is that everyone around you will hear your conversation, so this may only be something you do when you're at home or somewhere private.

- Turn your cell phone off when you are not using it..

- Avoid using your cell phone in places where you get a poor signal. Many consumers also don't realize that cell phones emit different amounts of radiation depending on where they are with respect to a wireless operator's cell phone tower. Cell phones are constantly communicating with cell phone towers, but the further away the subscriber is from the cell tower, the weaker the signal. In order to connect to the cell tower, the device must boost its power, which increases the amount of radiation emitted (news.cnet.com).

- Text, IM, or use the Net more than talking on your phone. When you're texting or using your phone to access the Internet, you aren't holding it up to your head the same way you would if you were talking on it. So texting and using other forms of communication that don't require you to put the phone to your head or right next to your body are good ways to reduce exposure.

- Carry your cell phone in your purse or backpack instead of in your pocket. Again, it's all about creating distance between you and your cell phone. So if you carry your phone away from your body, then you are reducing your exposure (http://news.cnet.com/cell-phone-radiation-a-self-defense-guide-faq/.)

CONCLUSION

High frequency radiation exists in free space around us from an increasing number of sources and cover a wide range of the electromagnetic spectrum. By for the most important and rapidly expanding source is the mobile phone base stations. Fortunately, the radiated power densities around these base stations are below the standard limits set by the different world organizations. It is important to take care in the design of new base stations to meet the guidelines set for the antennas and their mounting so that the minimum required distance can be observed for the public access. New trends in the design of such antennas such as the smart antenna concept, can be applied in order to further reduce the radiation power levels.

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Author Index

Aćin Natalija ... 257, 283
Adamović Živoslav ... 165
Aleksić Aleksandar ... 155
Anđić Zoran ... 262
Arbutina Dalibor ... 97
Arsovski Slavko ... 155
Batanjski Vera ... 58
Batrićević Ana ... 58
Berković Ivana ... 525
Bjelica Momčilo ... 649, 662
Bodáné Kendrovics Rita ... 191
Budak Igor ... 319
Bulatović Vladimir ... 479
Cakirlar Burak ... 181
Çalıcıoğlu Ozgul ... 206
Cekova Blagica ... 335
Ćoćkalo Dragan ... 375
Ćurić Nedeljko ... 396
Davidović Branko ... 566
Demirer Goksel ... 181, 206
Dervić Kemal ... 649
Desnica Eleonora ... 497
Despotović Branko ... 40, 231
Despotović Željko ... 649, 662
Dimkić Milan ... 238
Djapić Nina ... 586
Djurić Aleksandar ... 127
Doichinova Vania ... 451
Dramlic Dragan ... 97
Dramlic Stefan ... 97
Dukić-Mijatović Marijana ... 508
Dulcea Daniel ... 14
Duran Metin ... 202
Đalović Sara ... 544
Đorđević Amelija ... 105
Đorđević Dejan ... 350, 375
Đurić Ivan ... 424
Erguder Tuba Hande ... 181
Fidanovski Zoran ... 79
Figdore Bryce ... 202
Filip Snežana ... 173, 225
Filipović Marko ... 262, 573
Gligorović Bojana ... 375
Glišović Srđan ... 339, 540
Glušac Dragana ... 400
Golovach Maria ... 610
Golubović Tatjana ... 339, 540
Gošnjić Nebojša ... 381
Grsic Zoran ... 97
Halas Dragan ... 252
Hamuda Hosam ... 591, 601
Ilić Andreja ... 442
Ilijazi Venezija ... 50
Ionel Ioana ... 14, 21, 30, 366
Ionel Raul ... 366
Ivanović Lozica ... 442
Ivin Dragica ... 508
Ivšić-Bajčeta Dragana ... 143
Jaćimovski Marija ... 68
Jaćimovski Stevo ... 50, 68, 640
Jankov Jelena ... 400
Janković Slobodan ... 560, 662
Janjić Goran ... 287
Jašin Danijela ... 243, 252, 269, 278
Jeftenić Goran ... 149
Jevtić Dragan ... 416
Jevtić Sanja ... 79, 344
Jevtić-Novaković Katarina ... 544
Josifović Danica ... 442
Jovanović Aleksandar ... 566
Jovović Aleksandar ... 112
Kamberović Željko ... 143, 262
Karličić Nikola ... 112
Karpe Blaž ... 319
Karuović Dijana ... 400
Kaya Durmus ... 181
Kaymak Baris ... 181
Kazi Zoltan ... 173, 525
Kerleta Vojin ... 649, 662
Kiurski-Milošević Jelena ... 243, 252, 269, 278
Kljajin Milan ... 325
Kolaković Slobodan ... 149
Kolaković Srđan ... 149
Komatina Petrović Snežana ... 459
Kondić Veljko ... 325
Kondić Živko ... 325
Korać Marija ... 143, 262
Kosec Borut ... 319
Kosec Gorazd ... 319
Kovačević Srđan ... 238
Krstić Ivan ... 105
Krukouskaya Tatsiana ... 610
Krunić Nikola ... 486
Kucora Ištvan ... 165
Kunosić Ivan ... 620
Kuvendziev Stefan ... 225
Lazarev Svetislav ... 657
Lazić Miodrag ... 155
Lečić Dušanka ... 518
Letić Duško ... 216, 566
Letić Ivana ... 216
Letić Ljubomir ... 216
Lisichkov Kiril ... 225
Lontis Nicolae Stelian ... 21
Ludajić Gordana ... 243, 269
Ljubojev Nadežda ... 356, 508
Maksić Milica ... 469
Manojlović Vaso ... 143, 416, 573
Marinkovski Mirko ... 225
Marinović Dragan ... 344
Markoska Vesna ... 335
Marković Ivana ... 269, 278
Marušić Željko ... 36
Mašić Borislav ... 149

Mašković Ljiljana 629
Medić Duško 293
Melnov Sergey 610
Mihajlovic Ivana 220
Miladinović Slobodan 50
Milanović Đurđe 79, 344, 620
Milanović Srđan 344, 620
Milinčič Miroljub 97
Miloradov Milorad 406
Milošević Lidija 105
Milutinovic Predrag 97
Milutinović Slobodan 469
Mironga John 133
Mirontchik Alexandr 310, 552
Mitrović Nebojša 79
Moturi Wilkister 133
Murgašová Marta 120
Nachevski Goran 225
Nanu Sorin 366
Nasev I. 335
Németh-Katona Judit 533
Nenadović Luka 657
Nikolić Milan 350, 497
Nikolić Vesna 216
Nikolić-Topalović Marina 544
Nikolin Tatjana 257, 273
Ninkov Toša 479
Obradović Marko 112
Obradović Slobodan 344, 620
Ogut Gece Cansu 181
Opalić Milan 325
Opricovic Serafim 406
Oruko Richard 133
Ostojić Stanko 79
Patkó Csilla 591
Patkó István 591
Paunović Olivera 302
Pavlović Aleksandar 127, 578
Pavlović Milan .. 30, 143, 262, 273, 391, 416, 573, 578
Pekez Jasmina 165
Petković Anđelka 238
Petrić Jasna 486
Petrov Konstantin 451
Petrović Velimir 560
Pop Nicolina 640
Popov Dušan 629
Popov Miodrag 629
Popović Snežana 344
Požidajeva Viara 433
Protić Isidora 283
Protić Zoran 283
Prvulović Slavica 391
Radić Dejan 112
Radonić Jelena 220, 238
Radovanović Ljiljana 165, 497
Radovanović Radovan 50
Radović Vesela 518
Radulović Biljana 525
Rakić Boris 442
Rašić Marija 105
Rodjenkov Igor 90
Sajfert Branimir 640
Sajfert Dragana 375, 629
Sajfert Vjekoslav 68, 79, 344, 620, 629, 640
Sekulić Petar 216
Simić Marko 143, 356, 416, 573, 578
Simić Stojan 30, 40, 231
Sinđelić Stanislava 173
Sinevich Elena 610
Slavković Nikola 79
Soković Mirko 319
Spanik Ivan 220
Srećković Milesa 79, 344
Sremački Maja 238
Stamenković Vojislav 381
Stanisavljevic Nemanja 406
Stanojević Miroslav 40, 112
Stojiljković Evica 339, 540
Sušić Zoran 479
Šetrajčić Igor 46
Šetrajčić Jovan 68, 640
Ševaljević Miladin 273
Ševaljević Mirjana 30, 257, 273, 283
Ševaljević Petar 257
Šinik Vladimir 560, 649, 662
Šooš L'ubomir 120
Šućurović Aleksandra 243, 252, 269, 278
Tadić Danijela 155
Tasić Ivan 400
Terek Edit 350, 497
Tobolka Erika 502
Todorović Dušan 112
Todorović Ljubiša 127
Tolmač Dragiša 391
Tolmač Jasna 391
Tomić Željka 79
Tomović Aleksandar 143, 416, 573, 578
Tošić Desanka 257
Tričković Jelena 252, 278
Trifković Slobodan 127
Tubić Dajana 400
Tucu Dumitru 366
Uludag-Demirer Sibel 181
Vasić Dejan 479
Vasiljević Miomir 344
Velikic Zoran 97
Veljković Zlatibor 416, 586
Vetres Ion 21
Vojinović Miloradov Mirjana 220, 238, 243
Vranić Petar 469
Vujašanin Milan 287
Vujić Bogdana 356, 518
Vujić Snježana 231
Vujović Svetlana 149
Vyviurska Olga 220
Yilmaz Vedat 202
Yilmazel Yasemin 202
Zagorsky Sergey 610
Zakin Mila 165
Zarubica Veljko 344

Zhezhov Gjorgji 225
Zhiyanski Miglena 451
Zorić Vojkan 46
Žigić Halid.. 459
Živković Dragan... 433
Živković Katarina... 433