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ENVIRONMENTALLY IMPACT ASPECTS AND REDUCING THE GREENHOUSE GAS EMISSIONS IN CASE OF ELECTRICITY PRODUCTION WITH LARGE SCALE PHOTOVOLTAIC APPLICATIONS

Sandor BARTHA[1*]

[1] *ICPE-Institute for Electrical Research, Bucuresti, Splaiul Unirii 313,*
Tel. +40215893300 / Fax +40215893434
** E-mail: sandor.bartha@icpe.ro*

ABSTRACT. One way to reduce the greenhouse gas emission is possible to realise with use of the renewable energy sources in electrical energy production. The present paper describes one model for evaluation of the energy production of the Photovoltaic solar energy conversion systems and established the environmentally impacts of this systems. The paper indicated the cumulated energy demand in case of production the different photovoltaic modules. The paper indicated the reduction of the electricity demand by recycling of PV products and shows the legal aspects for these recycling procedures. In finally is presented the actual electricity production with this PV conversion systems in Romania and is indicated the environmental impact of target value in the energy mix established by the EU directives.

Key words: *solar energy, photovoltaic, greenhouse gas emission*

INTRODUCTION

The worldwide energy consumption is presented a growing tendentious; in 2000 this energy consumption was 397.40 quads (1quads = 2.93 10^{11} kWh) and from this energy, 75 % would be consumed by the developed countries, while nearly 2 billion people from developing countries live without electricity, in 2005 the energy consumption is arrived 462 quads, bat the problem of the energy supplying of this 2 billion people still is not resolved. Base on IEA- US Energy Information Administration date the energy consumption is growing in every year, this predicted values of the world energy consumption is presented in figure. 1. The energy production is an important element in carbon dioxide emission. The worldwide CO2 emissions predicted values can be seen in figure 2. This value has small increasing trends, in case of European OECD states.

One way to reduce the CO_2 emissions is realise by growing the energy production with helpful of renewable energy sources. This paper is concentrated to the environmentally impact of energy production with helpful of photovoltaic conversions

system. In generally in case of PV solar energy conversion systems the environmental impact means land use, visual impacts, and after the end of life cycle of the PV product the local pollution of soil, water, air. That can be produced negative effects in local, regional and global area.

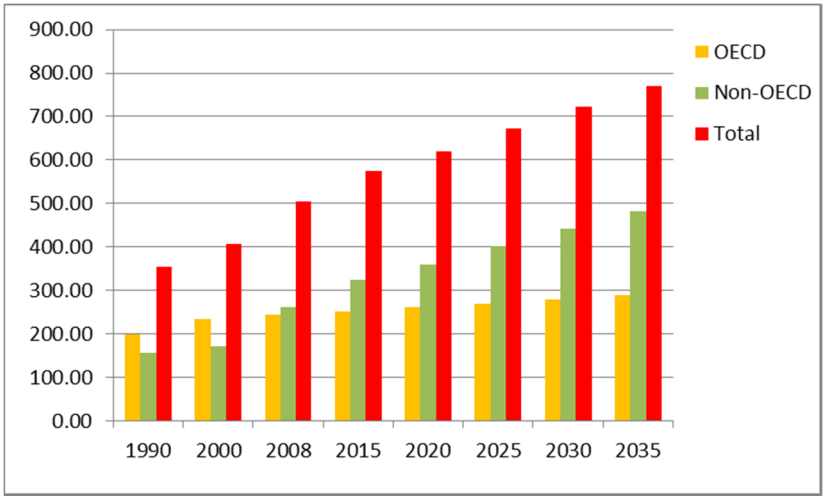

Fig. 1. *World energy consumption from IEA dates*

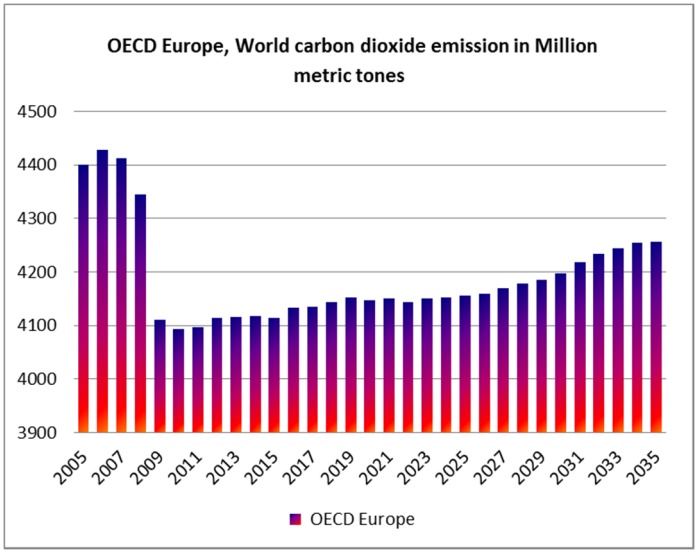

Fig. 2. *EU carbon dioxide emission*

Is necessary the evaluation of health impacts of the PV system after the end of live. In 2011 more than 69 GWp were the installed PV capacity and this produced 85 TWh electricity in every year. This energy volume is sufficient to power annually the supply needs of over 20 million households. Europe still is a lieder in the PV industry; more than 51 GW PV capacities are installed in this continent that is about 75 % of the world's total solar photovoltaic cumulative capacity. In 2011 Italy was the top market for the year, with 9.3 GW connected PV installed capacities, followed by Germany (7.5 GW), these two markets were followed by France (1.7 GW), and United Kingdom (784 MW), Germany with more than 24 GW installed PV capacities is the leading country in Europe. In this year the European market has been presented a growing trend from the statistical data presented by the European Photovoltaic Industry Association in this year in Europe has been installed around 22 GWp greed connected new PV installations, that has increased its cumulative capacity base by over 50%, compared to 2010. This statistical data distribution is presented in figure 3. From this data we can observed that 3 EU stats recently has important economical problems and UK for the first time entered in the top 10 in EUN PV market.

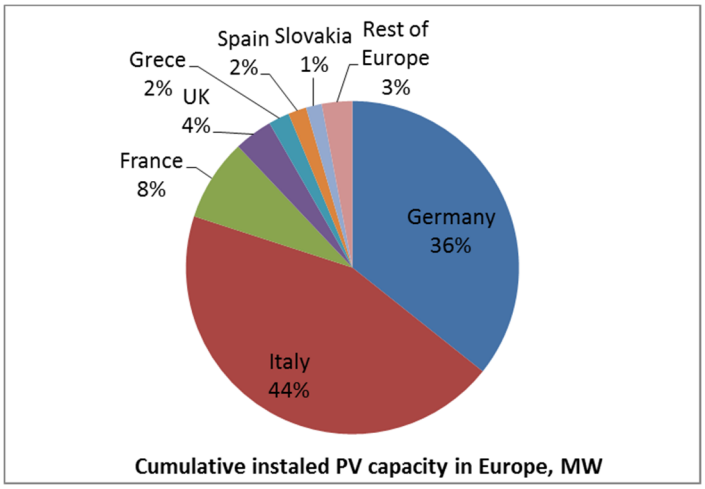

Fig. 3. *European PV market split in 2011*

In this statistical report Romania is present with only 3 MW_p grids connected PV capacity in rest of Europe capacity. Bat this value is presented a growing trends. The national Authorities planning to arrived more than 160 MWp cumulative installed Photovoltaic capacities in 2013. From the statistical data Romania has an important PV market capacity. Those values can arrive in 2020 in Romania 3000 MW, which is mentioned in Paradigm Shift Scenario of the target of the European PV market. From the predicted value of the scenario the PV solar energy conversion units, the PV Park will be supplying up to 12 % of the EU electricity demand by 2020, this represents about 380 GW of cumulative capacity by 2020. Recently the energy

values produced now by the Photovoltaic conversion systems' is around 2% of the energy demand in European electricity mix and roughly 4% of the peak demand. In Romanian in energy production mix the PV fraction is very low. From the statistical values of the renewable energy sources use for electricity production in 2011 was the hydro and the wind energy sources. The energy mix structure produced by different sources in Romania and EU is presented in table 1.

Table 1. *The electrical energy production system Mix in Romania in 2011 and in EU in 2008*

Energy source type used for electricity production	% in national electricity energy mix	% in EU electricity energy mix
Hydro energy	26	10
Nuclear	19.4	28
Wind	1.9	-
Solid conventional energy sources, coal	40	28
Oil	1	3
Natural Gas	11.7	24
Biomass &Waste	-	3
Gheothermal+Solar +Wind	-	13
Total	100	100

From this table we can observed that the energy production with helpful of classical energy sources in Romania is very high comparative with EU values, only the wind sector has an important value in the national energy mix. In this context is necessary to develop the energy production with other green sources. The PV sector in the near future needs to grow, to achieve the energy production values with photovoltaic conversion presented in EU Action Plans. For this the Romanian authorities offer a favourable support framework for the investors. In energy low published in 2011 is indicated to providing 6 green certificates for each MWh energy produced by this photovoltaic grid connected sources. The National Energy Action Plan for Romania indicated a target of the 24% RES in energy mix, that can be achieved by installing important new RES capacities. That can be realised with helpful of new investors and new integrator in especially in photovoltaic market.

MATERIAL AND METHODS

Life cycle analysis of the PV systems

The presented paper based on experience of the author in design and developing activity of the photovoltaic conversion systems. The context to be realise this study is offered by the ICPE, more than 30 years research and developing structures in field of renewable energy. In generally the environmentally impact of the large scale Photovoltaic system can be analysed by life cycle analysis. The method

offers a tool for evaluation of the electricity generation by the power plant and analyse the energy and the material flows in the power plant in phase of production, construction, exploitation and decommissioning of the power plant. The method uses two streams; the upstream process contains the material flow and energy imputes for the construction of the power plant and the extraction, conversion and transport that may also include the impact of decommissioning and demolition of the power plant. The structures used in life cycle analysis used in electricity sector are presented in figure 4.

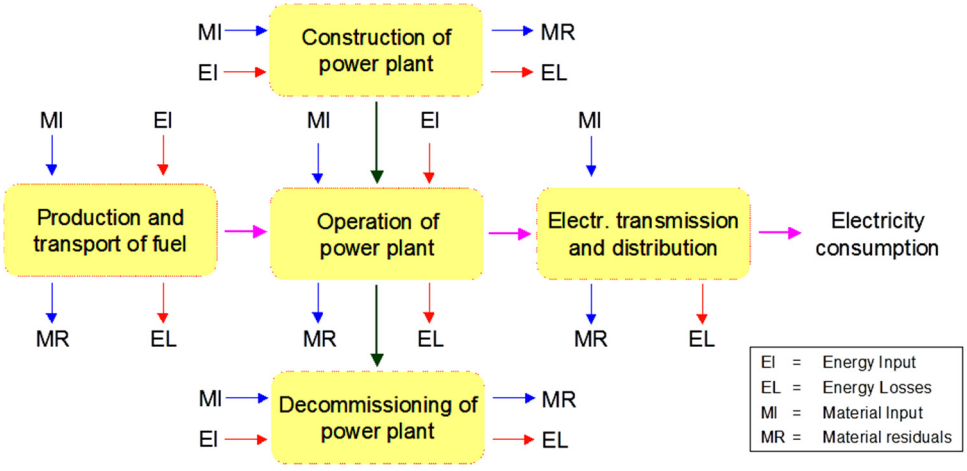

Fig. 4. *LCA model used in electricity sector (Source: Solarpraxis AG, Berlin, Germany)*

The downstream process includes the material flow and energy imputes for the required to transmit and distribute the electricity from power plants to consumer, included the associated losses in line and transformer.

In case of large scale PV system all level of the LCA model is necessary to take into account. But this study can be realised after a log monitoring period of the solar park, in generally in phase of design of the PV system, the greenhouse-gas emission is evaluated base on reference level indicated by the National Authority that is 566 gram CO_2/kWh in electrical energy production. The designer need to take into account this constant and need to evaluate the energy production of the solar park in every year. That value can be measured or estimated using different predictive models. Use the predictive energy production models for example one 10 kWp PV grid connected system in condition of the solar radiation potential reprehensive for south part of Romania, produced 12000 kWh energy in every year. The present paper indicated the reducing of the CO_2 emission in case of the 10 kWp power system built with Si-crystalline, CIS and Cd-Tl photovoltaic modules. That value is around 7000 kg CO_2/year. In lifecycle analysis of the power generation system can be used different computer models like Global Emission Model for Integrated System (GEMIS) developed by the Oko- institute that can be used for analysis of

greenhouse gases emissions of the energy production industry, and evaluate the cumulated energy demand (CED) for different energy production technologies. The CED summarises the total energy inputs required for the production of the power plant and the energy content of the materials requires for plant operation that can be defined as the total of the cumulated energy demand for the production item, its use or operation and its disposal. This indicator can be used in economically analysis of the different PV modules and cell technologies. The photovoltaic industry produced monocrystalline and multicristalyne solar cells and today important manufacturer use other technologies, base on cadmium- telluride (CdTe) and cooper –indium-diselenide, (CIS). The CED value is difficult to evaluate in case of large scale solar park, but can be used in analysis from the following table, table 2.

Table 2. *Cumulated energy demand of PV systems (results from the GEMIS model)*

	CED non-renewable kWh/kWh	CED-renewable& other kWh/kWh	CED - total kWh/kWh
PV mono-crystalline Si	0.411	1.009	1.420
PV mono Si with frame	0.480	1.016	1.496
PV mono Si with frame & mount. rack	0.557	1.016	1.574
PV multi-crystalline Si	0.327	1.007	1.335
PV multi Si with frame	0.400	1.014	1.414
PV multi Si with frame & mount. rack	0.494	1.015	1.508
PV amorphous Si	0.200	1.003	1.203
PV amorph. Si with frame	0.301	1.013	1.313
PV amorph. Si with frame & mount. rack	0.452	1.014	1.466

The presented method can be used in theoretically study bat for the large scale technical applications, in case of solar parks, is possible after the monitoring of the technical performances of the solar energy conversion systems from the beginning to the end of life. This method can be used for evaluation of the energy pay-back time of the solar energy photovoltaic conversion system. This performance varies between 2 and nearly 6 years depending from the cell technologies and the system auxiliaries.

Recycling of the PV modules

There are three major reasons why it is important to develop procedures to recycle used PV modules:

- The need to capture toxic substances contained in many thin-film solar cells (as discussed in the previous section)
- The chance to reduce the cumulated energy demand of PV modules significantly
- The use of recycled material might reduce the overall production costs of PV systems

From the energy balance of the solar cell technologies, the most energy-intensive part of the production process of crystalline silicon PV modules is the generation of the silicone slices. Therefore, the recycling of used silicon from worn-out modules could reduce the CED of solar cells drastically. The following table, table 3, illustrates the reduction of electricity demand for producing a crystalline silicon module if recycled silicon is used (Timpe 2004).

Table 3. *Electricity demand for the production of silicon PV modules (regular vs. recycled)*

	New Si module	Recycled Si module
Production of silicon wafer	7.55 kWh $_{el}$/wafer	-
Recycling of silicon	-	0.1 kWh $_{el}$/wafer
Production of solar cell	0.65 kWh $_{el}$/wafer	0.65 kWh $_{el}$/wafer
Production of PV modules	1.12 kWh $_{el}$/wafer	1.12 kWh $_{el}$/wafer
Total energy demand	9.32 kWh $_{el}$/wafer	1.67 kWh $_{el}$/wafer
Specific electricity demand	**4.26 kWh $_{el}$/W_p**	**0.85 kWh $_{el}$/W_p**

(Source: Timpe 2004)

Recently this specific electricity demand results in production of the PV modules is not take into account in evaluation of the energy balance for the PV conversion systems. That is included in module price.

For most types of solar cells, the frames and racks required to mount the modules are another important energy-consumption factor. Again, consistent recycling of these structures could reduce the energy demand for PV plants, thus improving their overall environmental performance.

Within the production processes of solar cells and modules, recycling of production waste (semiconductor material, glass and by-products) is already common. However, with regard to recycling of used modules, only very limited activities have taken place so far although several research activities have been carried out in the past years. This is understandable, because the total volume of used modules available for recycling is still rather low. Since the world-wide boom for PV systems started between 1985 and 1989 and modules have a lifetime of 20 – 30 years, it is clear that we can expect a sharp increase in the volume of used PV modules in the next years. That recycling process in Romania can be started from 2040. The PV industry should be prepared for the task of recycling a large share of these modules.

The recycling strategies developed to date include

- Separation of silicon wafers from the module compound using acids
- Separation of glass, solar cells and metal fractions from modules by burning the polymer laminate
- “Down-cycling” of frameless modules by melting the modules into FeSi, which can be used for steel production

The following requirements for an optimal recycling system have been identified.
High coverage of collection systems for used PV modules

- Large volumes of recyclable material
- Sorting the used modules by manufacturer

- Separation of PV modules into their main fractions
- Recycling of glass components
- Recycling of silicon wafers for cell production

The silicon based modules consist of 80% glass therefore the flat glass recycling industries can treat this product in their current recycling lines, doe similar morphology, structure and composition of the PV modules and flat glass products.

RESULTS

Energy balance and reduction of the CO_2 emission used the PV conversion system. In this paper the energy balance of the photovoltaic conversion system is presented for on 10 kWp power grid connected system that is a reasonably practical size limit for studying the PV conversion grid connected system. The values of the monthly energy production of the conversion system are presented in figure 5. That has been evaluated for the classical Si based modules for the CIS and for the panel build from cadmium- telluride (CdTe) cells.

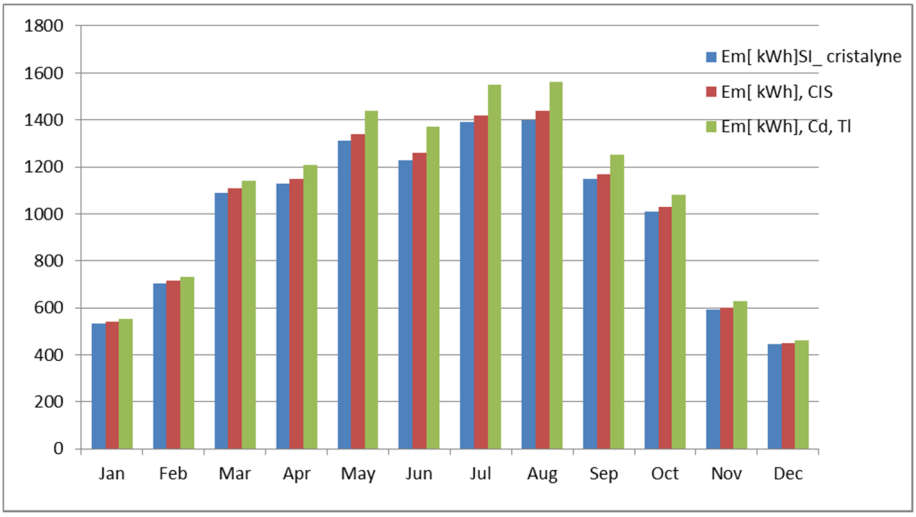

Fig. 5. *The monthly energy production of the 10 kWp power PV system builds with different solar modules.*

Using the conversion method indicated by the National Energy Authority (ANRE) I has been evaluate the equivalent CO_2 quantity for this energy conversion system. The monthly values for the conversion system built with different solar modules can be seen in figure 6. From this data can be seen, that the CO_2 emission reduced yearly with 7000 kg in case of 10 kWp power conversion grid connected system. Take into account the 20-30 years for the life period that conversion system can be reduced the CO_2 emission with 210 tonnes.

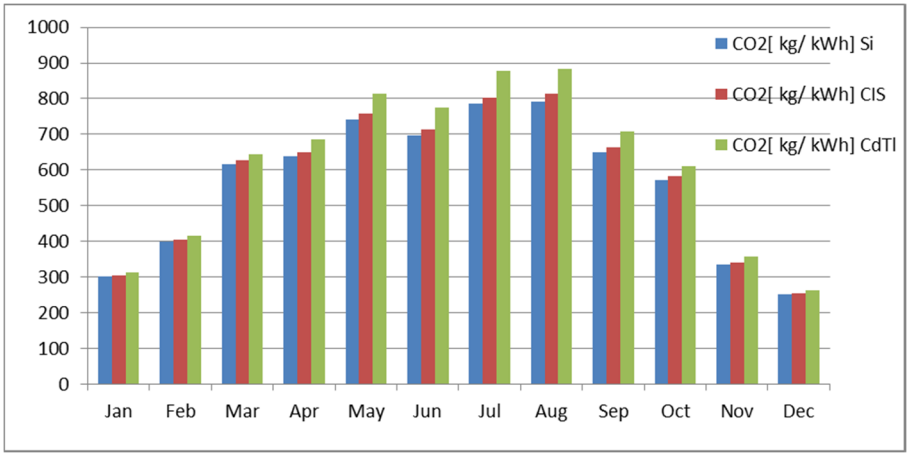

Fig. 6. *The monthly CO_2 emission reduction in case of the 10 kW_p power PV system builds with different solar modules*

Payback time of the PV modules

Using the GEMIS model it has been evaluated the pay- back time for different silicon cells technologies; this is shown in figure 7. The model has been evaluated by Öko-Institut Freiburg. Recycling results of PV modules.

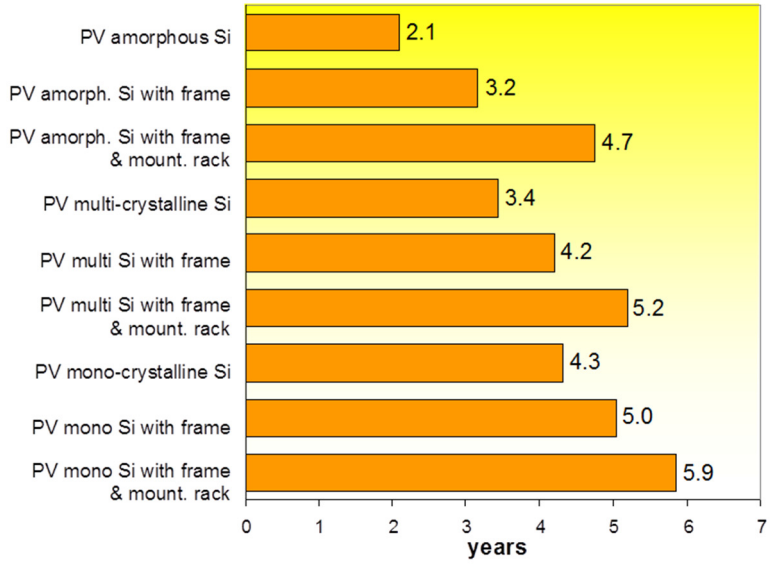

Fig. 7. *Non-renewable energy pay-back time of PV modules (based on results from the GEMIS model) (Image: Öko-Institut e.V., Freiburg, Germany; Solarpraxis AG, Berlin, Germany*

For this evaluation model I take into account the physical structure of the PV conversion system is necessary to the mechanical parameters of the PV modules, dimension, mass, nr of modules integrated in the conversion system. I received this data from an important photovoltaic installer, from Renovatio Solar LTD; this integrator has been realised different large scale PV grid connected application in south region of Romania. The technical parameters of the studied system are presented in table 4.

Table 4. *Technical parameter of the Solar Park, build by Renovatio Solar LTD.*

Location	Size of PV Park/ operated by Renovatio	Cpacity, MWp	Nr. Of integrated PV Modules	Modules Capacity, Wp	Areea [mp]/ module
Singureni, Jud. Giurgiu	1	1	4176	240	1.65
Scornicesti, Jud. Olt	1	1	4176	240	1.65
Crevedia, Jud. Dambovita	2	2	8400	240	1.65
Corabia, Olt	7	7	28602	245	1.65

In generally from the PV modules can be recycled the glass, the aluminium frame and different organic materials. Today the first generation PV modules must be recycled, that has in structure different heavy metals like Pb, Cd, Zn, and one PV module from this generation, which weight is about 22 kg contain 12.67 g Pb. If the modules are not deposed properly can be produced the following negative impacts on the environment and human health: leaching of lead, leaching of Cd, loss of conventional recourses primarily glass and aluminium and loss of rare metals, Ag, In, Ga. In this paper I evaluate the quantity of the principal row material which can be recycled an end of life of the solar park. I represented in graphically form for the studied solar parks. The diagram can be seen in figure 8.

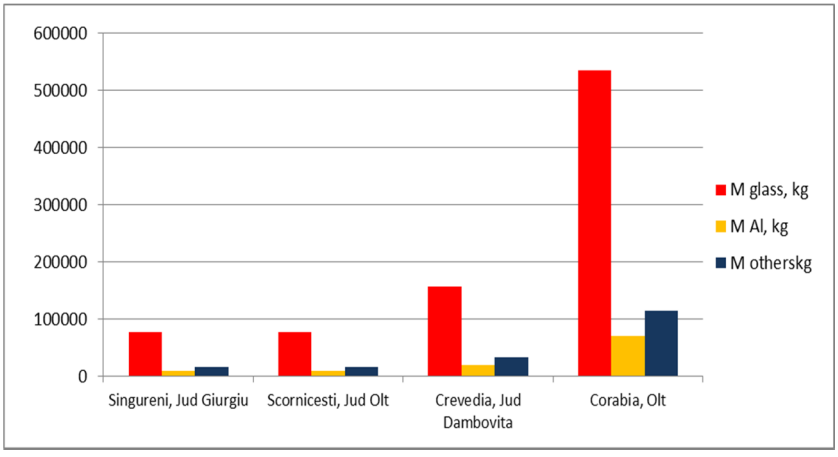

Fig. 8. *The predictive value of weight of the recycled materials in case of principal solar parks builds by Renovatio Solar LTD*

CONCLUSION

The energy production with photovoltaic conversion of the solar energy is a clean technology and has an important positive impact to reducing the CO_2 emission. Theoretical on 10 kWp grid connected PV system in period of the optimal working period reduced the CO_2 emission with 210 tones. This value can be used to evaluating the total CO_2 quantity if the Romanian energetica industry achieved the target values in field of photovoltaic.

The lifecycle analysis method can be used in evaluation techniques of this conversion system, the parameter, the specific energy demand of the production of the Si based PV module is an important values in procedure of the energy balances analysis.

From this year the PV modules is included in WEEE Directives, that reduced the negative environmentally impact produced by the improper disposal. Limiting the quantity of improperly disposal photovoltaic panels can be reduced the concentration of lead and cadmium leaching, so the environmental impact can be also reduce. Because the PV modules contain different dangerous components is necessary in project phase to establish the way of a good management of these in the end of life cycle, when these all will became waste. The European legislation in the WEEE domain in the DIRECTIVE 2012/19/EU of 4 July 2012 on waste electrical and electronic equipment (WEEE)

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ENVIRONMENTAL INFORMATICS - SOLUTIONS AND EMERGING CHALLENGES IN ENVIRONMENTAL PROTECTION

Bogdan CIORUŢA[1*], Mirela COMAN[2]

[1] Tehnical University of Cluj-Napoca – North Center University of Baia Mare
[2] Mineral Resources and Environment Faculty; Adress: nr. 62 A, Dr. Victor Babeş str., 430083, Baia Mare, Maramureş; tel.0262-218922 / fax 0262-276153
** E-mail: bciorutza@yahoo.com*

ABSTRACT. Ever since "the environment" gained its place in the public international agenda (environmental legislation, sustainable development or disaster and hazard management) it has been bundled with data, information, knowledge and information systems. Environmental Monitoring Systems (EMSs), Environmental Monitoring and Analyzing Systems (EMASs) and especially Environmental Information Systems (EISs) are integrated part of what we call Environmental Informatics (EI) platform. As we speak the area of EI is becoming more complex due to the current context and trend of making the EISs available to the public and end-users access; this phenomena is based on the assumption that public and environmental information end-users awareness, participation and acting is improved by the rate of access to the environmental information to solve the complex problematic covered by the research, engineering and environmental protection fields. In this sense, Environmental Information plays a major role in environmental protection, planning, management and, of course, decision making. This working paper is a review of the historical development of environmental information systems, and it focuses on the creation, management, use and role of Environmental Information Systems; at the same time, the paper explores the typology of EISs and examined the common definitions of them in the light of these major issues: the concepts of data, information and knowledge in EISs, the connection between EISs and EI, the problems and obstacles to the development of EISs and finally, the emerging demand for public access via EISs and EI to environmental information and environmental protection, engineering and research.

Key words: *Environmental Management Systems, Environmental Informatics, Environmental Information Systems*

INTRODUCTION

Ever since "the environment" gained its place in the public international and national agenda, it has been bundled with data, information, knowledge and information systems. Environmental Monitoring Systems (EMSs), Environmental Monitoring and Analyzing Systems (EMASs) and especially Environmental Information Systems (EISs) are integrated part of what we call today Environmental Informatics (EI) platform (Haklay, 1999).

As we speak the area of EI is becoming more complex due to the current context and trend of making the EISs available to the public and end-users access. This kind of phenomena is based on the assumption that public and environmental

information end-users awareness, participation and acting is improved by the rate of access to the environmental information and environmental informatics culture formed need to solve the complex problematic covered by the research, engineering and environmental protection fields.

In this sense, Environmental Information and Environmental Information Systems play a major role in environmental protection, planning, management and, of course, decision making. The development of these systems is tightly connected to the environmental awareness of the last decades at international and national level. This working paper is a review of the historical development of environmental information systems, and it focuses on the creation, management and use of Environmental Information Systems (EISs) (Cioruţa and Coman, 2011); at the same time, the paper explores the typology of EISs and examined the common definitions of them in the light of these major issues: the concepts of data, information and knowledge in EISs, the connection between EISs and EI, the problems and obstacles to the development of EISs and, finally, the emerging demand for public access via EISs and EI to environmental information and environmental protection, engineering and research (Cioruţa and Coman, 2011).

Following the description, the existing definitions of environmental information systems are examined - in the practical sense and in the more theoretical sense. EISs are divided into two groups:

- information systems in the strictest sense (they are used to store and retrieve information);
- analysis and simulation systems of environmental information.

INFORMATICS FOR ENVIRONMENTAL SCIENCE

The protection of our environment remains one of the greatest challenges in all kind of industrialized societies or communities. This challenge is addressing politics, economy, sociology, as well as technology, informatics and research. It is also evident that the various problems in environmental protection, environmental planning, research and engineering can be only solved on the ground of a comprehensive and reliable information basis, where the implication of IT&C systems are more than crucial.

State and dynamics of the environment are described by biological, physical, chemical, geological, meteorological and finally by the social-economic data (Avouris, N. M., Page, B., 1995). This data is time and space dependent and addresses past or current states. The processing of this data and the production of information on the environment, on its stress factors and on its influence mechanisms are fundamental for any kind of environmental planning and preventive measures. Therefore, environmental problem solving is mainly an information processing activity handling a wide range of environmental data and adequate solutions in a sense or another (Cioruţa, B., 2012).

Solutions to our environmental problems are strongly dependent on the quality of accessible information sources; information is a very critical factor in making decisive political, administrative and economical actions and in changing people's attitudes related

on the local, regional or global environment. This information referring on environmental aspects is just as important as basis for decisions on actions and elaborating various strategies, programs and methodologies in environmental protection as for gaining knowledge in environmental protection and research.

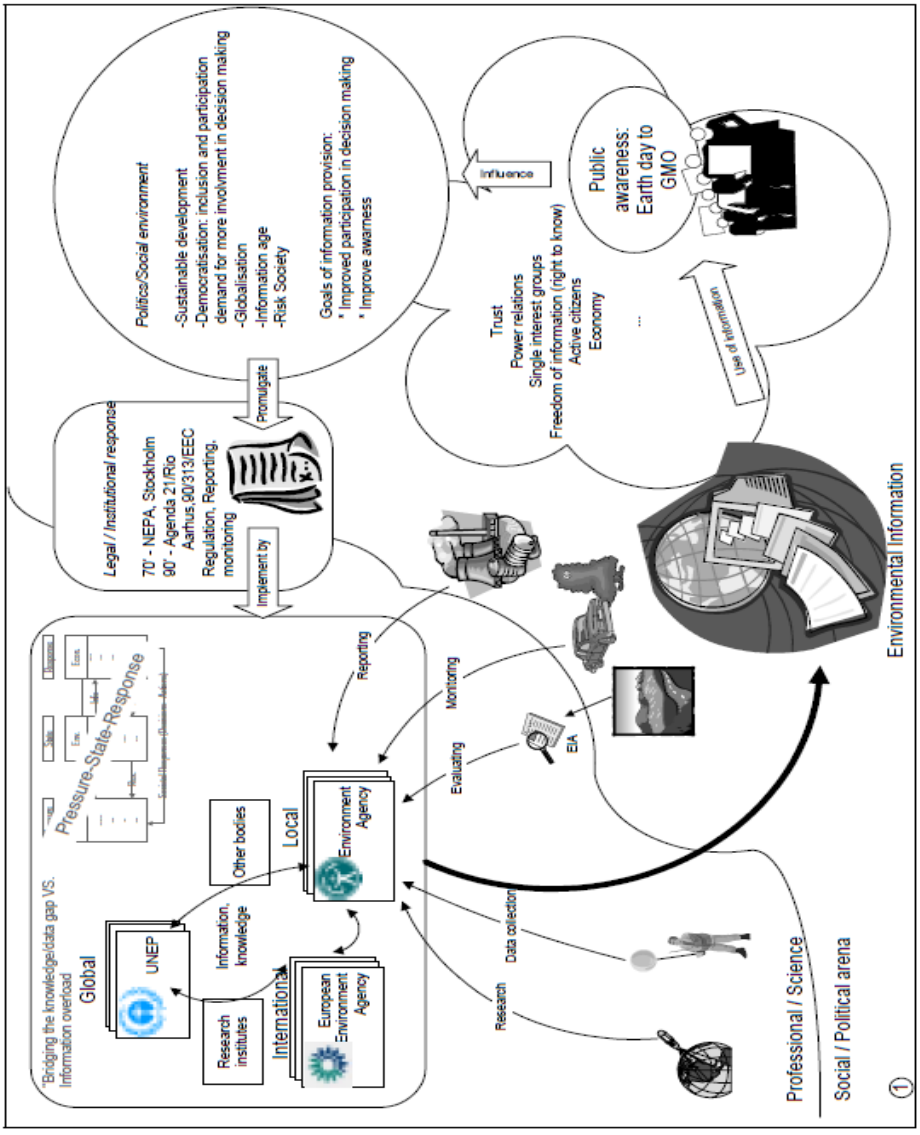

Fig. 1. *The relation between science and socio-politics in developing Environmental Information Systems*

In the last decades, application of information technology has become vital in the environmental domain, in industry and public administration, for providing the required environmental information on the appropriate level of detail, completeness, accuracy and speed. In this way, one of the main goals of Environmental Information Systems is addressed, namely to prepare the mass of collected environmental data in such a way that they can be used for routine operational environmental administration tasks as well as for political-strategically decision making.

Environmental data processing has recently focused (Avouris, N. M., Page, B., 1995) on the following trends, explicitly mentioned at international level:

- environmental monitoring by means of remote sensing and the combination of data streams from all over the world;
- a policy for sharing and integrating environmental information across political, technical and organizational boundaries making wide use of internet and information technology;
- advanced model-based data analysis techniques, shifting the focus from data to dynamic informatics system structure;
- industrial applications of environmental information processing, aiming at higher ecological efficiency of the economic system.

It is obvious that advanced computing technologies or applications play an important role in these developments. Data processing in the environmental domain has been lacking a conceptual and scientific basis since there has not been a significant research in this special domain for a long time.

This is certainly not only a matter of applied informatics, but a multi-interdisciplinary task where many scientific disciplines should be involved (bio-sciences, chemistry sciences, geo-sciences, hydro-sciences, environmental engineering, economics, law, measuring technology, management sciences etc.) (Cioruţa, B., 2012). On the other hand, the growing field of environmental information processing is a great challenge to informatics methodologies and their applications, because from this process of mutual stimulation, some years ago, most precisely in 1995, according of course to the implication of staff management, computers, GIS and data (capta-information), a new discipline emerged, named as *Environmental Informatics*. Much more, the development of the chapter related to information environmental technologies has been in extraordinarily rapid progress, every year starting with 1995 new techniques and tools have applied to environmental management. In many cases the roles of these technologies have been limited in the provision of improved convenience for system implementation and presentation (Coman, M., Cioruţa, B., 2011).

Further development of high performance computing and knowledge management potentials associated with artificial intelligence techniques, a field with great impact in environmental problematic management, is desired to promote the long-term viability and direction of interest both for environmental informatics and environmental sciences (Avouris, N. M., Page, B., 1995).

To monitor actual condition and development of metabolisms with aid of metabolic key indicators, various complementary modeling approaches are required (continuous and discrete event simulation, material flow analysis, life cycle assessment, environmental risk management, environmental management accounting).

The approaches demand sophisticated data processing techniques and computer-based information and knowledge systems, for instance process simulation tools, computer-based environmental accounting systems, geographical information systems, visualization tools, reporting modules, as much as possible integrated into a consistent modeling framework (Cioruţa, B., Coman, M., 2011).

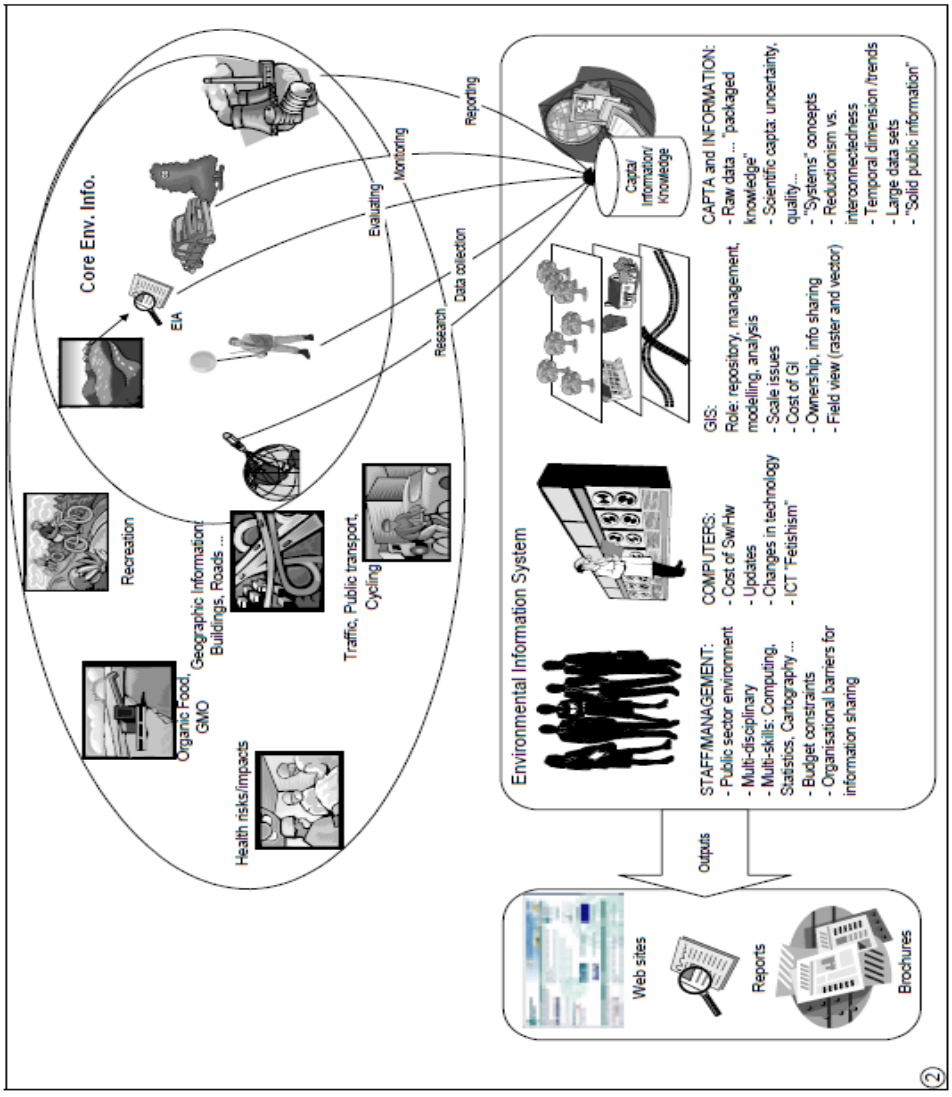

Fig. 2. *The specific components of the Environmental Information Systems*

To facilitate exchange of experience and know-how between academics and professionals, scientists and politicians or managers in this research field there exist at international level the EnviroInfo conference, where specialists in environmental sciences and informatics focus on environmental informatics and industrial ecology. This is the case when Environmental Informatics, as well as bio-informatics, chemo-informatics, geo-informatics, hydro-informatics and eco-informatics are at the forefront of research in the application and deployment of new and emerging software and computer technologies (Cioruţa, B., 2012). This is happening because of its immense appetite for large databases and the underlying complexity of the physical phenomena to be modeled.

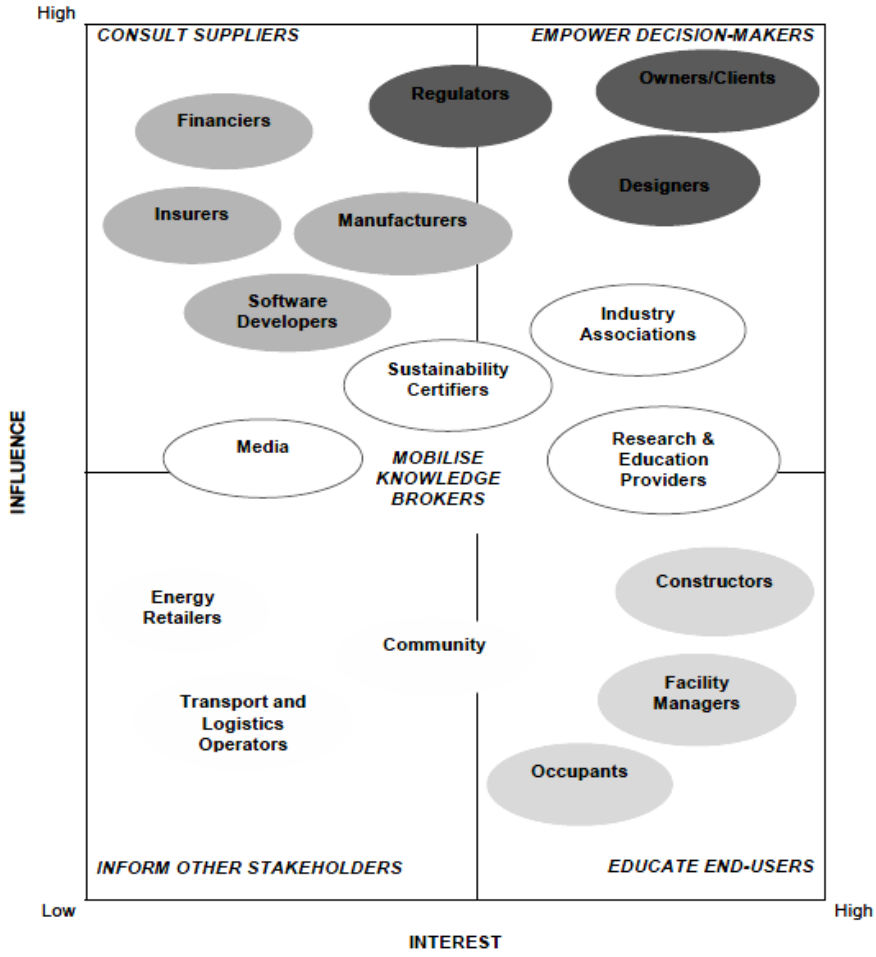

Fig. 3. *The main actors interested in Environmental Informatics*

More and more environmental data are being made accessible on the internet, now when we are facing two major problems:

- data are often locked in databases, being dependent on private schemas and database engine;
- finding the right environmental models to process these data is more an art than an engineering task.

A FEW WORDS ABOUT ENVIRONMENTAL INFORMATION SYSTEMS

The discussion starts with a description of systems that have been called "Environmental Information Systems" (EISs) in order to identify the specific attributes of these information systems. There is a wide range of environmental information systems (Cioruţa, B., Coman, M., 2011) in industry, public administration and science which can be classified based on the nature of the information and the type of processing. This classification (Page and Hilty, 1995) includes monitoring and control systems, conventional information systems, computational evaluation and analysis systems, planning and decision support systems, and integrated environmental information systems.

Monitoring and control systems (MCSs)

These systems are connected to the classical area of measuring and control and deal with the automation of measurements (including telemetry and remote sensing) in water, air, soil, noise, and radiation control.

This also includes basic data analysis techniques and methodologies such as the aggregation of time series data, the classification of environmental objects or the identification of hazardous substances based on the measured data.

Today there are huge satellite based remote sensing environmental monitoring systems on the international and national scale in operation. Computerized process control systems, however, are either directly employed in environmental technology such as in air emission control, sludge or refuse processing, or used in production process automation with secondary effects on environmental protection (energy conservation, emission reduction). Monitoring and control systems often require the processing of vague data and information.

Conventional information systems (CISs)

These systems are employed for the input, storage, structuring, integration, retrieval and the presentation - visualization of various kinds and forms of environmental information such as raw measurement data, descriptions of environmental objects, as well as documents such as environmental regulations or literature references (Cioruţa, B., 2012). Spatial and temporal aspects often play an important role in the management of these kinds of information. To handle spatial environmental data, Geographical Information Systems (GIS) are now integrated into environmental

information systems as one of their modules. For dealing properly with time in environmental information, temporal extensions of relational data base systems are needed. The application direction of these environmental information systems is in industrial and public environmental protection.

Computational analysis systems (CASs)

Computational analysis systems support the in depths processing of environmental data by employing complex mathematical-statistical analysis methods and modeling techniques; they also deal with the aggregation and visualization of state of the environment information. In simulation modeling, we can combine state of the environment information with structural environmental information, and with simulation applications we can investigate various environmental scenarios for various problematic (Cioruţa, B., 2012). Typical applications of these systems are the identification of possible causes of environmental impacts or the derivation of possible effects of different planning measures, so this is the reason why computational analysis systems are widely used in environmental research.

Decision support systems (DSSs)

Decision support systems provide action oriented environmental information helping decision makers in environmental decision processes. They kind of systems offer methods for the evaluation of alternatives and for justifying decisions. In a sense or another, for a few essential problematic such as environmental impact analyses, handling hazardous substances, water resources management or for technological risk assessment.

Integrated environmental information systems (IEISs)

Almost all actors in environmental management and administration (enterprises, communities, provinces, federal level or international organizations), represented some of them in the figure 6, are operating or implementing computerized systems for environmental information processing. However, they are not uniquely related to one of the system types mentioned above, because they consist of multiple components serving various purposes.

Many complex real world environmental information systems are of an integrated nature (Porter, 1994). It turns out that integrated environmental information systems are increasingly designed as distributed systems where usually a later integration of existing subsystems and components takes place.

The integration of various technical components at the development of integrated environmental information systems is a challenge to informatics and environmental sciences methodology in particular in the environmental field with a high degree of technical, institutional and interdisciplinary(Cioruţa, B., 2012).

To complete the exploration of EISs typology, it is worth examining how others have described EISs, so we presented the followed definitions:

a) "*Environmental Information Systems is the umbrella term for those systems used for: monitoring, data storage and access, disaster description and response, environmental impact reporting, state of the environment reporting, planning, simulation, modeling and decision making*"

b) "*Environmental Information Systems are an important factor in environmental research, decision support, management and policy. EISs implementations have a number of requirements which are hard to satisfy, even with the information technology of today. After a period of 2 decades of trial and error, of failures and successes, the study of EISs has matured. The subject is still growing, in a multidisciplinary work environment which changes quickly, both in the IT and the environmental sector.*"

International Symposium on Environmental Software Systems (ISESS)

c) "*Environmental Information Systems (EISs) are computer systems that use a variety of tools and technologies to facilitate the management and use of environmentally-related data and information*."

(ESSA technologies)

d) "*Environmental information systems are concerned with the management of soil, water, air and species in the world around us. This textbook describes a framework for systems based on four phases of data processing: data capture, aggregation, storage, and analysis. The first part of the text concerns the collection of environmental raw data. The second part explains how this raw data is condensed and enriched to extract semantically meaningful entities. How aggregated data is then stored in a file or database is described in the third part of the text. In the final section the available information is prepared for decision support purposes*."

"Environmental Information Systems" (Gunter, 1998):

Since the early 90s, a new field of research has been created for EISs research, coined "environmental informatics".

A shorthand definition: "environmental informatics is the field that deals with the development, management and research on Environmental Information Systems" or:

"*Environmental informatics is a field of applied computer science that develops and uses the techniques of information processing for environmental protection, research, and engineering... basic methodological issues and typical applications across a wide range of topics, including monitoring, databases and information systems, GIS, modeling software, environmental management systems, knowledge-based systems, and the visualization of complex environmental data. A sampling of topics: networking protocols and tools for the environmental science community, an adaptable architecture for river quality monitoring...*"

(Avouris and Page, 1995)

By searching the scientific literature for the context in which “informatics” is used, it is clear that it is used over a wide range of fields - for example we have “healthcare informatics”, “genome informatics”, “agriculture informatics”, “legal informatics” etc.

Usually the terminology and the semantic approaches for EI are used as an umbrella definition for computer, telecommunication and embedded systems integrated and implemented in environmental sciences, so using this scale; it seems that there is a relation between the “environment” and “informatics”, a relation by which it is possible to conclude that IT is a central domain into present and future environmental research.

FROM EISS TO EI: BACKGROUND AND MAIN ISSUES

Like many other aspects of our “information age”, EISs have grown and evolved in the last years, this ascending trajectory being closely related to the changing trends in the field of computing. By the period 1995-1998, the computers were seen as the only possible container for EISs and other associated applications (Gunter, 1998). This reliance on rapidly changing technology is causing major tension in the creation and maintenance of EISs – the balancing act between the latest technology and the declared aims of the EISs and EI.

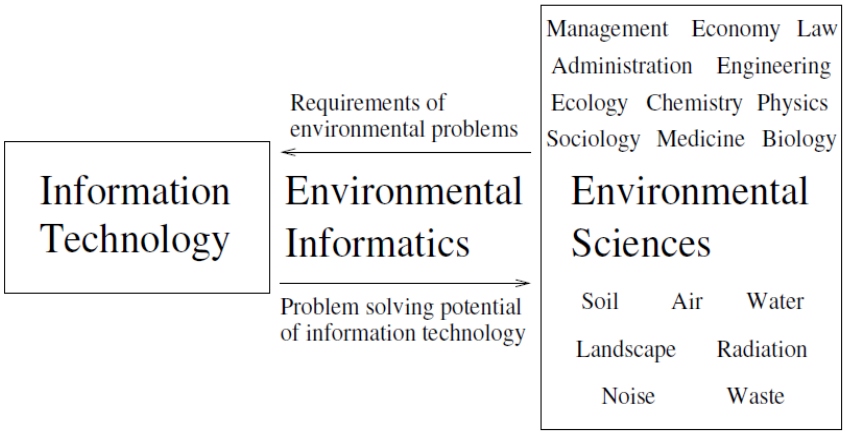

Fig. 4. *The position of Environmental Informatics between IT and ES*

EI - CHALLENGES FOR SUSTAINABLE DEVELOPMENT

Computer-based systems for processing environmental information have been in use for some time now and a broad range of applications is covered by these systems, including:

- ✓ monitoring and control systems;
- ✓ information management systems;
- ✓ data analysis systems, as well as
- ✓ planning and decision support.

Progress in informatics has made an invaluable contribution to our ability to analyze the biological, chemical, physical, geological, hydrological, meteorological processes taking place in the environment. Inversely, the complex nature of problems occurring in environmental contexts is a great challenge to informatics. From this process of mutual stimulation (Hilty, 1997), a special discipline has emerged in 1995 known as Environmental Informatics. It combines computer science topics such as database systems, geographic information systems and simulation modeling with respect to their application to environmental research and protection.

The environmental informatics community maintains an international annual conference series Informatics for Environmental Protection (EnviroInfo) that started in 1986. Even if Environmental Informatics is a rather young field (Porter, 1994), a critical assessment of achievements and directions should be appropriate. It seems that the early work had its main focus on system developments for monitoring the status of the environment.

Although diagnosis is indispensable, it is no solution if no therapy follows, so applying sophisticated computing methodologies just to cure the symptoms of environmental problems should certainly not satisfy us. Since the Rio Summit has claimed *sustainable development*, which means a way of living and a form of using resources that does not discriminate against future generations, although it is certainly difficult to elaborate such a development, it is clear that *information* will be a very critical resource in changing attitudes and making decisive political actions into that direction possible (Hilty, 1997).

Thus, Environmental Informatics should accept the challenge to play an active role in the local and global transformations that will be necessary to approach sustainability by providing the high quality information processing concepts and solutions required for environmental research, impact assessment, planning and management, dynamic-simulation modeling and statistics, in a variety of scientific and professional endeavors, ranging from landscape mapping and watershed ecology to pollution detection, hydrometeorology, geomorphology, geology etc.

PERSPECTIVES OF ENVIRONMENTAL INFORMATICS

Many challenges exist in the applications of modeling techniques to environmental management; most of environmental models can only deal with limited spatial and temporal units in a system due to difficulties in computational requirement and data availability. However, what decision makers desire to know might be either detailed plans based on much finer units or just a broad justification. The insufficiency of data about pollution sources, mitigation measures, natural conditions or environmental quality records, as well as the lack of information relevant to cultural, social, economic and political factors often hinders the development of effective sustainable management strategies at local, regional or national level.

When models are used for providing decision support, researchers and IT&C specialists have to conduct solid on-site works to gain as much insight of the study system as the local managers before claiming that they are wiser (Checkland, P., Holwell, S., 1998).

Involvement of information technologies would be desired for facilitating research to gain profound knowledge and understanding of study systems without heavy involvement of on-site investigation. This is the factor that motivates many organizations to build up on-line environmental database management system and decision support system to aid in various environmental impact assessment and policy decision-making under a fast and friendly environment useful for communities.

CONCLUSIONS

The traditional environmental systems - models, technologies, methodologies and applications - have been challenged by the difficulties in handling dynamic and uncertain features of real-world environmental systems. Conditions for environmental management will keep changing with time, demanding periodically updated decision support. It is thus desired by users and decision makers that the research outputs be dynamic and innovative (Checkland, P., Holwell, S., 1998).

With the recent vision we have formatted and gained from studying the multi-disciplinary area of Environmental Informatics and Environmental Information Systems, on-line real time large-scale model synthesis and data exchange for environmental engineering, research and protection will become feasible in near future in all the countries.

This means that the provision of integrated computer software packages that allow users to input updated information into a software system, run the system and obtain updated results under the informatics environment is anticipated. Obviously, in line with this trend, more information technologies will be taken for addressing the complex environmental concerns that we cannot handle them successfully today. This must rely on fostering and nurturing a new field Environmental Informatics as a new niche in the area of environmental science and engineering (Checkland, P., Holwell, S., 1998). As a conclusion, it can be said that modern data analysis methods are useful tools in environmental informatics and environmental statistics. Good methods are understandable for the environmental scientists and at the same time reliable, robust and helpful for discovering important relationships in the data. In cooperation between environmental scientists and information scientists, what makes the relationship flourish is the knowledge of both sides about their field and efficient communication concerning the specific needs of a certain problem and the properties of the methods. Without these ingredients, the results of cooperation projects may not be satisfactory.

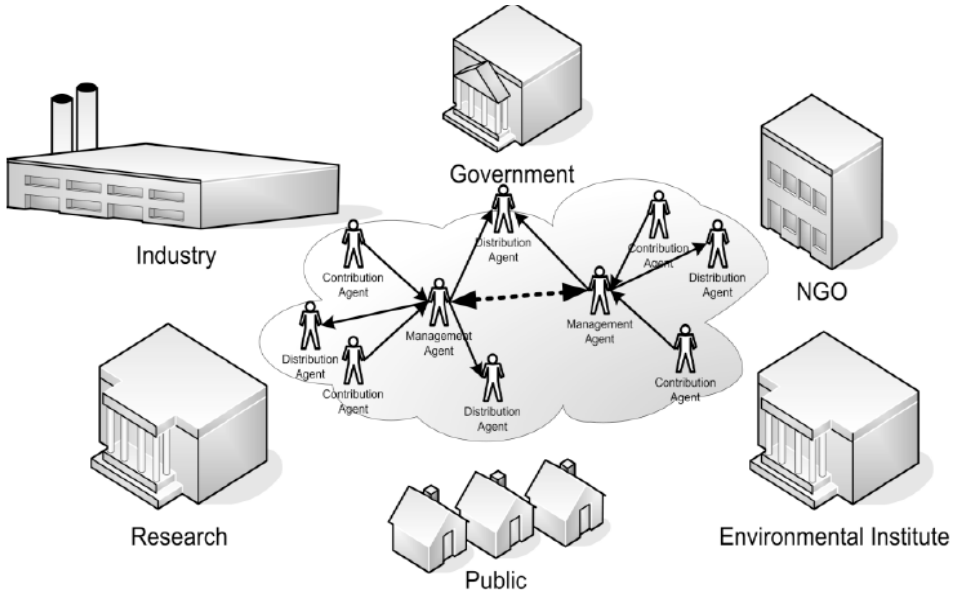

Fig. 5. *General perspective according the environmental informatics societies*

The importance of this work paper is that the data analysis methods specific to EISs were found useful in gaining new knowledge of ecosystems and also the methods are understandable to the environmental scientists and making possible to draw meaningful conclusions about changes in the environment and their possible causes. In this sense the concepts of EISs and EI were proposed for characterizing the future perspective in project research and environmental protection and engineering to the research, industry or public area, but not only limited only to them.

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STUDY ON THE EX-SITU BIOREMEDIATION TECHNIQUES APPLICABLE FOR SOILS CONTAMINATED WITH PETROLEUM PRODUCTS

Andreea COSTE[1], Valer MICLE[1*], Calin George ROGOZAN[1], Maria PRODAN[1]

[1] Technical University of Cluj-Napoca, Faculty of Materials and Environmental Engineering, Environmental Engineering and Sustainable Development Entrepreneurship Department, 103-105 Muncii Bd., 400641 Cluj-Napoca, Romania
** E-mail: valer.micle@sim.utcluj.ro*

ABSTRACT. In the present paper is made a study on the ex-situ bioremediation methods, to determine the most adequate techniques of bioremediation for soils contaminated with petroleum products.

Pollution with petroleum hydrocarbons, due primarily to the increase of oil and petroleum products consumption represents a major problem for the environment with serious repercussions for humans, plants and animals. Bioremediation is a biological, natural method, being successfully used in remediation of sites contaminated with petroleum hydrocarbons, without adversely affecting the ecosystem and having a relatively low cost. Bioremediation is based on the presence of indigenous microorganisms in the soil and on the introduction in the contaminated area with petroleum products of microorganisms capable of degrading pollutants. The degree of degradation of petroleum hydrocarbons is influenced by several factors, of which the most important are: temperature, pH, soil humidity, oxygen concentration, nutrient concentration, concentration and type of hydrocarbons.

Key words: *bioremediation, petroleum products, microorganisms, soil*

INTRODUCTION

Pollution is the contamination of the environment with materials that interfere with human health, life quality or natural ecosystem function (*ro.wikipedia.org/wiki/Poluare*).

Petroleum products are an important energy source for industry and day to day life (Das and Chandra, 2011).

Oil industry, including both its extractive and its manufacturing branches, is among the industries with a considerable weight in environment pollution (Ciulache and Ionac, 2002). In figure 1 are presented the main sources that contribute to soil contamination in Europe, oil industry occupying an important place (*http://themes.eea.europa.eu*).

Causes of soil contamination with petroleum products are presented in table 1.

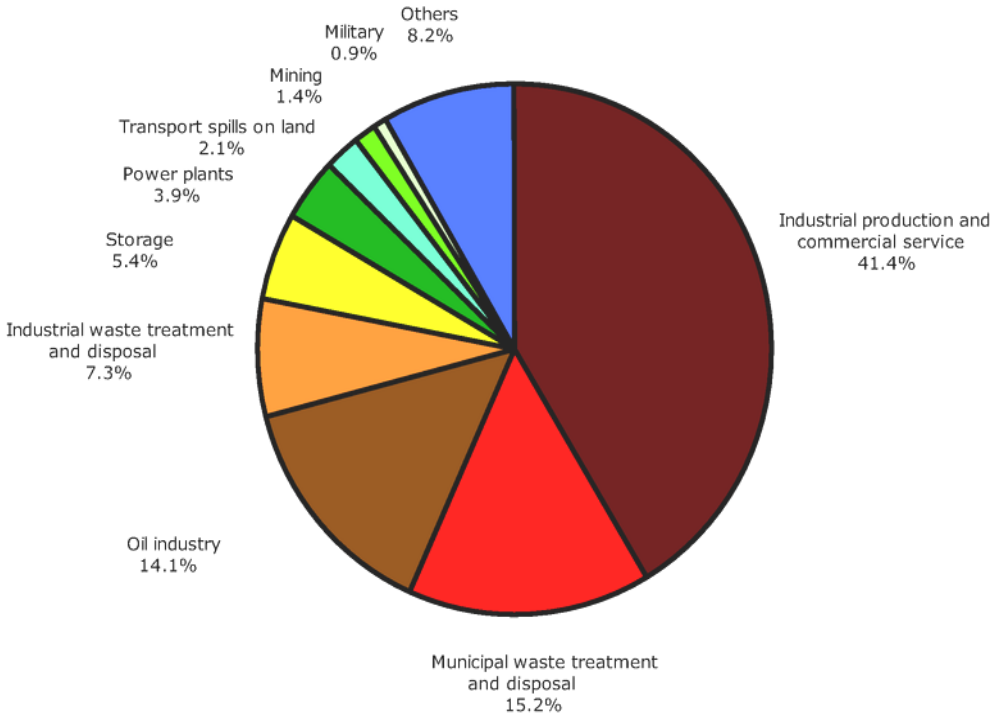

Fig. 1. *Causes of soil contamination* (http://themes.eea.europa.eu).

Table 1. *Causes of pollution with petroleum products* (Ciulache and Ionac, 2002)

Stages of activity	Causes of environmental pollution
Extraction stage	Physical and moral obsolescence of facilities and equipment, improper use of materials during specific technological processes, unreasonable use of some facilities
Refining stage	Processing crude oil with high sulfur content and utilization of resulted fuels; incomplete burning of fuels in obsolete installation; deterioration of storage tanks and of pipes transporting oil and petroleum products; burglaries caused to oil transportation pipelines
Distribution stage	Physical and moral obsolescence of tanks and equipment; breaches that occur due to advanced corrosion; technical accidents
Transportation stage	Breaking of pipes for gasoline theft

Modifications of the soil properties due to contamination with oil derived substances can lead to deficiency of water and oxygen, as well as lack of available forms of nitrogen and phosphorus. Petroleum hydrocarbon contamination may adversely affect the chemical characteristics of soil, reduce fertility and negatively influence plant production (Njoku et al., 2009).

The retention capacity of petroleum products in the soil depends on the content of clay, allowing them to infiltrate, generally up to 70-80 cm in the soil, making the clean-up process harder. The basic indicator of retention of such products into the soil is the C/N ratio (www.anpm.ro).

In accordance with the Annual Report of the State of the Environment in Romania in 2012, in the five counted counties (Bacău, Covasna, Gorj, Prahova and Timiş) 751 hectares of soil are affected with petroleum products, of which 248 hectares are heavily affected (www.anpm.ro). The evolution of oil production in Romania is represented in figure 2. (ro.wikipedia.org/wiki/Industria_petrolului).

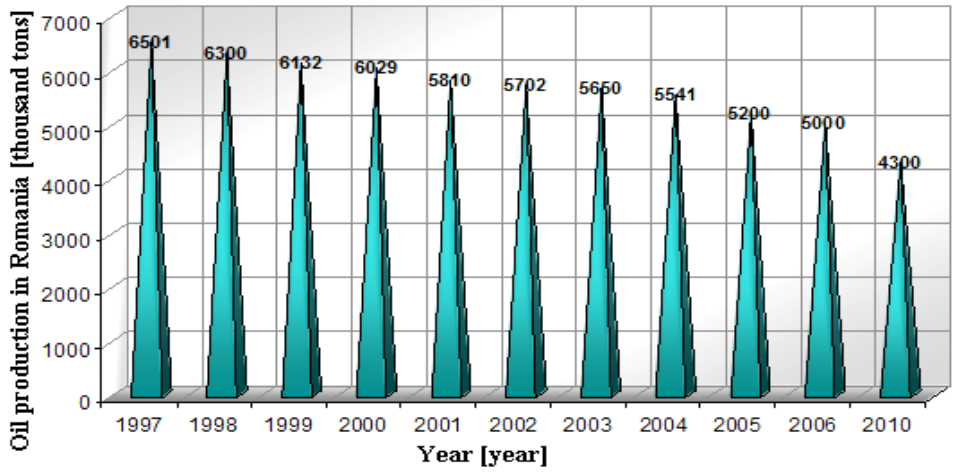

Fig. 2. *Evolution of oil production in Romania* (ro.wikipedia.org/wiki/Industria_petrolului).

The general image of the compounds that contribute to soil and groundwater contamination in Europe is presented in figure 3 (*http://themes.eea.europa.eu*).

Contaminated soil remediation can be done in several ways, including both physico-chemical and also biological methods. Biological methods are more economical and efficient, followed by chemical and physical methods. A large number of biological methods were developed to increase the degradation rate of petroleum products in the soil, because it takes more time than in the case of physical and chemical methods of remediation (Thapa et al., 2012).

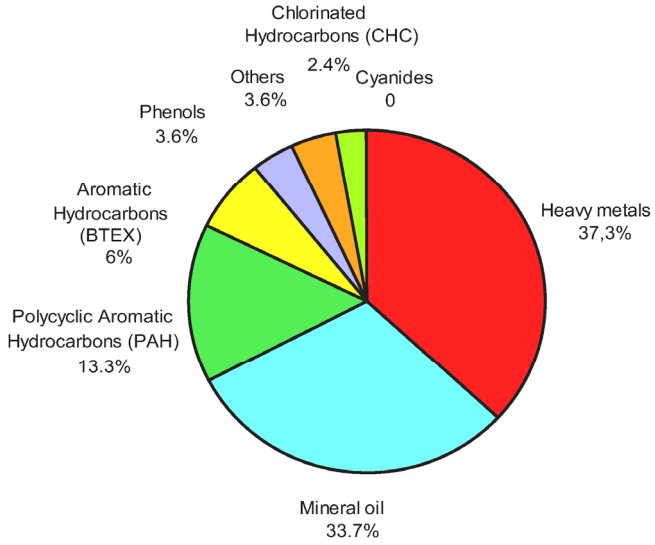

Fig. 3. *Distribution of contaminants in soil and groundwater in Europe* (http://themes.eea.europa.eu).

METHODS OF BIOREMEDIATION

Bioremediation is based on the presence in the soil and underground environment of microorganisms (bacteria, fungi) capable of degrading most organic carbonate pollutants and a good portion of inorganic pollutants. Biodegradation is a natural phenomenon, soil, subsoil and groundwater representing the normal life environment for microorganisms such as:

- bacteria: Pseudomonas, Bacillus, Arthrobacter
- fungi: Trichoderma, Penicillium and Aspergillus (Micle and Neag, 2009; Micle, 2009).

The biodegradation process develops through a chain reaction in which carbonic compounds are transformed by successive degradation in molecules becoming less and less complex, to obtain simple by-products (water and carbon dioxide) (Micle and Neag, 2009; Micle, 2009).

The bioremediation technology exploits different natural processes of reduction: natural attenuation, biostimulation and bioaugmentation. Besides monitoring, bioremediation without human interference is often called natural attenuation.

- Natural attenuation is based on the natural conditions and behavior of indigenous microorganisms in the soil.
- Biostimulation uses, also, microbial indigenous populations for contaminated soil remediation. Biostimulation consists of adding nutrients and other substances in the soil to stimulate the natural processes of attenuation.

- Bioaugmentation involves introducing exogenous microorganisms (coming from outside the soil environment), capable to detoxify a particular contaminant, sometimes using genetically modified microorganisms (Dana and Bauder).

The optimum ratio of nutrients for an efficient biological activity is carbon/ nitrogen/phosphorus equal to 100/10/1 (Micle and Neag, 2009; Micle, 2009). The optimum conditions for oil degradation are represented in table 2 (Thapa et al., 2012).

Table 2. *Environmental conditions necessary for degradation of hydrocarbons* (Thapa et al., 2012)

Parameters	Optimum value for hydrocarbon degradation
Soil humidity	30-90%
pH	6,5-8,0
Oxygen content	10-40%
Temperature	20-30
Nutrient content	C:N:P=100:10:1

Hydrocarbon degradability is influenced by the molecular structure and number of carbon atoms. Compounds with a small number of carbon atoms are most easily biodegradable, the C6-C20 compounds are easily degradable, C21-C29 compounds are medium degradable and compounds with more than 30 C-atoms are less degradable. Reactions of aerobic degradation of certain pollutants are presented in figure 4 (Micle, 2012).

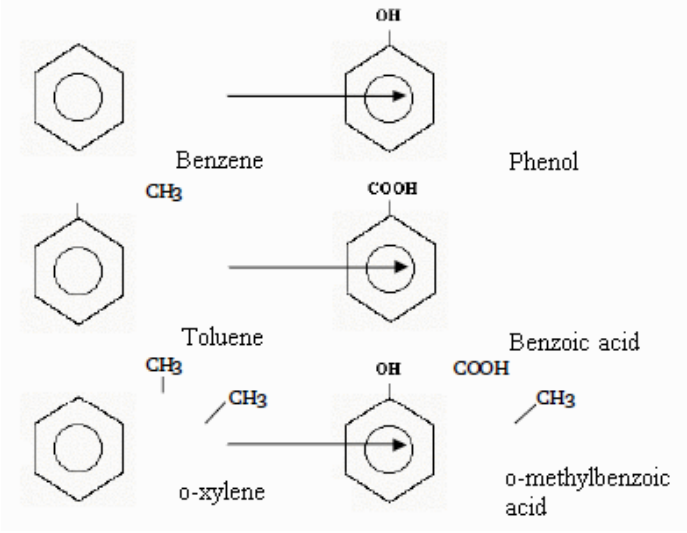

Fig. 4. *BTX degradation intermediates* (Micle, 2012).

Ex-situ bioremediation methods:

The bio-pile method is a bioremediation method where the excavated soil is mixed with amendments, formed in compost piles, which afterwards are closed for treatment. These piles are usually equipped with an air distribution system, using blowers or vacuum pumps. Several parameters of the process, such as nutritive substances and oxygen, can be controlled to improve the efficiency of the remediation process. This technology is used to reduce the petroleum compounds' concentration in the excavated soil. The treatment area is generally covered with an impermeable lining to minimize levigation of contaminants in the uncontaminated soil (*www.eugris.info*).

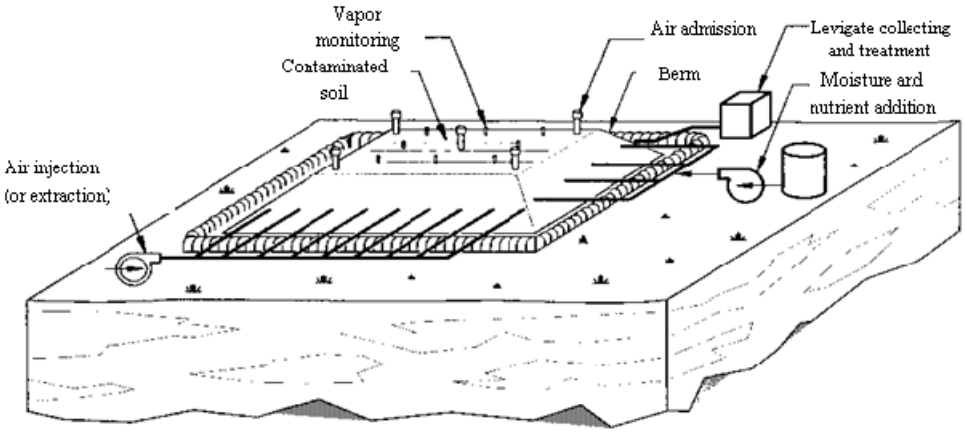

Fig. 5. *Bio-piles* (www.tankonyvtar).

Composting is a biologically controlled process by which organic contaminants in the soil are converted by microorganisms, both in aerobic and anaerobic conditions, in harmless products. Soils are excavated and mixed with bulking agents such as wood chips and plant wastes. Usually, the thermophilic conditions (54 to 65 °C) must be maintained in the compost. Appropriate conditions of oxygen and moisture help to achieve maximum degradation efficiency (*www.eugris.info*).

There are three main methods used in compost:

1. compost is formed into piles and aerated with blowers or vacuum pumps,
2. mechanically agitated in a composting vessel – compost is placed in a reactor vessel where it gets mixed and aerated,
3. compost is placed in long piles, periodical mixed with mobile equipment (www.eugris.info).

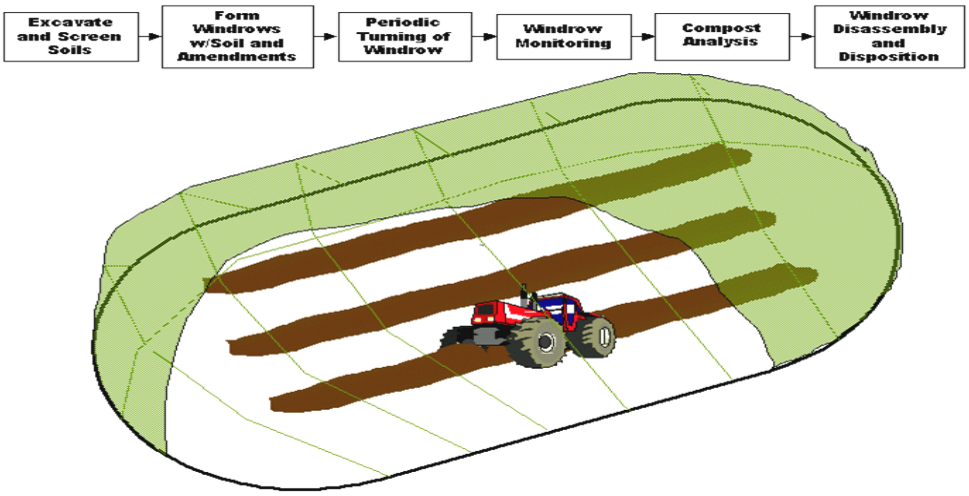

Fig. 6. *Composting* (www.frtr.gov).

Land farming is a soil remediation techniques consisting of soil excavation and deposition on a plain impermeable surface, a few centimeters thick, so that it can be worked with agricultural machinery. Soil is treated with fertilizer or manure and after that it is mixed with polluted soil. The soil is periodically excavated and turned for aeration and homogenization purposes (Micle and Neag, 2009).

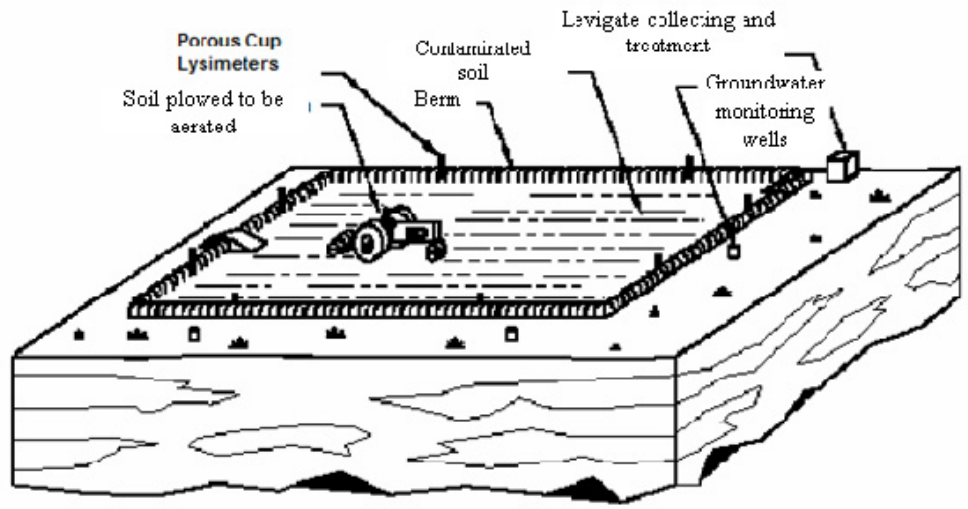

Fig. 7. *Land farming* (www.tankonyvtar).

Soil treatment in a bioreactor. Soil requires a prior suitable mechanical preparation: mixing, grinding, volumetric classification. Once prepared, soil is mixed with water, the result being a mud which is pumped into a system of bioreactors connected serially. In the first reactor the substances and sometimes additional bacteria are dosed. The bioreactor provides a vigorous mixing of nutritive substances with the polluted soil, and also an intense aeration through a device situated at the bottom of the bioreactor (Micle and Neag, 2009).

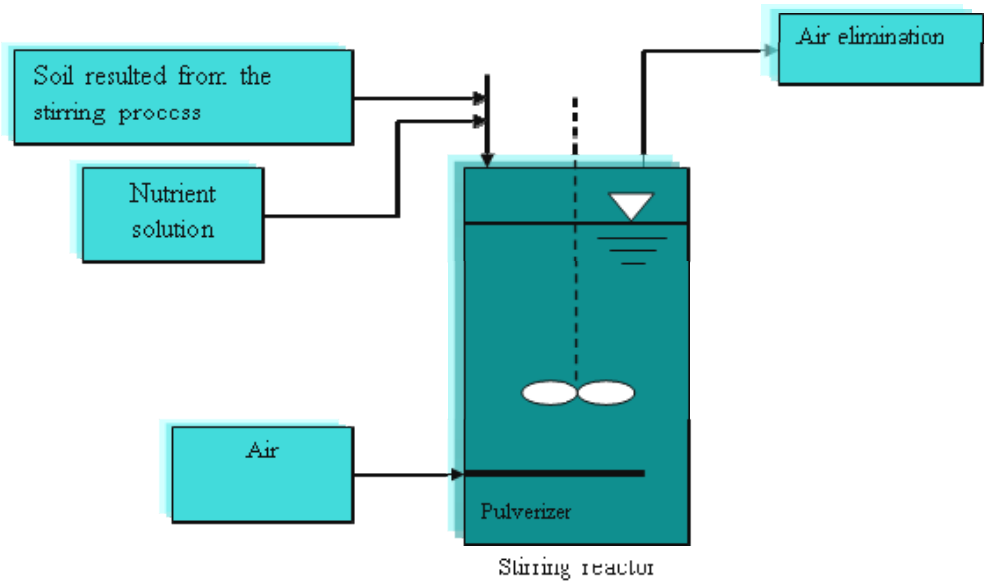

Fig. 8. *Soil treatment in a bioreactor (www.frtr.gov/matrix2/D01-4-14.gif.).*

Bioremediations presents a series of advantages, such as: (Kumar et al., 2011)

- Bioremediation is a natural process,
- Bioremediation is used to destroy a large number of contaminants,
- Bioremediation can often be performed in situ, without causing a major disruption of the normal activity,
- Bioremediation is less expensive than other technologies.

Bioremediations presents a series of disadvantages, such as: (Kumar et al., 2011)

- Bioremediation is limited to those components that are biodegradable. Not all compounds are sensitive to rapid and complete degradation.
- Bioremediation often takes more time than other remediation methods.
- Research is needed to develop bioremediation techniques that would be adequate for the contaminated site, with complex mixtures that aren't uniformly dispersed in the environment.

CONCLUSIONS

❖ Oil hydrocarbon pollution of the site is due to extraction, refining, distribution and transportation of oil. Oil and petroleum product consumption on a world wide scale is in a continuous growth, thus pollution with petroleum hydrocarbons represents a major problem for the environment.

❖ Bioremediation, a natural process based on the presence of indigenous microorganisms in the soil and on the introduction into the contaminated area of microorganisms capable of degrading a large number of pollutants, is successfully used in the remediation of soil contaminated with petroleum products. The degree of degradation of petroleum hydrocarbons is influenced by factors such as temperature, pH, soil humidity, oxygen concentration, nutrient concentration, concentration and type of hydrocarbons.

❖ The presence of oil in the ground has the effect of reducing nutrients (nitrogen, phosphorous, potassium and oxygen), which are essential for plant growth and development.

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LIDAR SIGNALS PRE-PROCESSING WITH PHYTON

Mihail Nicolae DĂNILĂ[1*]

[1] *"Alexandru Ioan Cuza" University of Iaşi, Faculty of Physics, Atmosphere Optics, Spectroscopy and Lasers Laboratory, 11 Carol I Blvd., 700506 Iaşi, România*
** E-mail: danila.mihail@yahoo.com*

ABSTRACT. In our days, a complex research of the atmosphere requires cutting-edge remote sensing techniques. The LIDAR (LIght Detection and Ranging) systems represent the main methods of profiling the atmosphere. The high spatial and temporal resolutions (3.5 meters and 1 minute respectively) and the possibility to monitor Earth's atmosphere to heights up to 100 kilometers, make the LIDAR a very attractive and necessary system. The variety of interactions between the atmospheric constituents and the radiation emitted by the LIDAR, allows the determination of the atmospheric variables of state (i.e. temperature, pressure, air density) and the determination of the aerosol concentration.

The implementation of Python programming for the analysis and interpretation of LIDAR signals was initiated in order to obtain the Range Corrected Signal Time Series, the atmosphere's molecular parameters and the atmospheric variables of state. Also, together with the Tele-cover method, one can determine if the LIDAR system is properly aligned. The measurements were made with the mini-LIDAR system from the Atmosphere Optics, Spectroscopy and Lasers Laboratory, "Alexandru Ioan Cuza" University of Iasi, partner of the Romanian Atmospheric Research 3D Observatory (RADO).

Key words: *LIDAR Network, laser and spectroscopy, python*

INTRODUCTION

Climatic changes, whose effects are seen increasingly even in Romania, are the result of human activity. This was one of the conclusions of the 2007 IPCC report (International Panel of Climate Change). The problem of accurately detecting the causes that produced and still produce significant changes in climate evolution is a delicate one, the anthropogenic influence overlapping the natural climate variability. Over the last few years, more and more is spoken of global warming as a result of the greenhouse gases concentration increase in the atmosphere. In the same time, scientific study has shown that variations in atmospheric composition can have an opposite effect than the one of greenhouse gases. This effect is due to the atmospheric aerosol, its increasing presence in the atmosphere causing a cooling of the climate system. Indeed, the aerosol and the anthropogenic aerosol (pollutants) in particular, have a direct radiative effect on the climate, by the reflection and absorption of the

solar radiation and an indirect influence by modifying the cloud's optical properties and lifespan. The loading of the atmosphere with aerosol and the resulting radiative influence had increased in the industrial period almost simultaneous with the influence of the greenhouse gases (Timofte et al., 2010; Stefan et al., 2008; www.ipcc.ch, 2007).

The necessity of compatible and reliable software tools, led to the implementation of Python programming for the LIDAR signals analysis. The goal is obtaining the Range Corrected Signal Time Series, the atmospheric variables of state and the atmosphere's molecular parameters.

The measurements were made with the mini-LIDAR system from the Atmosphere Optics, Spectroscopy and Lasers Laboratory, "Alexandru Ioan Cuza" University of Iasi (LOA-SL).

EXPERIMENTAL DETAILS

Our LIDAR system was developed in the framework of ROmanian LIdar NETwork (ROLINET) (Figure 1) research project and is mainly used to monitor the atmospheric aerosols and clouds in the troposphere. This is a multi - wavelength mini-LIDAR system with the transmitter based on a coaxial UV (355 nm), VIS (532 nm) and NIR (1064 nm) emission of a powerful and stable Nd:YAG laser with a variable repetition rate up to 30 Hz. The initial divergence of the 6 mm laser beam of 0.75 mrad was improved 5 times, by using a 3λ beam expander resulting in a beam of 30 mm diameter and a final divergence of 0.15 mrad. These features of the laser offer the possibility to measure at high altitudes for one minute integration time and a spatial resolution of 3.75 meters (Cazacu et al., 2012).

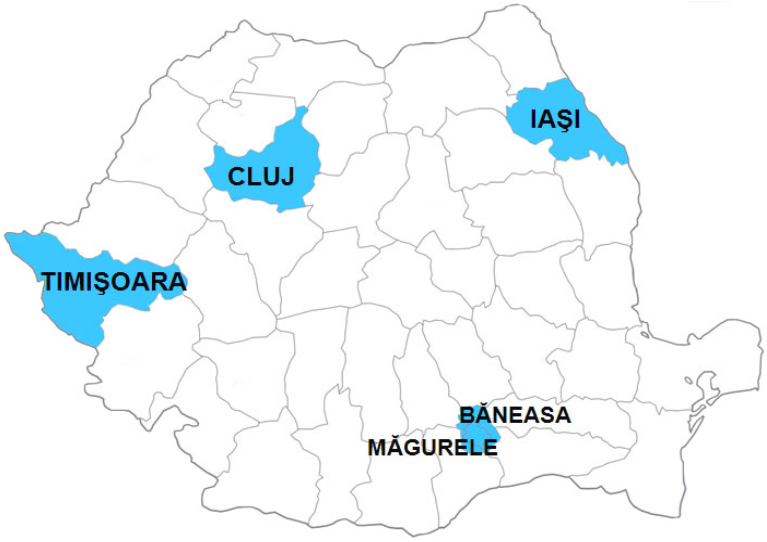

Fig. 1. *The Romanian LIDAR Network (ROLINET).*

Besides the laser, the LIDAR system from Iasi has a Newtonian telescope and an acquisition block that allows data to be recorded to a PC. A sample from a data file as well as a photo of the LIDAR setup, are shown in Figure 2.

RESULTS

Python(x,y) is a handy scientific and engineering development application specially designed for numerical computations, data analysis and data visualization. It is based on Python programming language, Qt graphical user interfaces, Eclipse integrated development environment and Spyder interactive scientific development environment. With Python(x,y), one can do: interactive calculations including for example 2D and 3D plotting or symbolic math, simple functional programming (with MATLAB-like syntax) as well as powerful object-oriented programming, scientific projects development from the simplest script to the most sophisticated application (*www.pythonxy.com, 2012*).

File Edit Options Help

```
i1152610.103558
Iasi     19/09/2012 10:09:35 19/09/2012 10:10:35 0170 0027.6 0047.2 00
0000000 0030 0001801 0010 02
1 0 2 12000 1 0850 3.75 00532.o 0 0 00 000 12 001801 0.500 BT0
1 1 2 12000 1 0900 3.75 00607.o 0 0 00 000 00 001801 3.1746 BC0
532.000 .o analog 0     607.000 .o photon 0
 19.6681          0.0000
 19.6765          0.0000
 19.6734          0.0000
 19.6976          0.0000
 19.3392          0.0000
 19.7477          0.0000
 19.4154          0.0000
 19.7098          0.0000
 19.6831          0.0000
 19.6459          0.0000
 19.6644          0.0000
 20.4856          0.0000
 24.1387          0.0000
 27.0111          0.0000
 25.1200          0.0000
 23.2787          0.0000
 23.5554          0.0000
 23.5505          0.0000
 23.3536          0.0000
 23.3504          0.0000
 23.1332          0.0000
 22.9720          0.0000
 22.8828          0.0000
 22.7172          0.0000
 22.5690          0.0000
 22.4925          0.0000
 22.4401          0.0000
 22.3704          0.0000
 22.2532          0.0000
 22.1381          0.0000
 22.0765          0.0000
 22.0484          0.0000
 22.0219          0.0000
 21.9992          0.0000
 21.9539          0.0000
 21.9224          0.0000
 21.9803          0.0000
 22.0565          0.0000
 22.1393          0.0000
 22.3746          0.0000
 22.8304          0.0000
 23.5251          0.0000
```

Fig. 2. *LIDAR setup (left) and data file example (right).*

In order to obtain accurate results, the first file in the measurements folder must contain data of the noise generated only by the LIDAR system's electronics (dark file). This is done by covering the telescope's mirror and closing the photo detector's diaphragm while making a measurement. If such a file is present, the noise will be subtracted from the other data files. Although the system records data from altitudes up to 60 kilometers, our system's telescope can "see" only up to 12 kilometers during daytime and 18 kilometers during night time. So, the values recorded at very high altitudes, are background noise. To reduce this noise, an average of values from the last 500, is also subtracted from the data files. With the corrected data, it is now possible to calculate the Range Corrected Signal (RCS). This is necessary because the signal's intensity decreases with the distance squared. Examples for both LIDAR and Range Corrected signals are given in Figure 3 (Danila et al., 2012).

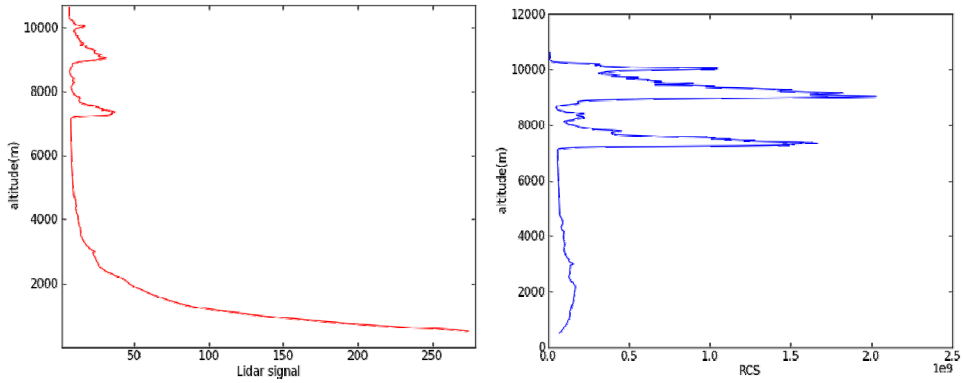

Fig. 3. *Example of plots for the LIDAR (left) and Range Corrected (right) signals.*

With the help of 3D arrays, which contain the file number from the data folder, the channel number and the signal or RCS value, the signal data from the LIDAR system is processed. 2D arrays are used to store data from the header of each input file. Also some simple arrays are used for getting the altitude from the bin number and the ASL (Above Sea Level) and converting the file number to time (for measurements done with 60 seconds time resolution, each file represents one minute on the time axis). A part of the code used for processing is given as an example in Figure 4.

```
#Get Files
for infile in glob.glob( os.path.join(path, '*.txt') ):

    f = open(infile)
    ln = 0  # line number

    #Get Header Info
    for line in f.readlines():

        if ln < 6:
            ln = ln+1
            # loop over the elemets, split by whitespace
            for i in line.split():
                # convert to integer and append to the list
                header[fn].append(i)
    f.close()

    #Get Values
    f = open(infile)
    ln = 0
    j = 0
    for line in f.readlines():

        if ln > 5 :
            ln = ln + 1
            # loop over the elemets, split by whitespace
            for i in line.split():
                if j % 2 == 0:
                    # convert to integer and append to the list
                    first_values[fn].append(float(i))
                    j = j+1
                else:
                    second_values[fn].append(float(i))
                    j = j+1
        else:
            ln = ln+1
```

Fig. 4. *Example of the code used to process the LIDAR data.*

After all the calculations are done, the 3D RCS Time Series can be plotted, giving information about the atmospheric constituents (Figure 5).

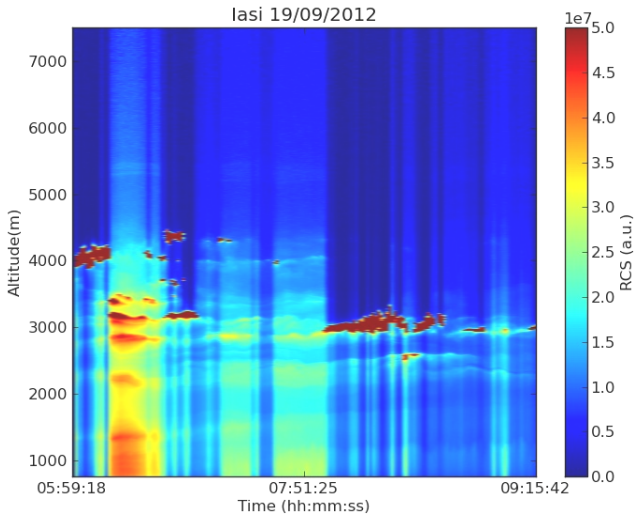

Fig. 5. *3D RCS Time Series example, night time profiles, elastic channel, 532 nm wavelength, 60s temporal resolution, 3.75m spatial resolution*

Also, at this point it is possible to determine the atmospheric variables of state (temperature, pressure, air density) (Figure 6) (Danila et al., 2012).

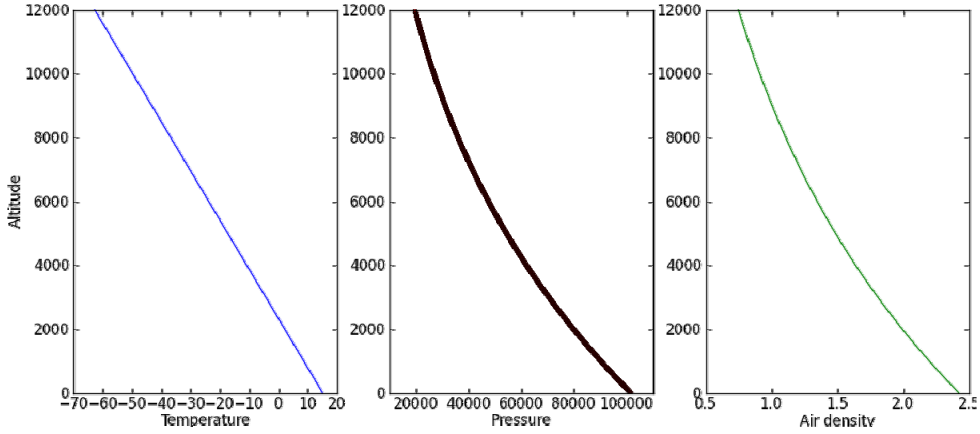

Fig. 6. *Plot example of the atmospheric variables of state*

As a side feature of the Python application, one could check if the LIDAR system is properly aligned using the Telecover method. LIDAR signals taken with different parts of the telescope covered are compared to each other (Figure 7). If the system is aligned properly, the signals don't show any differences apart from the overlap range. Telecover signal differences indicate range dependent transmission changes in the optics, which cause signal distortions in the total signal (Freudenthaler, 2008).

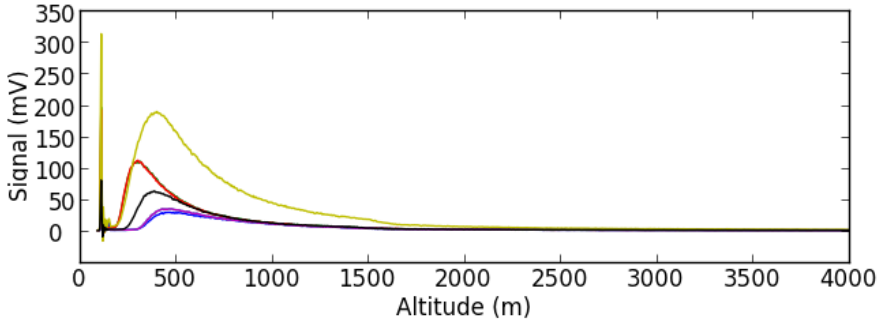

Fig. 7. *Example of Telecover signals, 532 nm wavelength elastic channels.*

CONCLUSIONS

Due to the interaction between the atmospheric constituents and the radiation emitted by the LIDAR, the determination of the atmospheric variables of state and the determination of the aerosol concentration is possible. To this end, the use of Python programming for the analysis of LIDAR signals was initiated. Also, the Range Corrected Signal Time Series was obtained and further development will improve the understanding and characterization of tropospheric aerosols.

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EXPERIMENTAL RESEARCHES REGARDING THE THERMAL BEHAVIOR OF ASBESTOS CEMENT WASTES USING THERMOGRAVIMETRIC ANALYSIS

Silvian IONESCU[1], Cristian DEAC[2,*], Toderiţa NEMEŞ[2], Valentin PETRESCU[2], Marius BIBU[2]

[1] PFA, Bucharest, Romania
[2] "Lucian Blaga" University of Sibiu, Romania, Faculty of Engineering
** Email: cristian.deac@ulbsibiu.ro*

ABSTRACT. The paper presents experimental laboratory studies for the inertisation of asbestos cement containing wastes through heat treatment. The objectives of this study were the characterisation of wastes, before and after the heat treatment and the determining of optimal inertisation parameters for the asbestos-containing wastes. The main stages of the experimental researches were the identification and preparation of samples, the calcination of samples and the thermogravimetric analysis of asbestos cement wastes. Following the researches, a heat treatment regime was identified that implied a lower calcination temperature (1050°C as compared to 1200°C) and a much lower duration (5 h instead of 16 h) than indicated in the previous studies found in the specialty literature.

Key words: *wastes, asbestos, calcination, thermogravimetric analysis*

INTRODUCTION

The term asbestos refers to a whole class of silicate minerals with fibrous crystals, containing compounds with different chemical compositions and crystal structures. These compounds can be grouped into two mineralogical categories: serpentines and amphiboles. Asbestos crystals have some exceptionally good properties, such as a high resistance to chemical agents and fire, an extremely low thermal, electrical and acoustic conductivity, high tensile strength etc. (Ionescu, 2011).

However, Asbestos has been recognized in the last few decades as a hazardous, carcinogenic substance and its production and use have been banned or at least severely restricted in most countries. Nonetheless, at world level there exist currently large amounts of asbestos, especially as asbestos cement, since its outstanding properties mentioned above have allowed it to be extensively used for construction works in the 20th century.

The preferred method of disposal is currently the storage in special landfills for hazardous materials. However, this would lead in time to the need for setting aside huge areas of land for this storage, so there have been sought alternative means for treating, inertising asbestos-containing wastes. Following the researches carried out so far, it has been determined that the best method for reducing the hazard level of asbestos cement is thermal inertisation (Ionescu, 2011).

The major disadvantage of currently applied technologies resides in the high consumption of energy for the calcination of asbestos-containing wastes, which sometimes exceeds the costs for its storage.

In the speciality literature there can be found studies of thermal decomposition between 200ºC and 1200ºC for pure asbestiform minerals, especially crysotile (Gualtieri et al., 2008a; Zaremba and Peszko, 2008; Zaremba et al., 2010), riebeckite (Gualtieri et al., 2008a) and tremolite (Gualtieri et al., 2008a). Similar studies are presented also for asbestos cement, but only for monoblock samples (tiles with a dimension of ca. 1220 x 570 x 10 mm) (Gualtieri et al., 2008a; Gualtieri et al., 2011; Gualtieri et al., 2008b). In (Gualtieri et al., 2008b), the authors considered that the decomposition process ended at over 1150ºC and proposed the temperature of 1200ºC as being the minimal value that can be recommended for the thermal inertisation of asbestos cement in an industrial oven, for a duration of 16 hours.

The current paper intends to optimize the temperature and duration of the calcination process, within the limits allowed by the physical-chemical properties of the various types of industrial asbestos and to determine precisely the composition of the solid phases resulted from the heat treatment. Also, the authors used ground or crushed asbestos cement samples rather than whole tiles.

EXPERIMENTAL METHODOLOGY

Identifying and preparing the samples

The samples included in this study consisted of asbestos cement tiles waste (figure 1.a) supplied by SC Remat Holding SA, Bucharest, Romania. These tiles were ground to micrometric dimensions or crushed to medium sizes of about 10 x 10 x 5 mm (figures 1.b and c). The samples were coded as indicated in table 1.

The main chemical components of the asbestos cement waste taken into account were:

- Asbestos components:
  - Crysotile, $Mg_3Si_2O_5(OH)_4$;
  - Amphiboles: Tremolite, $Ca_2Mg_5\ Si_8O_{22}(OH)_2$
    Actinolite, $Ca_2(MgFe)_5Si_8O_{22}(OH)_2$
    Antofilite, $(MgFe)_7Si_8O_{22}(OH)_2$
    Riebeckite, $Na_2Fe_3^{II}Fe_2^{III}\ Si_8O_{22}(OH)_2$
    Grunerite, $(FeMg)_7Si_8O_{22}(OH)_2$

- Cement components:
  - C2S – Larnite (Belite), $2CaO \cdot SiO_2$ or Ca_2SiO_4;
  - C3S – Alite, $3CaO \cdot SiO_2$ or Ca_3SiO_5;
  - C3A – Tricalcium aluminate, $3CaO \cdot Al_2O_3$ or $Ca_3Al_2O_6$;
  - C4AF – Brownmillerite, $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ or Ca_2AlFeO_5;
  - Gypsum – Calcium sulfate dihydrate, $CaSO_4 \cdot 2H_2O$;
  - Calcite – Calcium carbonate, $CaCO_3$;
  - Portlandite – Calcium hydroxide $Ca(OH)_2$.

a) b) c)

Fig. 1. *Asbestos cement plate waste: (a) whole, (b) crushed and (c) ground*

Table 1. *Coding of the samples used during the experimental researches*

• **Pm:**	Ground samples, not heat treated;
• **Pb:**	Crushed samples, not heat treated;
• **Pm-Θ-t:**	Ground samples, calcinated at the temperature Θ (ºC), for t minutes;
• **Pmm-Θ-t:**	Ground samples, calcinated at the temperature Θ (ºC), for t minutes and fine grinded after calcination;
• **Pb-Θ-t:**	Crushed samples, calcinated at the temperature Θ (ºC), for t minutes;
• **Pbm-Θ-t:**	Crushed samples, calcinated at the temperature Θ (ºC), for t minutes and fine grinded after calcination.

Thermogravimetric analysis of the waste samples

The ground waste sample (Pm) was subjected to a thermogravimetric analysis (TGA) in order to determine its thermal behaviour and the heating regime necessary for the subsequent calcination stage. The thermogravimentric analysis allows the study of some physical-chemical properties of a substance function of temperature and/or time. For example, there can be determined:

- the melting, sublimation and crystallisation temperatures of the substance;
- the chemical decomposition temperatures of the substance and the corresponding chemical process;

- the caloric effects associated with physical-chemical processes;
- the kinetics of chemical processes etc.

The thermogravimentric analysis (TGA) actually can refer to three types of tests:

- the proper thermogravimetric analysis, TG;
- the derivated thermogravimetric analysis, DTG;
- the differential thermal analysis, DTA.

The proper thermogravimetric analysis, TG, determines the nass variation for the analysed sample function of the temperature. It is carried out using a high precision thermal balance, placed in an oven and employing an automated system for monitoring the sample's mass and temperature. The measurement can be carried out in an inert atmosphere (nitrogen) or in air, with a static or dynamic gas circulation regime. The interpretation of the TG curve offers information on the chemical behaviour of the substance function of the temperature and allows the determining of the composition and stability of the solid at various temperatures.

The derivated thermogravimetric analysis, DTG, is designed to increase the sensitivity of the thermogravimetric analysis by representing the derivative of the mass variation in relation to the temperature variation, function of the temperature. Thus, the DTG curve may indicate mass variations corresponding to chemical processes that are not visible on the TG curve or which come in rapid succession. The DTG curve can precisely indicate the temperature at which the chemical reaction unfolds at maximal speed and thus allows to carry out kinetic studies.

The differential thermal analysis, DTA, measures the temperature difference between the sample and a reference material such as alumina or quartz, function of the temperature. The DTA curve allows the interpretation of caloric effects associated with the physical-chemical processes by indicating the endothermal and exothermal phenomena.

For the studies describes in this paper, there has been carried out a simultaneous TG/DTA/DTG analysis, using an SDT Q600 TA analyser from the Faculty of Chemistry and Chemical Engineering of the ″Babeş-Bolyai″ University of Cluj-Napoca. This analysis was recorded in the temperature interval 50–1000ºC, in air current (100 ml/min), at a heating speed of 10ºC/min. During the heating, the sample was placed in an alumina crucible.

Calcination of the waste samples

The authors have calcinated amounts of ca. 10 g of ground (Pm) and crushed (Pb) waste samples in the temperature interval 800–1050ºC, for time periods between 1 and 6 hours, in a heat treatment furnace Nabertherm Controller P320 owned by the Materials Science laboratory from the "Lucian Blaga" University of Sibiu (figure 2), using ceramic crucibles (figure 3).

The goal of these researches was to determine the optimal temperature and duration of the calcination process for the ground and crushed asbestos cement waste samples.

The calcination temperatures were chosen as follows:

- The calcination temperatures of 800 and 850ºC were chosen based on the decomposition temperature indicated in the speciality literature for chrysotile (Gualtieri et al., 2008a; Zaremba and Peszko, 2008; Cattaneo and Gualtieri, 2003; Gualtieri et al., 2004);
- The calcination temperatures of 950ºC was chosen based on the decomposition temperatures indicated in the speciality literature for amphiboles (except for tremolite) (ATSDR, 2012);
- The calcination temperature of 1050ºC was chosen based on the decomposition temperature indicated in the speciality literature for tremolite (ATSDR, 2012).

Fig. 2. *Calcination of asbestos cement samples in the Nabertherm Controller P320 furnace*

(a) (b)

Fig. 3. *Asbestos cement samples after calcination: a) ground sample; b) crushed sample.*

STUDY OF THE THERMAL BEHAVIOUR OF ASBESTOS CEMENT WASTES THROUGH THERMOGRAVIMETRIC ANALYSIS

For the purpose of the current researches concerning ground and crushed, respectively, asbestos cement waste samples, there has been carried out a simultaneous TG/DTA/DTG thermogravimetric analysis on the temperature range between 50–1000ºC, in air current. The resulting TG, DTA and DTG are presented in figure 4, while the chemical processes unfolded during calcination are indicated in table 2, compared with data collected from the speciality literature.

The TG curve indicates a continuous mass loss of about 7% in the temperature range 50–400ºC, corresponding to the elimination of water adsorbed by asbestos cement and to the dehydration of hydrated silicates, marked on the DTA curve as a minimum at 450ºC. The mass loss (around 1%) continues until a temperature of 500ºC, this time attributable to the dehydration of portlandite in an endothermal process. This thermal behaviour is confirmed by similar processes occurring in samples of pure crysotile (Zaremba and Peszko, 2008) and cement (Hoffmann, 2008), studied separately.

Between 500 and 750ºC there occurs a major mass loss (around 17%) in the samples, marked on the DTA by endothermal effects, the most visible one presenting a minimum at 717ºC. This mass loss can be attributed to the dehydroxylation of crysotile.

Between 750 and 1000ºC there occur no significant mass losses, even if the DTG presents several chemical processes that finish at around 860ºC. These can be attributed to the decomposition of minor amounts of carbonates and sulfates and/or to the decomposition of some amphiboles. The speciality literature (Gualtieri et al., 2008a; Zaremba and Peszko, 2008; Cattaneo and Gualtieri, 2003; Gualtieri et al., 2004) indicates that the dehydroxilation products of crysotile will recrystallise between 800 and 850ºC, mainly as forsterite.

Table 2. *Thermal decomposition processes of ground asbestos cement waste as resulted from the experimental researches, compared to data from the speciality literature*

$\Delta\Theta_{exp}$, TGA (ºC)∗	**Processes**	**$\Delta\Theta_{ref}$, TGA (ºC)∗**		
		Crysotile (Zaremba and Peszko, 2008)	**Cement** (Hoffmann, 2008)	**Asbestos cement** (Gualtieri et al., 2008[a], Cattaneo and Gualtieri, 2003, Gualtieri et al., 2004)
50–400	Dehydration	150–500	50–350	< 600
400–500 450	Dehydroxilation $Ca(OH)_2 \rightarrow CaO + H_2O$	–	430–460	
500–750	Decarbonatation $CaCO_3 \rightarrow CaO + CO_2$	–	790	850–900
717	Dehydroxilation $Mg_3Si_2O_5(OH)_4 \rightarrow Mg_3Si_2O_7 + 2H_2O$	600–725 710	–	700–800
750–1000	Recrystallisation $Mg_3Si_2O_7 \rightarrow Mg_2SiO_4 + MgSiO_3$	725–1000 840	–	

∗ *exp = experimental data; ref = data from the speciality literature*

The stabilisation of a first flat line on the TG curve (figure 4) confirms the decomposition temperature of crysotile indicated in the speciality literature (Gualtieri et al., 2008a; Zaremba and Peszko, 2008; Cattaneo and Gualtieri, 2003; Gualtieri et al., 2004) and supports the selection of the calcination temperatures of 800 and 850ºC in the present study.

The last flat line present on the TG curve (figure 4) confirms the decomposition temperatures of most amphiboles (ATSDR, 2012) and supports the selection of the calcination temperature 950ºC in the present study.

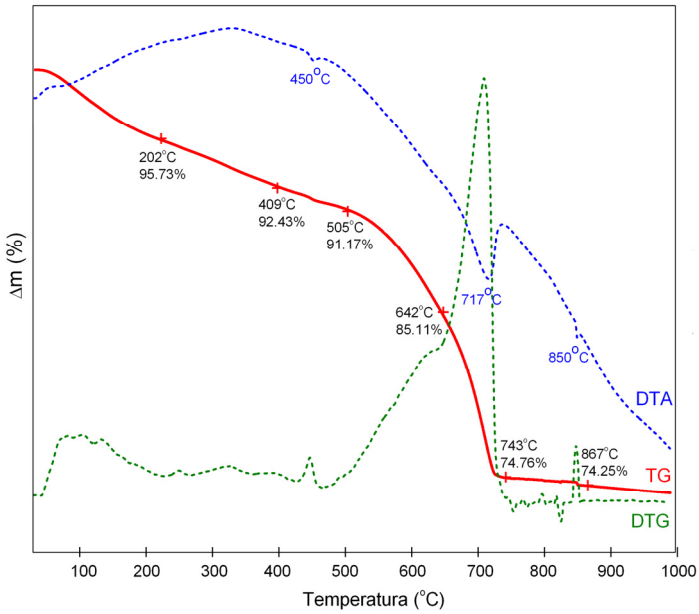

Fig. 4. *Simultaneous **TG/DTA/DTG** curves recorded for the studied asbestos cement samples*

CONCLUSIONS

Following the experimental researches carried out by the authors, following aspects can be noted:

- There were identified thermal inertisation parameters based on which there can be set up a an industrial thermal inertisation procedure for asbestos cement waste.
- The experiments showed that it is possible to significantly reduce the calcination temperature and duration for crushed asbestos cement waste as compared to previous similar studies in the speciality literature (1050°C/5h compared to 1200°C/16 h), at the same time providing safety limits for the destruction of crysotile and amphiboles.

- The calcination durations for the samples (1 – 6 hours) are relevant in the context of the evolution of crystallisation processes, the higher values, in accordance also with the temperature considered as optimal (1050ºC / 5 hours) allowing a disappearance of fibrous asbestos-type crystals from the structure.
- The crushed samples showed a similar thermal behaviour to the ground ones, which allows a discarding of the grinding process, thus significantly reducing the risks of exposure to asbestos.

Based on these facts and conclusions, it can be stated that the ground or crushed asbestos cement waste, calcinated under laboratory conditions at a temperature of 1050ºC for 5 hours is certainly free of asbestiform fibres and presents a good crystallisation of the constituent phases.

These researches will be followed up by crystallographical analyses (XRD), SEM analyses and FT-IR spectroscopy analyses.

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EXPERIENCE OF 3D WIND MEASUREMENTS WITH SODAR IN DEBRECEN, HUNGARY

Andrea KIRCSI[1*], István LÁZÁR[1], Károly TAR[2], Monica COSTEA[3]

[1] *University of Debrecen, Department of Meteorology, Egyetem tér 1, 4032 Debrecen, Hungary*
[2] *Collage of Nyíregyháza, Institute of Tourism and Geography, Hungary*
[3] *University of Oradea, str. Universitatii nr. 1, Oradea, Romania, Romania*
** Email: kircsi.andrea@science.unideb.hu*

ABSTRACT. Utilizations of wind energy quickly spread around the world which results in growing number of wind measurements but not only in near-surface region (10 m) also higher altitude are able to provide datasets. The SODAR (Sound Detection And Ranging) represents terrestrial remote sensing techniques which are becoming more and more popular tools today to exploring wind conditions of a few hundred meters thick atmosphere. The Department of Meteorology at University of Debrecen purchased a PCS.2000-24 type phase – array, monostatic Doppler SODAR equipment which give an unique possibility to carry out 3D wind monitoring in Debrecen. We collect information about properties of wind profile between 20 and 400 m height above surface, parameters and process of planetary boundary layer in order to accomplish objectives of REGENERG HURO project. Our main objective was to discover geographical distribution of wind speed in Hajdú-Bihar and Bihor County in order to promote wind energy in this region. In research we adapted a well-known CFD based numerical model to mapping wind regime, and we used SODAR dataset to make verification of modelled results.

The implementation of the research project is supported by HURO/0802/083_AF REGENERG.

Key words: *wind measurements; SODAR; wind energy; wind resource assessment*

INTRODUCTION

Increasing wind energy utilization receives priority in the European Union and in many countries in the World as fighting against climatic change becomes a key issue of national energy policies. In numerous countries the free wind-power potential is applied to ensure energy supply safely. In order to develop wind energy utilization it is highly important to study the availability of wind energy both in space and time. Furthermore, it is important to know those characteristics of wind energy that helps to integrate wind power plants into the electric energy system without threatening security of supply.

By the end of September of 2012 the European Union has passed 100 gigawatts (GW) of installed wind power capacity (EWEA, 2012a). This value end of 2011 was 94GW, which capacity able to produce with normal wind condition approximately

204TWh electricity and meet 6,3% of EU's total electricity demand (EWEA, 2012b). The wind energy became an important contributor of electricity production of EU in the last years. The Energy Roadmap 2050 of European Commission expects the wind energy will be a key technology in electricity production and to reach CO_2 emission reduction target by 2020 (EC, 2011). The quick growth of wind industry can help development of wind power meteorology, which applied research area important to discovery wind regime of an area to utilize energy from wind.

Our common target with University of Oradea in REGENERG HURO project is to help with information the efficient utilization of renewable energy sources in Romanian Bihor and Hungarian Hajdú-Bihar County. The main aims of wind energy workgroup are to investigate wind condition based on measurements in this two county. In first research period we determined three own measurement points to our wind resource assessment: one near to Debrecen in Hungary, a two points in Romania (Stane de Vale and Oradea) with wind mast (Fig. 1.). In this article we present our common result in Hungarian site of research area.

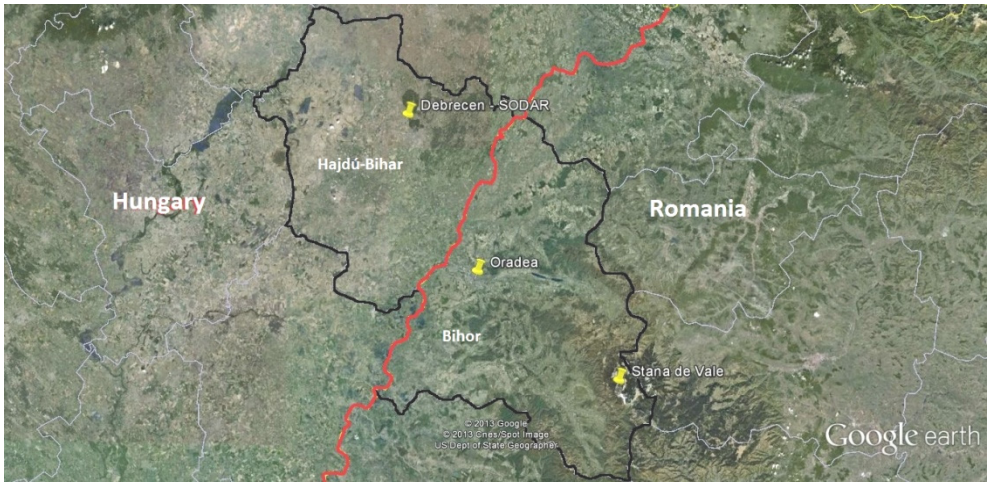

Fig. 1. *Wind measurement points in HURO REGENERG project (GoogleEarth image)*

DATA AND METHODS

Onto the aim of the wind climatology research the Department of Meteorology at University of Debrecen purchased a PCS.2000-24 type phase –array, monostatic Doppler SODAR equipment from METEK Gmbh, Germany (Fig. 2.). This wind monitoring system is unique in Hungary, which gives an excellent possibility to carry out 3D wind monitoring in environment of Debrecen city. We collect information about properties of wind profile between 20 and 400m height above surface, parameters and process of planetary boundary layer.

Fig. 2. PCS.2000-24 Doppler SODAR (by METEK) in Debrecen, Hungary

Our research area is located around 5km north from Debrecen city in the Hungarian Great Plain, over a relatively flat area (47°34'35.71"N and 21°34'54,49" altitude:125m) (Fig 3.). The SODAR took place in Agrometeorological Observatory of University of Debrecen. In wind resource assessment we used a 5 months long period between 10th of May and 30th of September in 2012.

Fig. 3. Panorama photo by István Lázár about environment of SODAR in Debrecen, Hungary

The SODAR (Sound Detection And Ranging) represents terrestrial remote sensing techniques which are becoming more and more popular tools today to exploring wind conditions of a few hundred meters thick atmosphere. Coulter and Kallistratova (2004) provide a detailed review about evolution of SODAR technology in two decades between 1981 and 2002 and determine that SODAR provide excellent estimates for mean wind speed and direction. The PCS.2000-24 type SODAR developed by METEK GmbH and this equipment produce acoustic pulses of certain frequencies which backscatter into the atmosphere. The frequency of the Doppler-shifted returning pulse is related to the radial velocity, the components of the wind vector are obtained using three antennas aimed in orthogonal directions (Viana et al,

2012). We are operating our SODAR with multi-frequency mode, carrier frequencies range between 1800-2300Hz, vertical resolution 10m, averaging period 10 minutes. Height range of sounding is from 20m to 250-390m. The maximum accessible height depends on thermal stratification of the boundary layer and on the level of ambient acoustic noise. We calculate 10m wind speed time series from measured windprofile.

RESULTS AND DISCUSSION

Main characteristics of wind climate around Debrecen

The climatic and energetic analyses of the SODAR measurements were performed with the help of the software Windographer 1.49 developed by the Mistaya Engineering Inc. We calculated statistical parameters of wind speed in different height and it has been found that average wind speed changed in summer months of 2012 between 3,28-6,59m/s. Energetical utility wind speed (>5m/s) we found above 100m from ground in Debrecen.

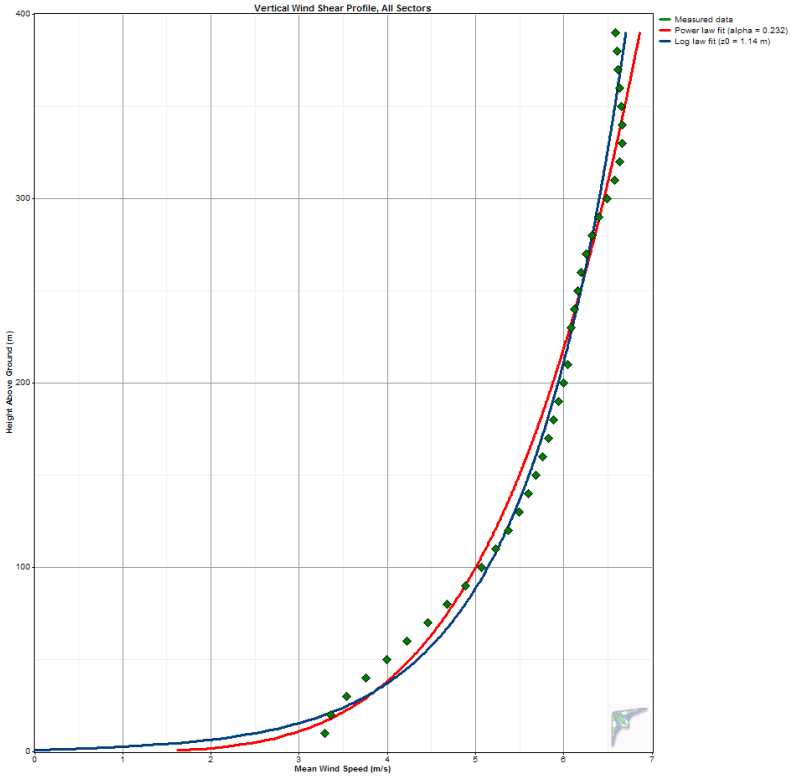

Fig. 4. Averaged vertical profile of wind speed between May and September 2012 in Debrecen, Hungary

Based on SODAR datasets the measured vertical wind profile (Fig 4.) we approached by power low and logaritmical wind profile function. The power law assumes that the wind speed varies with the height above ground according to the following equation:

$$\frac{U(z_2)}{U(z_1)} = \left(\frac{z_2}{z_1}\right)^{\alpha}$$

Where $U(z)$ is the average wind speed (in m/s) at some height above ground z (in m) and α is the power law exponent.

The value of the power law exponent change between 0,14-0,4 depend on stability of atmosphere, and roughness of environment. Based on SODAR measurement we calculate $\alpha = 0.232$.

The logarithmic law assumes that the wind speed varies logarithmically with the height above ground according to the following equation:

$$U(z) = \frac{U^*}{k} \ln \frac{z}{z_0} \text{ if } z > z_0$$

Where $U(z)$ is the wind speed [m/s] at some height above ground z [m], U^* is the friction velocity [m/s], k is von Karman's constant (0.4), z_0 is the surface roughness [m], *ln* is the natural logarithm. In this equation the main parameter is z_0. We calculated it: $z_0 = 1{,}14$ m, which correspond a suburban landscape type.

Fig 5. presents mean daily profile of wind speed in different heights based on SODAR measurement. As you can see in the daytime is higher wind speed in lower level, characteristically until 50m, while above these levels we found at night very high wind speed. The average wind speed reaches 8m/s at 4-5 hour near 300m above ground.

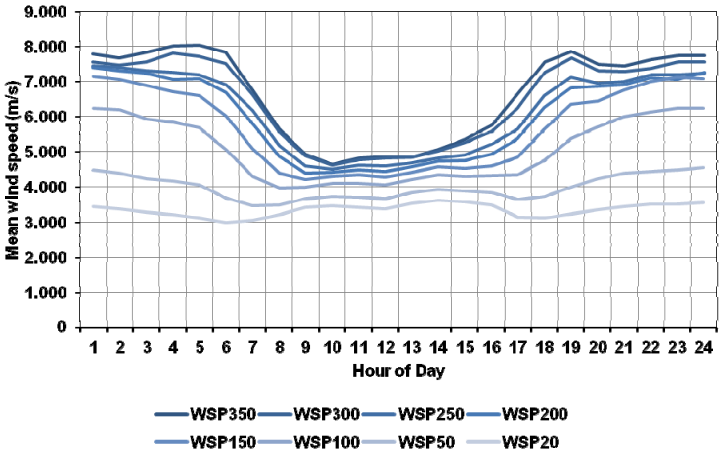

Fig. 5. Averaged diurnal profile of wind speed on different heights between May and September of 2012 in Debrecen, Hungary

In Fig 6. we shows an example of a vector plot (wind speed by colour, wind direction by arrows), where we detected wind shear and any properties of nocturnal and daytime boundary layer until approximately 400m.

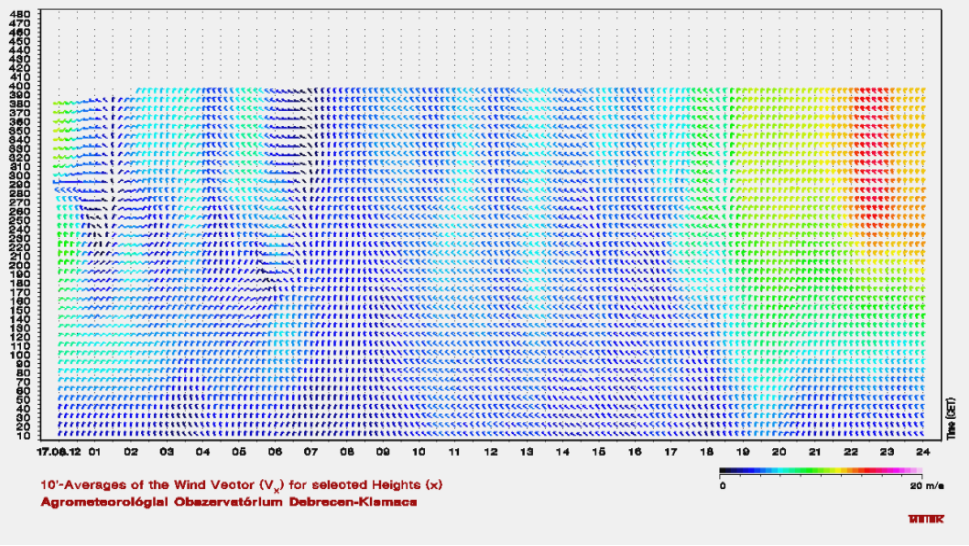

Fig. 6. Vectorplot of SODAR measured wind speed and direction on 17th August 2012 in Debrecen, Hungary

Modelling geographical distribution of wind speed near Debrecen

We compared it already in our earlier examinations (Kircsi, 2003), that what kind of principles doing the regional extrapolation of wind speed data. Above the surface have collectively influenced the velocity of streaming air by the exterior and inner friction, the topographic features, roughness of the surface and surface artificial obstacles. If the effect of the topographic features is negligible, then the roughness change admitting inner boundary layer models give a good solution (for example WAsP model). In terms of the turbulence a dynamic approach may be more suitable in case of sites with complex topographic feature.

We applied to examination of wind resource of Debrecen the 5.1 EV version of WindSim model. The wind farm design tool based on CFD (Computational Fluid Dynamic) analysis. It developed by Norwegian VECTOR AS. WindSim is based on a 3D Reynolds Averaged Navier Stokes (RANS) solver (Castro et al., 2003; Lopez et al, 2007). The name of this original software is PHOENICS. Solving the non-linear transport equations for mass, momentum and energy makes WindSim a suitable tool for simulations in both complex terrain, and in situations with complex local climatology.

The model with a modular construction the average wind speed influenced by the topographic features gets in more stair to a spatial distribution, that the selected wind power defines the expected power generation of utilising equipment in a final result.

The Terrain module generates a 3D model of the area based on elevation and roughness data. The Wind Field module simulates how the terrain affects local wind conditions in terms of speed-ups, direction shifts, and turbulence. Placement of turbines and measurement points is done in the Objects module. The Results module allows easy inspection of flow variables such as wind speed, directional shifts, turbulent intensity, and the vertical component of the wind. The wind resource map is established by weighting the wind database against measurements. The wind resource map is the basis for the energy optimization. The Energy module is where calculate the annual energy production (AEP) for each turbine within the wind farm. Practical aim is, that planned wind power plants get optimal place in terms of the wind potential.

The initial points to run WindSim model is a digital terrain map. In the first section of our research we used a terrain model from SRTM (Shuttle Radar Topography Mission) database which prepared in February of 2000 by NGA (National Geospatial-Intelligence Agency) és a NASA (Farr et al, 2007). The grid resolution of terrain model was 90m x 90m. The applied digital terrain modell shows Figure 7.

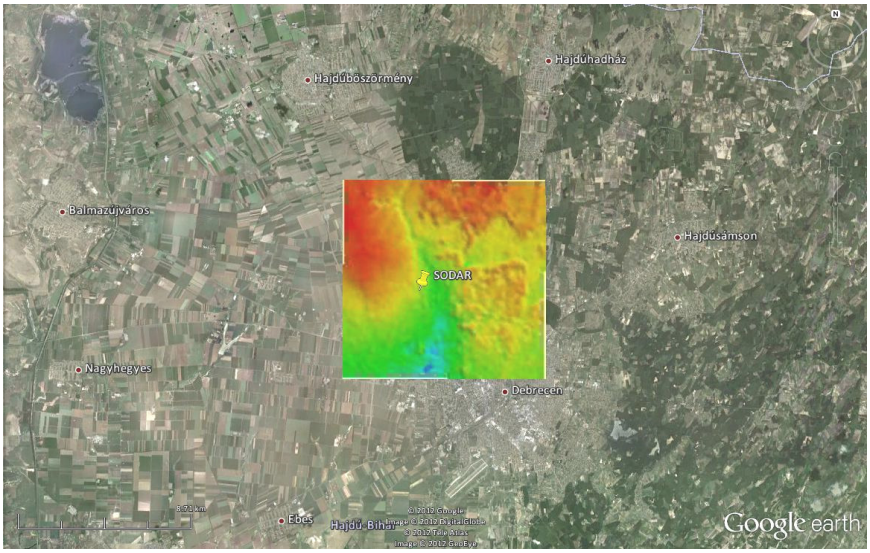

Fig. 7. *SRTM digital terrain model of the research area*

In flat landscape the WindSim requires a detailed roughness map of modelled area. We adapted an European surface roughness datasets from Dataforwind Service (http://www.dataforwind.com/).

The roughness information is based on the Corine Land Cover 2000 (CLC2000). It is produced by the European Environment Agency (EEA) and its member countries in the European Environment Information and Observation Network (Eionet). It is based on the results of IMAGE2000, a satellite imaging programme undertaken jointly by the Joint Research Centre of the European Commission and the EEA. Land-use categories were transform into aerodynamic roughness length by Dataforwind Service (Fig 8.). This dataset service for wind industry based on results of EO-Windfarm project which completed in 2004 (Ranchin et al, 2004).

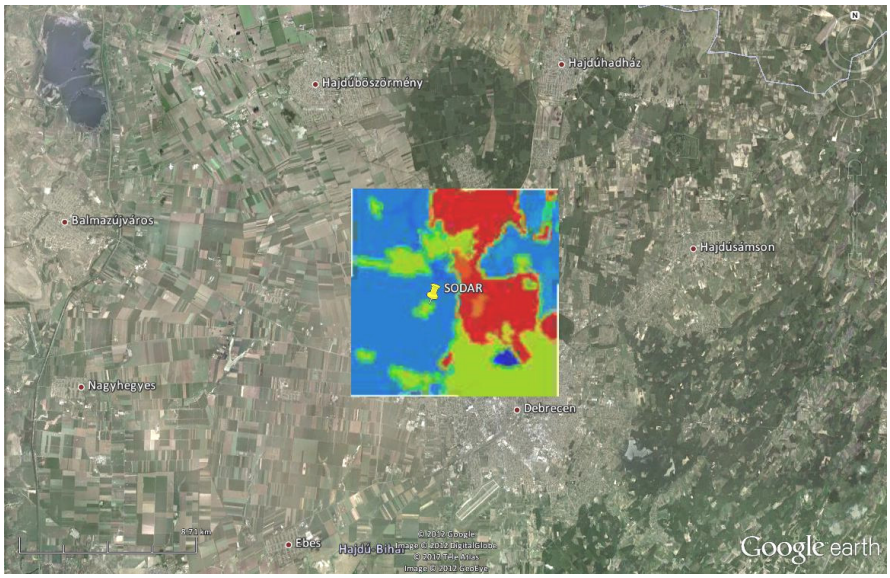

Fig. 8. *Aerodynamic roughness length model of the research area based on http://www.dataforwind.com/ (Red – forest, Green – town, Blue – arable)*

After the WindSim calculate the effects caused by topography and roughness, in the next step wind speed distribution of direction sectors must be taken into account. The frequency distribution of direction uses the model to calculate wind resource map (Fig. 9.), we used 50m dataset for this action. In north part of Debrecen we found that north-west, north and south-east direction is the most frequent wind direction. The prevailing wind direction is northwest.

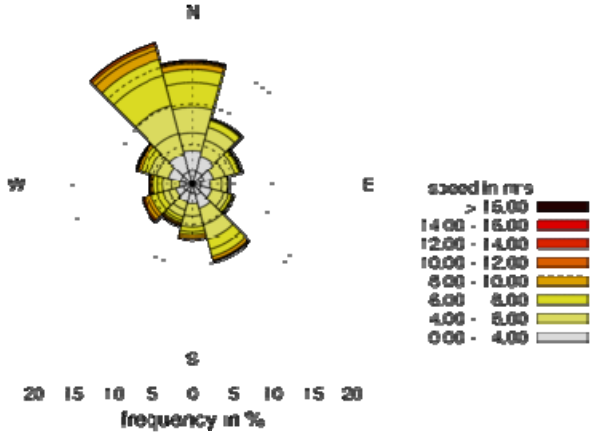

Fig. 9. *Frequency distribution of wind speed in 12 wind direction sector at 50m in Debrecen*

On Fig. 10 we presents preliminary wind resource map at 100m level which modeled by WindSim around SODAR measurement point in Debrecen.

We believe that we need to specify the databases which use in the model and necessary to refine model settings to do more accurate wind speed distribution in the future.

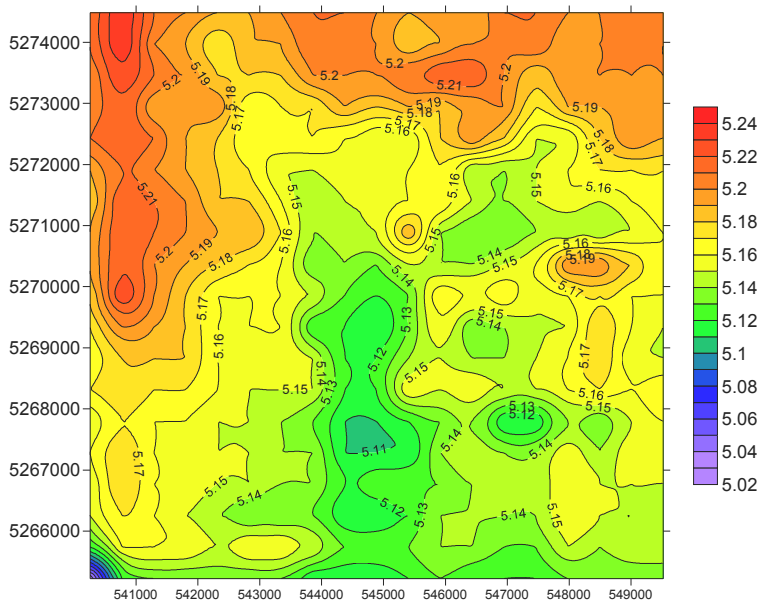

Fig. 10. *Modelled distribution of wind speed (m/s) of north part of Debrecen at 100m above ground*

CONCLUSIONS

SODAR excellent tools for detailed wind monitoring of lower planetary boundary layer of atmosphere. The state-of-the-art measuring technique can help discover unknown local wind climatology. WindSim model is a suitable tool for simulations wind field. We need to refine parameterization of model in the future. In preliminary results we found that above 100m height the wind potential of open areas in north-west direction from Debrecen seems favorable for industry-scale wind plants. In the south direction the city constitute an obstacle to the movement of wind, while in the east direction the forest areas.

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ENVIRONMENTAL STATE ASSESSMENT OF STREAM SÉD IN VESZPRÉM

Zsófia KOVÁCS[1*], Zoltán ZSILÁK[2], Tatiana YUZHAKOVA[1], Ákos RÉDEY[1]

[1] University of Pannonia, Institute of Environmental Engineering, 10 Egyetem St. Veszprém, 8200 Hungary
[2] University of Pannonia, Department of General and Inorganic Chemistry, 10 Egyetem St. Veszprém, 8200 Hungary
** E-mail: zsofiakovacs@almos.uni-pannon.hu*

ABSTRACT. The society has been playing more and more emphasized role in the environmental policy of the EU including Hungary. The environmental consciousness of the people has been increasing regarding the demand for environmental information and the public involvement in decision making. It is very important to investigate and the monitor the quality of the surface waters. The WFD (2000/60/EC) was created as a long-term water policy of the European Union. The good ecological condition of the surface waters can be achieved with prevention of the quality deterioration and by providing sustainable water management. The aim of the paper is that the load on the Stream Veszprém-Séd can be determined on the basis of comprehensive physical-chemical measurements. During the investigation the following issues were considered: inlet streams, rainwater inlet and sewage inlet. The physical (pH, temperature, conductivity) and chemical parameters (ammonium, nitrate and orthophosphate) were studied on the Stream Veszprém-Séd. The quality of the water was defined according to the WFD methods.

Information was provided to the Local Government on the water quality of the Séd in Veszprém. Assignments were done regarding the critical polluting sites for which action plans have to be worked out.

Key words: *Stream Veszprém-Séd, water monitoring, environmental state assessment, water quality*

INTRODUCTION

The high water quality can be achieved with prevention of the pollution and by providing sustainable water management. In order to contribute to the sustainable development the rationaluse of water should consider the efficient water utilization, water conservation, wastewater reclamation and wherever possible reuse of the water and application of alternative water resources to the benefit of our and future generations (Zikos and Bithas, 2006).

The Water Framework Directive (WFD) was created as the long-term water policy of the European Union. The objective of the WFD (2000/60/EC) is to achieve good ecological and chemical status in all bodies of surface water, ground water, artificial and modified water bodies by 2015 (Directive, 2000). It provides a framework for Member States to apply local measures. It is essential that the residents of small regions can easily have access to information on the state of their local environment and have the possibility to take part in the decision process.

Hungary River Basin Management plans should have been completed by 2010. The most important activity in Hungary is the installation of the three-stage monitoring systems (surveillance, operational, investigational monitoring) according to WFD rules. Surveillance monitoring will be carried out in order to complement and validate the impact assessment and to provide information of long term changes. Operational monitoring has to be undertaken in those water bodies, which are at risk of failing to meet the environmental objectives. If the reasons for this failure are unknown investigative monitoring has to be started (Frederiksen et al., 2007).

Aims of the project were to define the physical and chemical parameters of the surface water of Stream Séd in Veszprém city. In this way the knowledge of the actual situation and classification (according to WFD) of the surface waters were achieved. The Stream Séd is loaded by direct and diffuse pollutants. Water pollution comes from the close gardens, cultivated lands and sewage water treatment plants. The waters including the treated waste water contain nitrate, nitrite, ammonium ion and orthophosphate in high concentrations. An additional pollutant source is the urban drainage water.

MATERIAL AND METHODS

The middle section of the Stream Veszprém-Sédis situated in Veszprém County and is WFD within typology category of 1-13 (WMP, 2010). This is called North-Mezőföld and East-Bakony. Its length is about 70 km. The catchment of the Stream Séd has an area 256 km^2.The Stream Séd belongs to high altitude calcareous stream with coarse bed material.14 sampling sites and five polluted locations were identified along the stream (figure 1).

Fig. 1. *Sampling sites of the Stream Veszprémi-Séd*

It was assumed that at these locations strong impact on the water quality can be experienced. These polluting locations are as follows: discharge of the zoo, discharge line of the bus service station, output of city drainage, and output line of the sewage treatment plant, Stream Békatói and branches.

Town streams are natural water collectors of the rain water and treated wastewaters of the surrounding urban areas. The water base of Veszprém City is an open karst water basin which requires special attention. One part of this project aimed at to study the physical and chemical parameters of the surface water in accordance with the stipulations of the WFD. Calibrated and portable instrument Consort C535 was used to carry out outside pH level and conductivity measurement. The N and P forms were analysed by spectrophotometry (PO_4^{3-}-P, NH_4^+-N, NO_3^--N). The sampling was carried out in spring. The samples were maintained at 4°C during transportation to laboratory to perform standard measurements (MSZ standard, 1993). Categorization of the surface water was performed according to WFD and Decree No. 10/2010 (VIII.18) of Ministry of Rural Development (VM, 2010). The water quality test was carried out according to the EU WFD water classification protocol.

The status of each surface water body is judged using separate 'Ecological classification' and 'Chemical classification' systems. The overall status of the water body will be determined by whichever of these is the poorer (Table 1). To achieve 'good status' overall, a water body must achieve both good ecological and good chemical status (WFD, 2007).

Table 1. *Physical and chemical parameters according to component groups*

Component groups	Physical and chemical parameters
Acidification	pH-level
Salinity	conductivity, chloride-ion
Oxygen balance	dissolved oxygen, BOD, COD, ammonium-N, nitrite
Nutrient	nitrate-N, TN, orthophosphate-P, TP

RESULTS AND DISCUSSION

Measurements taken on field

Along the middle section of Stream Séd the pH-level was detected between values of 7.5-8 therefore the water is defined as mildly alkaline (figure 2).

The conductivity values of the Stream Séd were constant (500-800 µS cm^{-1}), extremely high value (1380 µS cm^{-1}) was detected at the point of the sewage treatment discharge.

On the basis of the measurements the Stream Séd can be classified into the category of moderately polluted water.

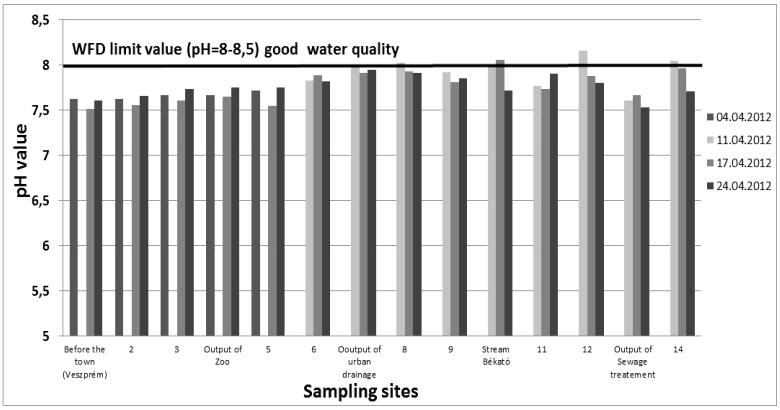

Fig. 2. *Change in the pH level*

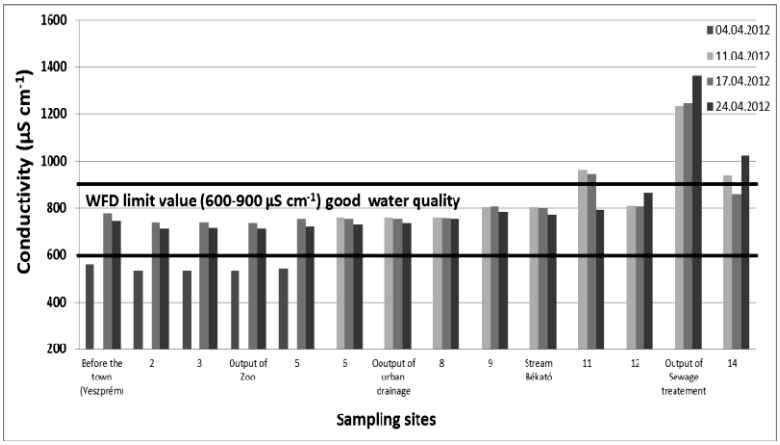

Fig. 3. *Change in the conductivity*

Measurements taken in laboratory

The ammonium-N concentrations were measured between 0.01mgl^{-1} and 0.05 mgl^{-1}. The high concentration values (0.35 – 0.95 mgl^{-1}) taken at fourth sampling sites, so the impact of the zoo (0.49 mgl^{-1}) can easily be detected (figure 4).

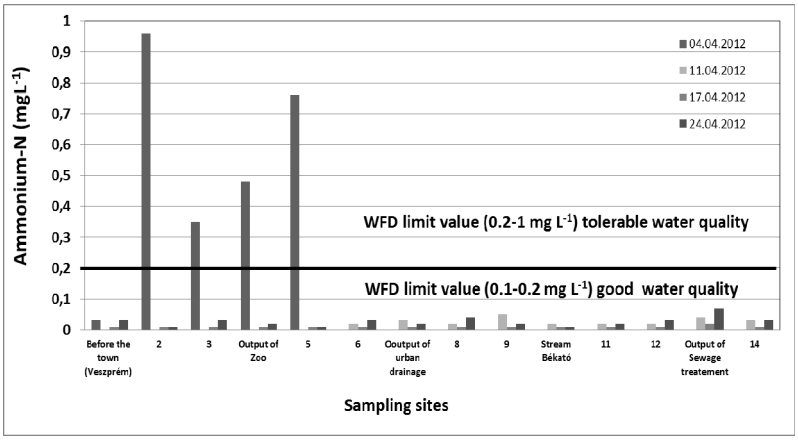

Fig. 4. *Change in the ammonium-N concentration*

Nitrate-N concentration level has increased (1-5 mgl^{-1}) continuously in the town. In the Stream Séd extremely high nitrate concentration level (21 mgl^{-1}) was measured at the location of the sewage treatment plant (figure 5).

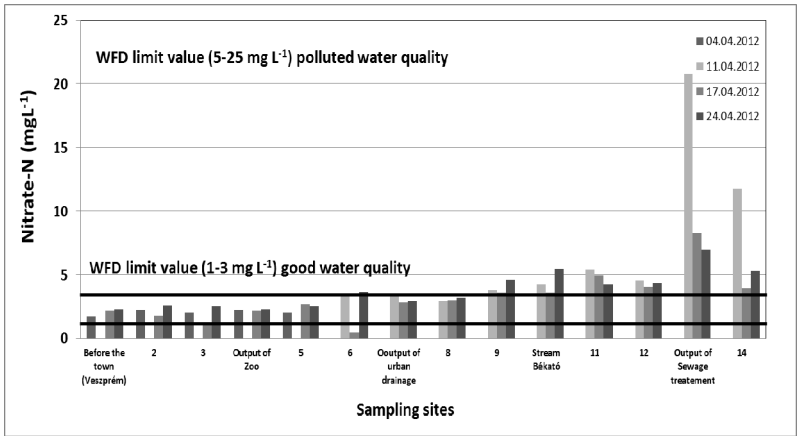

Fig. 5. *Change in the nitrate-N concentration*

Level of the orthophosphate-P concentration in Séd in Veszprém changed between 0.1-0.5 mgl^{-1} but high concentration level was measured at these wage treatment plant (0.6 mgl^{-1}) caused by heavy raining (figure 6).

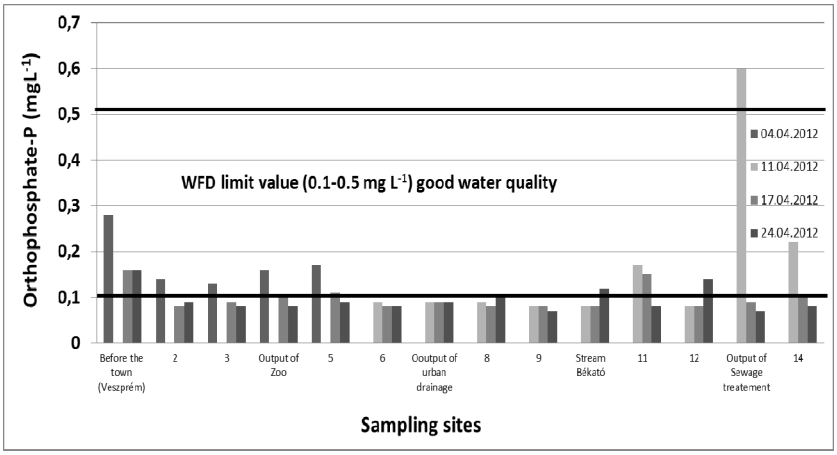

Fig. 6. *Change in the orthophosphate-P concentration*

DISCUSSION

Water quality of the Stream Veszprém-Séd

The date of the achievement of the good water quality of the Stream Veszprém-Séd was extended from 2015 to 2027. The reason of this is that the quality of the water body is not known reliably (WMP, 2010).

High nitrate-N concentration was measured on 11 April, 2012 therefore the water quality category was changed to polluted water category (Table 1). The results of the measures confirmed that the incoming sewage and different diffuse sources have a considerable impact on the Stream Veszprém-Séd.

The nitrate pollution comes from the nearby gardens, cultivated lands, urban drainage water, sewage water treatment plant where sewage and cleaned water contain nitrate, nitrite, ammonium ion and orthophosphate in high concentrations.

Table 2. *Results of the water quality of the Stream Veszprémi-Séd*

Categories of component	04.04.2012	11.04.2012	17.04.2012	24.04.2012
salinity (conductivity)	5 (excellent)	4 (good)	4 (good)	4 (good)
acidification (pH level)	5 (excellent)	5 (excellent)	5 (excellent)	5 (excellent)
oxygen balance (Ammonium-N)	3 (tolerable)	5 (excellent)	5 (excellent)	5 (excellent)
nutrient (Nitrate-N, Orthophosphate-P)	3.5 (good)	2.5 (polluted)	3.5 (good)	3.5 (good)
Categories minimum value	3	2.5	3.5	3.5
Water quality	tolerable water quality	polluted water quality	good water quality	good water quality

In recent years (2008, 2009, 2010, 2012), the categorization of the surface water was done according to WFD (Table 3).

Table 3. *Water quality of the Stream Veszprém-Séd*

Categories of component	2008	2009	2010	2012
acidification (pH level)	5 (excellent)	5 (excellent)	5 (excellent)	5 (excellent)
salinity (conductivity)	3 (tolerable)	4 (good)	4 (good)	4 (good)
oxygen balance (Ammonium-N)	4 (good)	4 (good)	5 (excellent)	5 (excellent)
nutrient (Nitrate-N, Orthophosphate-P)	2 (polluted)	3 (tolerable)	3 (tolerable)	3.5 (good)
Categories minimum value	2	3	3	3.5
Water quality	polluted water quality	tolerable water quality	tolerable water quality	good water quality

The evaluations showed that during the measurement period the water quality of Stream Veszprem-Séd has improved (in comparison with the values measured earlier) from polluted water quality to good water quality.

Acknowledgments

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EXPOSURE ASSESSMENT OF POPULATION FROM RADAUTI AREA

Emese KOZMA-KIS[1,2*], Anca-Olivia RUSU[2], Andrea BLAGA[2], Gabriel GATI[2], Irina DUMITRASCU[2], Iulia NEAMTIU[1,2], Eugen Stelian GURZAU[1,2*]

[1] Babes Bolyai University, Faculty of Environmental Sciences and Engineering, 30 Fantanele Street, Cluj-Napoca, tel. +40 264 307030, fax +40 264 307032, e-mail: enviro@ubbcluj.ro, website: enviro.ubbcluj.ro,
[2] Environmental Health Center, 58 Busuiocului Street, Cluj-Napoca, tel. +40 264 432979, fax +40 264 534404, e-mail: cms@ehc.ro, website: www.ehc.ro
** E-mail: emese.kozma@ehc.ro; egurzau@ehc.ro*

ABSTRACT. Inhalation is an important pathway for human exposure to contaminants that could cause severe health effects. The aim of this study is to evaluate the spatial distribution of air pollutants concentrations (SO_2, PM_{10}, $PM_{2.5}$, CH_2O and total VOC) in Radauti area and to calculate the risk of developing a malignant tumor in life following to the exposure to formaldehyde. The exposure dose and the risk of developing cancer due to formaldehyde exposure were estimated with the ATSDR Dose Calculator. The spatial distribution of the concentrations was modeled using Quantum GIS 1.8. and its GRASS 6.4.2. interface and the results were presented on maps. The high concentrations of hazardous substances in the area are probably generated by traffic and industries, the highest concentrations being measured in the city of Radauti and in the surroundings.

The estimated additional cancer risk when exposed for 15 years falls between 1.39E-05 and 9.19E-05, which predicts the likelihood of one to nine additional cancer cases in a population of one hundred thousand people; and when exposed for 30 years the estimated additional cancer risk falls between the range of 2.79E-05 and 1.84E-04, which predicts the likelihood of three to six additional cancer cases in a population of one hundred thousand people and one to two additional cancer cases in a population of ten thousand people.

Key words: *air pollutants, formaldehyde, cancer risk, spatial distribution*

INTRODUCTION

Formaldehyde (CH_2O) is mainly used in resin production and as a chemical intermediate. Formaldehyde based resins are used for insulations, as adhesives in the wood-industry and in textile treatment. (OSHA, 2012)

Small amounts of formaldehyde (0.1 to 0.5 ppm) can cause nasal and eye irritation, neurological effects and increased risk of asthma and allergy. An exposure to 0.6 to 1.9 ppm can cause eczema and changes in lung function. Animals which were orally exposed to a dose of 50-100 mg/kg/day showed liver and kidney damage, decreased body weight and gastrointestinal ulcers.

According to the Department of Health and Human Services formaldehyde is a known human carcinogen. (ATSDR, 2008)

Particulate matter (PM) could have several effects on the lungs and the heart depending on the size of it. Exposure to particulates can cause nonfatal heart attacks, irregular heartbeat, premature death in people with heart or lung disease, can aggravate asthma, increase respiratory symptoms like difficulty breathing, irritation and coughing and can decrease lung function. (Kappos et al., 2004)

Sulfur dioxide (SO_2) emissions are mainly from fossil fuel combustion and industrial facilities. (EPA, 2012) Sulfur dioxide exposures, ranging from 5 minutes to 24 hours, can cause adverse respiratory effects, such as bronchoconstriction and increased asthma symptoms. Small particles, which form in the atmosphere from SOx reactions with other compounds are able to penetrate deeply in the lung, causing emphysema, bronchitis and other respiratory disease and can worsen heart disease. (Pan, 2011)

Due to the variety of chemicals which are classified as Volatile Organic Compounds (VOC), exposure to them can cause various health effects, including eye, nose and throat irritation, headaches, fatigue, dizziness, nausea, allergic skin reaction, damage to kidney, liver and the central nervous system. Some of the organic VOCs are known or suspected carcinogens. Depending on the level of exposure, the length of time exposed and many other factors, the nature of the health effects will vary from severe to no health effects. (EPA, 2012)

OBJECTIVE

The aim of this study is to evaluate the spatial distribution of air pollutants concentrations in Radauti city and near Egger factory and to calculate the risk of developing health effects due to exposure to formaldehyde.

SOURCES OF POLLUTION IN THE STUDY AREA

Radauti is a city in Suceava county, Romania, with a population of 22 145 and a density of 686 people/km^2. (SCSD, 2012)

The EGGER factory in Radauti, is the 16-th unit of production of the EGGER Group, one of the leaders in the production of wood derived products, in Europe. According to EGGER group principles, the factory in Radauti has a modern technology that guarantees ecological products and a sustainable development. The EGGER factory in Radauti has a significant positive impact on the local communities and in the region from a social and economic point of view.

The pollutants generated by the activities in the factory are wood dust and PM from chipping of the wood and chip handling; formaldehyde and other volatile organic compounds from gluing the chips with synthetic resins. Due to the good control measures, the concentrations of those chemicals in the emissions are low, not exceeding the maximum allowable concentration.

Fig. 1. *Suceava County, Romania*

Other sources of PM in the area are unpaved road dust, constructions areas, an old furniture factory, a textile factory and a tool factory located in the southern part of the city.

Traffic in the city and on the roads surrounding the city (national roads – 17A, 2H; and county roads – 178C) can also generate hazardous substances such as formaldehyde, sulfur dioxide, carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2) ozone, etc. (Progiou and Ziomass, 2011)

In this study, we measured concentrations in the imissions of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CH_2O and total VOC in Radauti city and in the surroundings. NO_2 concentrations were below the detection limit with the methods used in these measurements, so we did not include them in the current study.

METHODOLOGY

Sampling method

Sampling was performed using specific absorbent solutions to determine SO_2, NO_2 (kept at 4°C until analysis - within 24h), XAD-2 cartridges with hydroximethylpiperidina for formaldehyde and charcoal tubes for VOC (kept at 4°C until the analysis - maximum 7 days). PM sampling was performed simultaneously with the other compounds measurement, using a PersonalDataRam model PDR-1200 series 4069 analyzer. The measurements performed were short time measurements (30 minutes).

The equipment used for sampling was a sampling pump APEX series 1311019; and the equipment used for the analysis was a SPECORD 30 series 30102, 2002 spectrophotometer, calibration certificate CJ-425-1974/2010, gas chromatograph coupled with mass spectrometer GC-MS QP 2010 Plus series O20504676086, calibration certificate 05.03 to 558/2010. Sampling point's distribution is presented in figure 2.

Fig. 2. *Sampling points*

Calculating exposure doses and quantitative analysis of risk for carcinogens

The exposure dose and the risk of developing a malignant tumor in life following exposure to formaldehyde were calculated with the ATSDR Dose Calculator, a computer program developed by the Agency for Toxic Substances and Disease Registry within CDC (Center for Disease Control and Prevention) to estimate the dose/amount of a toxic substance an individual may be exposed to. (ATSDR, 2010)

Exposure dose, daily intake and the risk of developing a malignant tumor when exposed for 15 and 30 years were calculated using the following equation and default air intake rates for a reference population (adult, child, adolescent and infant):

$$D = (C \times IR \times EF) / BW$$

where: D = exposure dose (mg/kg/day); C = contaminant concentration (mg/m^3); IR = intake rate (m^3/day); EF = exposure factor (unitless); BW = body weight (kg)

The air intake rate is influenced by several factors, including a person's activity level, physical condition, gender and age. (ATSDR, 2005)

Exposure doses were multiplied by a Unit Risk Factor to estimate a theoretical risk of developing a malignancy as a result of exposure to formaldehyde. This calculation estimates a theoretical excess of cancer risk expressed as a proportion of a population that may be affected by a substance able to cause the development of cancer. For example, the estimated cancer risk of 1x10^{-6} predicts the likelihood of one additional cancer case in a population of 1 million people.

This approach provides a theoretical risk estimate, so the actual risk is unknown. (ATSDR, 2005)

Modeling the spatial distribution

Mathematical modeling is defined as a mental representation of a schematized model of the environment, which allows a simplified vision of the reality, in order to understand and describe, or forecast the environmental processes and phenomena. (Muntean, 2010)

The generic methodology for the analysis and modeling of spatial data includes several steps. These consist in exploratory spatial data analysis; structural analysis; spatio-temporal predictions/simulations; model assessment and validation; and visualization trough Geographical Information Systems (GIS). (Kanevski, 2008)

The geostatistical and deterministic methods are well known approaches developed for spatial and spatio-temporal data. These methods provide linear and nonlinear modeling tools for spatial data mapping. (Kanevski, 2008)

Interpolation represents a process of defining a function that takes specific values in specific points. (Cleve, 2004) The inverse-distance weighted method is a versatile, accessible, and quire accurate under a wide range of conditions. (Cooke, 1998) The method can be described by the following equation:

$$P_i = \frac{\sum_{j=1}^{G} P_j / D_{ij}^n}{\sum_{j=1}^{G} 1 / D_{ij}^n}$$

where: P_i is the property at location i; P_j is the property at the sampled location j; D_{ij} is the distance from i to j; G is the number of sampled locations; and n is the inverse-distance weighting power. (Cooke, 1998)

For the modeling we used Open Source GIS Software, namely Quantum GIS 1.8. (Quantum GIS), and its GRASS 6.4.2. (GRASS, 2012) (Geographic Resources Analysis Support System) interface. The Stereo70 grid of the study area was acquired from the *USGS World Topographic Map*, through the Hydro Desktop 1.4. software. (CUAHSI, 2012)

RESULTS

The results of sampling, exposure doses and cancer risks, and the maps presenting the results from modeling and the spatial distribution of pollutants are shown in the tables and figures below.

Table 1. *Concentrations in imissions measured in the study area*

Nr.	SO_2	PM_{10}	$PM_{2.5}$	CH_2O	total VOC	Location	GPS Coordinates
	[mg/m^3]						
1	0.136	0.001	0.008	0.019	0.254	Dornesti, Stufului Street	N 47°51'39.6" E 25°59'04.5"
2	0.104	0.005	0.003	0.011	0.09	Egger parking	N 47°51'12.1" E 25°57'59.9"
3	0.067	0.012	0.008	0.005	0.124	Cucului, Cernauti Street	N 47°50'48.6" E 25°55'48.9"
4	0.08	0.007	0.008	0.007	0.483	Dobrogeanu Gherea and D. Dumitru Street	N 47°51'08.1" E 25°55'30.9"
5	0.095	0.005	0.007	0.033	0.065	B. Voda and S. Barnutiu Street	N 47°50'15.3" E 25°55'13.2"
6	0.061	0.012	0.008	0.033	0.047	C. Bucovinei and Luncii Street	N 47°50'10.6" E 25°55'49.6"
7	0.056	0.002	0.001	0.019	0.099	Satu Mare	N 47°50'26.2" E 25°59'06.2"
8	0.094	0.014	0.012	0.01	0.033	Unirii Square	N 47°50'48.8" E 25°54'54.3"
9	0.307	0.009	0.01	0.031	0.044	Teiului Street	N 47°50'45.1" E 25°54'27.3"
10	0.098	0.012	0.009	0.024	0.351	Putnei and Horea Street	N 47°51'01.7" E 25°54'10.3"
11	0.094	0.009	0.008	0.03	0.08	Pandurilor and A. Paun Street	N 47°51'15.9" E 25°54'46.1"
12	0.141	0.01	0.008	0.03	0.102	Fratautii Vechi	N 47°53'39" E 25°53'52.5"

Table 2. *Exposure dose and theoretical cancer risk when exposed for 15 and 30 years to formaldehyde, calculated for the formaldehyde concentrations measured in the area*

Nr.	CH_2O concentration [mg/m^3]	Exposure dose – Adult* [mg/kg/day]	Exposure dose – Child* [mg/kg/day]	Risk 15	Risk 30
1	0.019	4.13E-03	7.60E-03	5.29E-05	1.06E-04
2	0.011	2.39E-03	4.40E-03	3.06E-05	6.13E-05
3	0.005	1.09E-03	2.00E-03	1.39E-05	2.79E-05
4	0.007	1.52E-03	2.80E-03	1.95E-05	3.90E-05
5	0.033	7.17E-03	1.32E-02	9.19E-05	1.84E-04
6	0.033	7.17E-03	1.32E-02	9.19E-05	1.84E-04
7	0.019	4.13E-03	7.60E-03	5.29E-05	1.06E-04
8	0.01	2.17E-03	4.00E-03	2.79E-05	5.57E-05
9	0.031	6.73E-03	1.24E-02	8.64E-05	1.73E-04
10	0.024	5.21E-03	9.60E-03	6.69E-05	1.34E-04
11	0.03	6.51E-03	1.20E-02	8.36E-05	1.67E-04
12	0.03	6.51E-03	1.20E-02	8.36E-05	1.67E-04

* Adult – male, age between 19-65, weight 70 kg; Child – age between 6-8, weight 25 kg

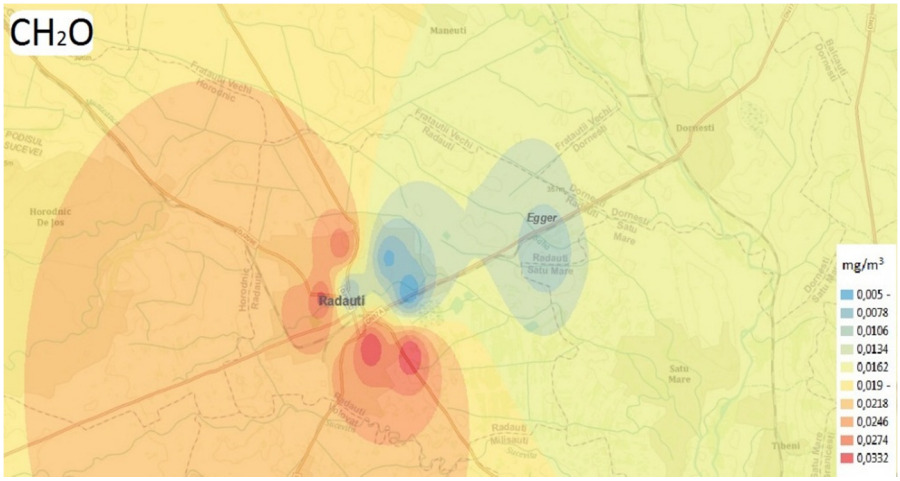

Fig. 3. *Spatial distribution of **formaldehyde** concentrations measured in Radauti area*

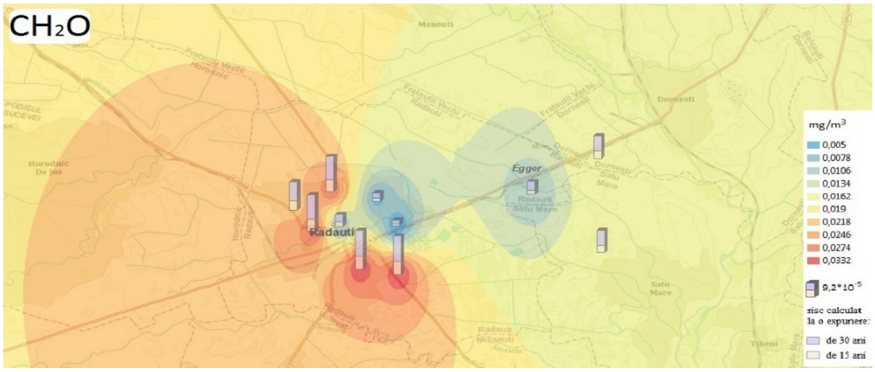

Fig. 4. *Spatial distribution of measured **formaldehyde** concentrations and associated **cancer risk** in Radauti area*

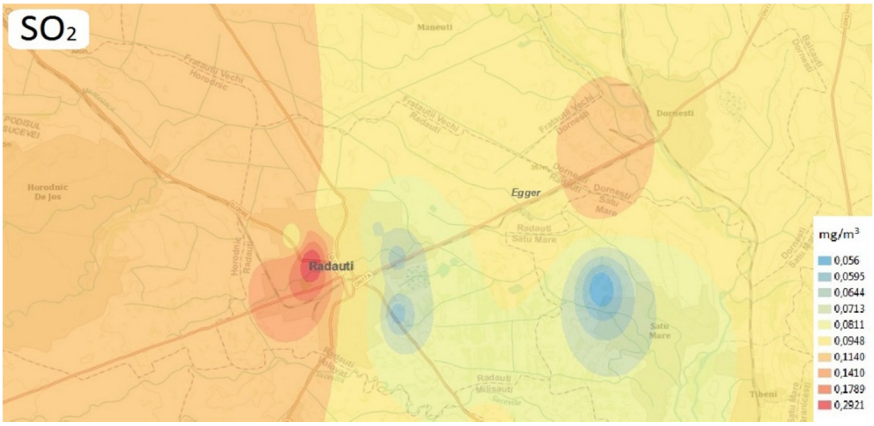

Fig. 5. *Spatial distribution of **SO2** concentration measured in Radauti area*

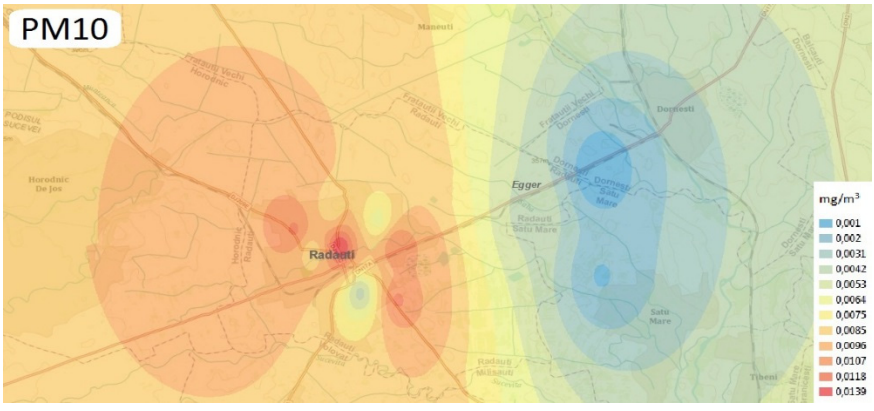

Fig. 6. *Spatial distribution of **PM10** concentrations measured in Radauti area*

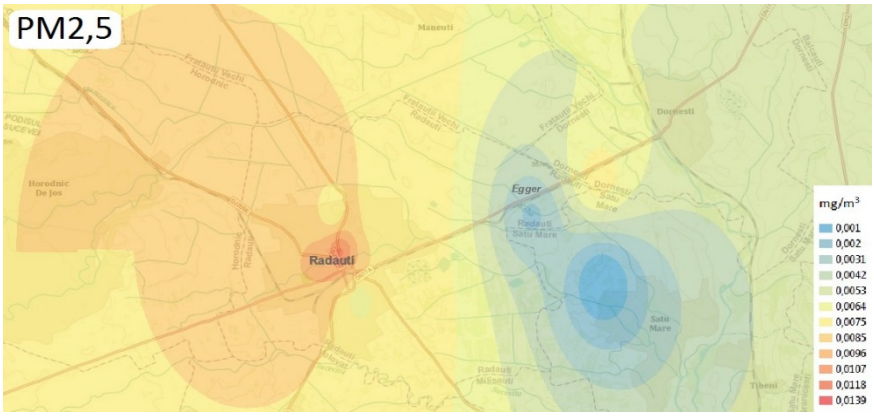

Fig. 7. *Spatial distribution of **PM2.5** concentrations measured in Radauti area*

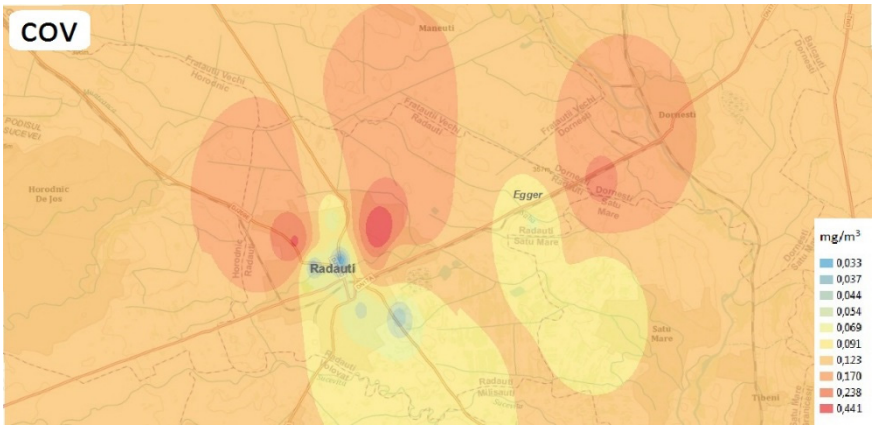

Fig. 8. *Spatial distribution of **total VOC** concentrations measured in Radauti area*

DISCUSSIONS AND CONCLUSIONS

The concentrations of formaldehyde measured in Radauti area were below the national allowable limits (0.035 mg/m^3). (STAS 12574-87)

Formaldehyde concentrations were higher in the western part of the city, were the furniture and textile factories are located. Near Egger factory the concentrations were lower as compared to the western part of the city.

Sulfur dioxide concentrations were higher in the north-western part of the city and the sources are probably traffic and other industries.

The PM concentrations were lower near Egger factory and in Satu-Mare village and higher in the city.

The highest concentrations of total VOC were measured in the northern part of the city and in the area near Dornesti village.

Cancer is caused by many synergic factors, which were not investigated in this study and were not included in the mathematical model, so this approach just provides a theoretical estimation of the additional risks that can be related only to the concentration of formaldehyde measured in Radauti area. The actual risk is unknown. So, considering what was previously mentioned, the theoretically estimated additional cancer risk when exposed to the concentration of formaldehyde measured in the study area for 15 years, fell between 1.39E-05 and 9.19E-05, which predicts the likelihood of one to nine additional cancer cases in a population of one hundred thousand people. The theoretically estimated additional cancer risk when exposed to the concentration of formaldehyde measured in the study area for 30 years fell between 2.79E-05 and 1.84E-04, which predicts the likelihood of three to six additional cancer cases in a population of one hundred thousand people and one to two additional cancer cases in a population of ten thousand people.

The estimated additional cancer risks based on formaldehyde concentration measured in the area have the same spatial distribution as formaldehyde concentrations: they are higher in the city and lower in the surroundings and near Egger factory.

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ENVIRONMENTAL IMPACT OF THE PRODUCTION OF WIND FARMS

Adriana MARINA[1*]

[1] Polytechnic University of Bucharest, Splaiul Independentei, No. 390, Bucharest, Romania, Phone: +40 742 992172
** E-mail: adriana_marina_business@yahoo.com*

ABSTRACT. The construction of wind farms involves processes excavation, dicing, rolling, welding, and cleaning. After commissioning time there is an impact on staff that ensures maintenance of wind farms, on human settlements and the local fauna. The article shows the environmental impact that occurs during the production of wind power.

Key words: *wind farm, welding process, environmental impact*

IMPACT ON BIODIVERSITY

Generally of wind farms are located in less populated biotopes that have some influence on the climate and structure of biocenosis. These conditions impact on biodiversity areas is insignificant. Note that the construction phase is affected a small part of the vegetation, which restores natural or artificial. During operation, the noise and vibrations of wind turbines and some creatures could move habitat at distances up to 150 meters where the effect of noise is negligible.

After the investment and commissioning of the turbines of the wind farm area will be said a sanitation activities of the land, topsoil recovery, recovery of flora in the area naturally or by planting plants and shrubs so as not to be affected turbine efficiency. Land management includes hydro-amelioration works to eliminate its possible failure. (local floods, landslides, collapses

Impact caused by noise

Noise change and endolymph metabolism leading and balance disorders. Premature hearing damage, that aging leads to disturbances in the balance. Critical threshold threatening ears still stands at 85 decibels, hearing threshold produce fatigue. But it can be recovered auditory fatigue. People perceive a transient hearing loss, but after a few hours rest in a state of tranquility around, hearing problems disappear. If a man remains in noisy environment, hearing disorders lead to deafness, some professional. Those who work in noisy rooms, after 40 years, the ear become more fragile and harder to recover following the hearing problems at noise.

The noise generated by the construction and assembly of wind turbines are characteristic participating in the operation of equipment investment. This noise can reach 100-110dB, since working with heavy machinery that works with high-powered thermal engines. Because the construction activity is limited in time, its effect on the environment in the area, even on the habitats of birds and animals can be considered insignificant.

Long distance to the village inhabited area is also Fântânele kind of insignificant impact. During operation of the wind turbine noise is generated by:

- function gear gearbox;
- function electric generator;
- functioning wind turbine blades.

Noise from rotating turbine blades is determined by two factors: the blades moving through the atmosphere and going through the mast right.

Because the speed of the blades through the air is inversely proportional to the size of the turbines (i.e., a low speed in a large diameter rotor) noise in this case will be much lower compared to other models of turbines. The impact analysis has taken into account the fact that at high wind speeds, turbine noise will be masked by the ambient. Measurements showed that, on total calm (wind speed up to 3 m/sec) average noise during the measurement has a value of 43 dB [A].

To simulate how sound waves propagate resulting from turbine operation was used a module for analysis of internationally recognized program and the estimate was made according to norm ISO 9613-2. Important fact mentioned technical characteristics 2.5 MW turbines allow operation in speed limit (default with Noise generated), making it possible to reduce the impact.

Impact caused by the proximity of electrical wiring

Connecting wind turbines to the transformer station (33/110 kV) is via underground cables of 33 kV from them, link to the main station (110/400 kV) underground cable is 110 kV. Finally, the connection to the national grid (400 kV) overhead is achieved through a distance of 400 m. Therefore, the expected impact due to this wiring is expected to be.

Impact of wind turbines on birds

The impact of wind turbines on birds is largely similar impact they have on their tall buildings.

During construction, disturbance of birds will be caused by human activity and machines present during construction, the operations performed maintenance and repair, new roads built and a greater flow of people who will visit the area. Visual and noise disturbance may cause displacement of birds in less favorable habitats followed by a decrease in their survival skills. Of the potential impact described above, the effect is greatly diminished by the fact that making a turbine construction and installation is done in a relatively short time and maintenance work involves not mind one way or the other birds. Impact is reduced by the fact that access to the area is the existing pathways. In this way, conditions are created for the least disturbance to local avifauna habitat. But the most dramatic impact that wind turbines can have on avifauna is the

collision between birds and turbine blades. This can lead to the death of a number of birds. Some of these birds have low maneuverability are more easily exposed. This can happen especially since with visibility (fog, rain) or strong wind.

Collision risks are influenced by many factors, individual sensitivity, the location of stations on routes used by birds for bad weather with poor visibility (rain, fog, night), flight speed, the skill of each species (and each individual), the size of each species. There are studies showing that the great parks of wind turbines at sea, near shore (offshore) are avoided even at night by flocks of birds.

As large urban areas (cities) have come to be known by the birds, which currently transiting probably just happens with the wind, which, once identified, can be easily avoided. In order to quantify the effect that these wind turbines have on bird populations, both studies are required before installing turbines as particularly after its installation, preferably in all seasons a year (Klitkou et al. 2008).

Impact of wind turbines on local flora and vegetation

The impact of wind turbines on local flora and vegetation: the area considered for this study is located in the Plateau Casimcei impact in its southern part to about 60 km west of the Black Sea.

During the trips made on the spot to watch the impact that a wind turbine or wind turbine park located on one of the hills of natural grasslands can have on surrounding local flora and vegetation. Of physic-geographical target area is characterized by slightly raised waves with heights up to 180 ... 190 m, with large plateaus and slopes extend to medium low inclination. In terms of geology, the hills are composed of limestone and calcareous sandstone, which often appear on the surface and are covered by blanket more or less thick loess. Specific soils are litho-researched area (shallow skeletal soils), which arise from surface rock hard and carbonated chernozem soil leachates balances, more or less washed by water from precipitation. Humus content and fertility of these soils is high as high moisture content. In the physical-geographical and climatic conditions, vegetation in the placement of wind turbines consists of xerofile and thermophilic plant communities adapted to dryness and high temperatures, consisting of a mixture of species Eurasian continental Balkan and Pontic-Balkan species.

In the steppe grassland vegetation is distinguished association called endemic plant species represented by A. brandzae (*Agropyron cristatum ssp brandzae*) (couch grass Christ), mentioned in the literature only in Dobruja and Bulgaria. This plant association has a large spread in the installation of wind turbines, but also in the adjacent uncultivated cereal. In this plant communities, *Agropyron brandzae* develop dominant, accompanied by several other species of grasses, but underrepresented in terms of number of individuals. Among them we can mention: Koeleria lobata (Ponto-Balkan species rare but nepericlitata, which grows spontaneously only in Dobrogea), *Callier Festuca, Bromus squarrosus - obsiga, Stipa capillata - Nagar, Avena fatua - oatgrass*. Among *dicotyledons*, I noticed in lawns with *Agropyron* species brandzae such *as Dianthus pseudarmeria - Garofita* and *Thymus zygioides* - thyme, *Anthemis tinctoria* - Flower pillow, *Achillea coarctata, Asperula cynanchica, Allium rotundum* - wild garlic, *Echinops ruthenicus* - velcro game, *Linum tenuifolium* - flax field.

But these species are poorly represented quantitatively compared with grasses, although located in the area around the places where wind turbines will be mounted, Agropyron brandzae and other species that are associated are not affected by their operation. Another plant association well represented in the study area, especially on sunny slopes is represented by *Valesiaca Festuca* (fescue steppe). *Valesiacae Festucetum* association is a widespread plant community on loess soils of the steppe, consisting of plants resistant to climate arid. Species accompanying xerofile are either grasses (*Festuca rupicola, Stipa capillata - Denial, Melica ciliata - Willow, Bromus squarrosus - obsiga, Bromus hordeaceus*) be different dicotyledonous plants, represented as isolated individuals or clusters. In conclusion, in the steppe grasslands, covering plateau and hill slopes, many rare floras coexist with common plants steppes of Dobrogea.

SOCIAL IMPACT

Social indicators aimed at analyzing the changes brought by investors in the area of the site, on revenue of population materials on its migration on family income, the level of qualification of the population growth in the area, on the request of public services such as health, education and public cleaning.

One can note that an investment in the site area brings significant changes to social indicators, especially as it involves a large number of wind turbines grouped in an assembly. We can also talk about changes in social indicators as mentioned in the national develop a wind industry in the area. Thus, in this respect can cite countries like Spain, Germany and Greece lately that developing unconventional energy sector of wind potential created only 150,000 jobs.

Developing industry in the field of wind potential is obvious that most social indicators will increase. Thus, depending on the degree of development of the field reveals a densification of the population, an increase in the level of qualification of staff employed in the field, an overall increase employment of the local population (Hammond et al. 2011).

As a consequence of industrial development of equipment for use wind potential all other social sectors will increase. Mounting technology of wind turbines in the area with high wind potential involves both simple and complex operations that require high qualifications. These operations require human resources that are provided in the area or areas immediately adjacent. In conclusion, for these operations require workforce average of 10 people / day for 40 days ... 45.

Considering the impact of social indicators can say:

• they become significant for the area (related to urban development) are mounted only if a number greater than or equal to five turbines;

• there is mounting between labor demand, which is as significant social indicator mounted turbines when the number is large enough;

• development of unconventional energy for industry-wide significant changes in social indicators analyzed.

• important social impact with economic impact analysis should be noted that analyzes at European energy demand is made on the current Europe to import 50% of the energy needed, and if not will find alternative solutions until 2030, energy imports will reach 75%.

This is one of the reasons why wind potential alternative should not be dismissed.

• important social impact can cite reducing production costs and hence electricity sales. Local community are known in Europe and the world in which local production of electricity from wind potential electric meant reducing energy prices by 50% compared to sales nationally.

EXPECTED WASTE

During the production a wind farm done mostly waste will result in the construction phase of the target (set of potential wind energy production).

Thus, following the construction of the lens will result:

- Waste construction materials, code January 17;
- Earth and stone from the excavations, cod May 17;
- Scrap metal (in small amounts) from the tower assembly to support the assembly of producing electricity from wind potential and other parts, as well as the construction fence enclosure, 17 04;
- Other types of waste in significant quantities, code 20 02;

During the process of producing electricity from wind potential, the process generates no waste of any kind. Can still treat it as waste resulting from applying technological process used in anointing oil of speed reducer and other mechanisms managed. Frequency change gear oil lubrication is very low and also used oil does not contain polychlorinated policlorinat/10. Significant amounts of oil are used in other transmissions and bearings of the plant which are also changed periodically. It is worth mentioning that the wind turbine is brought on site with Anticorrosive protection, turbine manufacturer delivering product in this form (Dalhoff 2009). In the maintenance of facilities, long enough periods corrosion protection and recovery occurs. Pollution on corrosion protection of plant recovery turbine is considered to be insignificant because the work could be done in stages and high reliability C5M class corrosion protection.

Waste water management regime produced during execution shall be subject to site organization, in accordance with regulations. Expected waste types are the following:

- Domestic or their equivalent;
- Metal resulting from the execution of steel structures resistance to wind activity and the execution of all maintenance work, construction machinery;
- Waste building materials resulting from any batch of concrete selection if not respect schedules;
- Wood waste from current activity on the site;
- Tires, batteries, oils, diesel and other petroleum products used;
- Cardboard, office paper from activities within the site organization.

According to H.G. no. 162/2002 on the landfill of waste, domestic waste and the equivalent thereof shall be collected within the site organization collection point type container bins provided. These wastes periodically be transported safely to the nearest landfill. In this respect, it should keep a strict on dates, quantities removed and means of transport. Metal waste will be collected and temporarily stored inside the site and will be used by specialized units. (Medan et al., 2008).

Waste building materials poses no particular problem in terms of environmental pollution. During the execution of these wastes together with inert waste from excavation will be temporarily stored in a specially designed the site to be used later in fillings, building walkways and parking spaces. Additional quantities will be removed from the site and transported in special places.

Wood waste will be selected, some of them will be reused and the remainder valued as firewood for the population. Accumulators with high potential for environmental pollution will be stored and kept properly to capitalize them through specialized units. Used tires will also be stored in special places.

• Waste arising after the entry into service of wind turbines Park: another source of waste generation is stuck on complex plant maintenance space after installing wind turbines. These wastes are vegetable scraps, code 02, leaves and grass, which are biodegradable or can be incinerated whereas a specially designed space. Their result with incineration ash is good fertilizer is a plant of the field.

It should be noted that both the quantity and quality resulting waste is not a major problem in terms of protecting the environment.

• The management of toxic and hazardous substances: analysis of manufacturing technology and operational technology wind turbine assembly results that are not toxic and hazardous substances used routinely, and therefore will not result in waste of this nature

• Soil sources can be grouped into three levels of significance, respectively:

- Level I standing pollution sources;
- The second potential sources of pollution;

-Level III indirect pollution sources:

Soil pollution is manifested by:

- Physical degradation, respectively compaction and structural degradation;
- Chemical degradation, caused by increased content of heavy metals, pesticides, and change in pH;
- Biological degradation, caused by pathogens;

Soil pollution is any action that disrupts its natural characteristics. Activities that may cause soil pollution are generally production activities which can generate one previously mentioned degradation. Soil from the site of the wind farm is affected only in the construction phase of assembly plants by excavations made for building and land subsidence due to transport and maneuver mounting and subassemblies turbine towers and substation construction due to transformation.

After building, restoring soil will consist of leveling land, fertile soil intake and planting, to the extent possible, the area features plants and trees adjacent places, remaining free of construction. Area is characterized by the presence of increased soil fertility, creating a surface coating plant will be relatively brief mention in duration.

It should be noted that any planting of trees in the free zone will be building so that performance is not affected by the use of wind potential.

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REDUCTION OF PLASTICS MATERIALS STORED RESULTS FROM FERROUS RECYCLING

Emil NAGY[1*]

[1] Technical University of Cluj-Napoca, Romania, emil.nagy@sim.utcluj.ro*

ABSTRACT. Increased use of different materials in the manufacture of industrial products alongside scale use increasingly larger plastics led to the complex problems related to recycling at end of life. Reducing the amount of material deposited is a goal that should be taken into consideration at all times complies in recycling of materials in accordance with the law more restrictive. Explore the possibility of reducing plastics recycling materials from ferrous stored results represents the desire of this article. Based on the analysis and determinations are capabilities and experimental results illustrated the fundamental data about recycling industrial exploitation of ferrous materials in reducing the amount of plastic land filled.

Key words: *ferrous materials recycling, automotive shredder residue, plastics materials recycling*

INTRODUCTION

Great changes have taken place in recent decades are made under the new paradigm: technological developments influence the economic, social and political. Ignored and unsupported truth to reveal: the earth's resources are limited and their preservation issue is not just a problem for the next generation. On the other hand, increasing the amount of material handled and industrialize caused a harmful interaction with environmental factors, one of which materialized by the appearance of very large amounts of waste.

Today waste is generated from a variety of sources and large amounts of material are deposited, resulting in difficulties in storage. Industrial processing or storage of this waste is extremely difficult and has become a social problem in recent years.

In the last 25 years, has Increased automobile manufacturing. Cars are essential in our modern society, but still reach the end of life, when out of use, and become unusable. These are collected and disassembled for scrap metal dealers to reuse or recycle parts. The remainder is stored somewhere as waste.

Materials involved in the manufacture of car are numerous, of various types, but most of them are non-renewable type, which is why recycling is and remains a key issue for increasing the competitiveness of the industrial activities.

Approximately 68-82% of the weight used cars are recycled in the EU. The rest, which are called auto wastes are dumps due to their complexity. It is a challenge to reduce the percentage that goes to dump. European Directives of 2006 states that 15% of the vehicle weight can be deposited in landfills, and the 2015 is only 5%. It also stipulates guidelines to no more than 10% incineration. Many countries do not have the technology to meet these guidelines, European Commission, (2006).

END OF LIFE VEHICLES RECYCLING ROUTE

The conventional route for end-of-life vehicle recovery and recycling is determined by standard practices of metal recycling Table 1. The process steps include the pretreatment or depollution and shredding and sorting the vehicle to recover valuable metals. These metals are recovered by separation recycled metal materials processing industry in various routes. Ferrous waste has become a major trend in the steel industry and is to strengthen the future, under the influence of sustainable development. This means in particular that these products will not only be used in the future to produce carbon and alloy steels, but will also be used for high strength steels. To achieve this goal the size and quality of ferrous materials loading regularity improved.

Table 1. *The conventional route for end-of-life vehicle*

Operations on end of life vehicles	**Recovered fraction**	**Waste material resulting after shredding**	
grind (Shredder)			
Air separation 1		Fine fraction	Plastic fibers
			Polystyrene
			Wood
			Iron And Minerals
Air separation 2		Light fraction	Primers
			Rubber
			Plastic
			Steel Cables
			Electric Cables
			Wood
			Small Pieces Of Glass, Earth, Rock
Magnetic separation	Ferrous materials		
gravity separation Induction and separation	Nonferrous materials		

Some of the debris resulting from the grinding used cars scrapped are used for secondary power generation. What remains after the separation, sorting and reprocessing of materials, a quantity of material representing about 20-25% of

the vehicle can not be processed by the technological processes economically viable at present, often called waste RA (Residue Automotive) or waste ASR (Automotive Shredder Residue) Romelot, P., et al. (1997).

These residues resulting from the recycling process are non-recoverable waste landfilled.

MATERIALS STORING

In the last two decades automobile production has grown to over 62 million. A statistical analysis shows a net increase Europe used cars scrapped from 8 million in 1996 to almost 11 million in 2015, European Commission, (2006).

The main areas of waste storage are usually outside, uncovered and unpaved landfill which could lead to soil pollution, but also and landfills are covered and paved. Depending on weather, volatile organic or inorganic substances may occur.

Problems facing waste management in Romania can be summarized as follows:

- Storage grounds are the most important way to their final disposal;
- Existing landfills are often located in sensitive locations (close to dwellings, surface water or groundwater, recreation areas);
- Landfills are not designed properly to protect the environment, leading to water and soil pollution in those areas;
- Lands occupied by landfills are considered degraded land that can no longer be used for agricultural purposes, at present, in Romania, more than 12,000 ha of land are affected by domestic and industrial waste disposal;

All these considerations lead to the conclusion that waste management requires the adoption of specific measures appropriate to each phase of the waste in the environment.

PROCESSING EQUIPMENT

Analysis limits recycling fundamentals suggest that high levels of recycling end-of-life vehicle required by EU legislation can be onerous because it relies on simple fundamental first principles. It is conjectural that recycling rates by monitoring legislation may be incorrectly controlled manner in terms of performance optimal recycling system in which each actor in the system optimizes its work within environmental limits legilsaţiei, physics, chemistry, which limits completely dictates recycling.

Modern technology requires a systematic approach according to which materials engineers are involved directly or indirectly related to compliance with product strategy to report the use of materials from traditional and new Van Schaik, A., Reuter, M.A., (2005). Using recycled ferrous materials is addressed their influence on both the quality and the process that produced technological system under the paradigm of sustainable development. This means in particular that these products will not only be used in the future to produce carbon and alloy steels, but will also be used for high strength steels.

To achieve this goal regularity size and quality of recycled ferrous materials should be improved. Crushing plays an important role in preparing and recycling. Facilities "Shredder" becomes an important factor in preparing materials end-of-life vehicle type. The central objectives of breakage are:

- Generate fragments whose size distribution ensures separation facilities or metallurgical processes;
- Release of constituents from multi component assemblies;
- Removal of surface coatings on steel.

Case study analysis was taken as the object type grinding plant "shredder" obsolete vehicle processing with main characteristics of the installation as shown in Table 2.

Table 2. *„Shreder" grinder*

Schreder type end-of-life vehicle processing equipment
Productivity 10-20 t / h
Materials processing 1-3 m
Pipes up to 6 m
Length 3000mm
Motor 600kw (820 Hp)
Energy consumption 1000 kW
Extraction plant (gas + dust)

Scrapped vehicles were subject to breakage cars of the '80s. In Table 3 are presented the results of sample analysis and data processing.

Table 3. *Materials in vehicle*

Share materials in vehicle - '80 years	
MATERIAL	**SHARE** [%]
Ferrous Materials	72
Nonferrous Materials	7-9
Rubber	4-6
Plastic	6-9
Glass	2,5-3,5
Other	3-4

Variations recovery after shredding residual fractions of components of end to Schredder were:

1 - Variant separation system mainly dry through a process of separating residual fractions after shredding the Schredder end-of-life vehicle;

2 - Option separation system with a wet separation process mainly residual fractions after end-of-life vehicle shredding the Schredder.

The first variant (variant separation system mainly dry through a process of separating residual fractions after shredding the Schredder end-of-life vehicle) included the following operations:

- Shredding residue to reduce the size;
- Classification of gravitational volumetric dry;
- Magnetic separation of ferrous volume classes;
- I-ferrous metal separator for recovery;
- Classification of volumetric wet gravity;
- Separator for recovery of non-ferrous metals II.

In Table 4 are given the results of the recovery global component separation system variant with a dry separation process mainly residual fractions after end-of-life vehicle shredding the Schredder.

Table 4. *The recovery of components I*

Shredder Residue	
Material	**Degree of recovery [%]**
Plastic	68
Rubber	65
Ferrous Materials	87
Nonferrous Materials	61

Because residue resulting after end-of-life vehicle shredding the Schredder is composed several types of polymers incompatible with each other, the second part of the analysis was done utilizeazand a wet flotation. The second variant (variant separation system with a wet separation process mainly residual fractions after shredding the Schredder end-of-life vehicle) included the following operations:

- Shredding residue to reduce the size;
- Wet flotation separation system;
- Classification of volumetric wet gravity;
- Magnetic separation of ferrous metals;
- Separator for recovery of non-ferrous metals.

The overall results are shown in Table 5 on the recovery of the components separation system version with a wet separation process mainly residual fractions after end-of-life vehicle shredding the Schredder.

Table 5. *The recovery of components II*

Shredder Residue	
Material	**Degree of recovery [%]**
Plastic	82
Rubber	68
Ferrous Materials	89
Nonferrous Materials	69

Different types of recycled materials have random qualities of several reasons:

- Bulk density, ie statistical geometric shape elements (parts) components, will condition can fully charge the different types of materials;
- Content waste materials or impurities that can not be removed at all or in part;

Essentially outside their geometric shape, the important features include a batch of recycled materials and chemical composition. Studies have shown, given the heterogeneity of lots and sizes of different parts of recycled materials, the chemical analysis by sampling leads to very scattered and imprecise.

For well-defined circumstances, shift from one category to another can be done primarily for economic reasons at least two reasons:

- Certain types of recycled materials may use zero or negative values, they can not be used even for null values;
- Certain types of recycled materials may be overstated.

RECOVERY OF PLASTICS

Recycling plastics from treatment and dismantling of end may be a solution for the reduction of environmental impact and efficient use of natural resources limited and the process of exhaustion, This is done either by using them at a value lower (as a filler composite) or by making them as energy sources in industrial installations or incineration or pyrolysis of organic Romelot, P., et al. (1997).

Use of plastic waste in industrial furnaces operating

In blast furnaces, heat is generated by burning coke, which ensures the temperature required for melting iron reduction processes and fully. Oil or pulverized coal is injected through holes wind often due to heating mode. Using waste plastic to replace traditional fuel use is a mass of plastic waste in the process of obtaining the first fusion iron. Almost no difference between plastic waste and fuel oil (petroleum). Both hydrocarbons are converted into gas at high temperatures in the bottom of the furnace, and the gas is used to reduce iron.

If we compare the use of plastics in classical furnace direct combustion power plants, or incineration plants (see table 6), it is clear that due to the growing demand for reducing energy consumption is only one of the classic furnace processes which can use energy content is converted from the plastic.

Table 6. *Various processes using plastic*

Various processes using plastic			
Domain use	Blast furnaces	Power plants	Waste incineration factories
Total use [%]	79	40	30
Loss [%]	21	60	70

When using furnace waste plastics over other combustion processes, and elements to consider environmental protection.

Newest iron making processes worldwide have failed to notice among experts, politicians and public authorities that injecting waste plastics into blast furnace is apparently advantageous Springorum, D., Steffes, B., (1996).

In the direct arc furnaces melting iron containing materials, such as ferrous materials recycling from the comminution, usually occurs in electric arc furnaces that have an important role in modern steelmaking concepts. Today the percentage of steel produced by electric arc furnaces of total steel production in the EU is 65.3%. Steel production from waste (scraps from steel processing, waste of steel producers and the results by browsing or using products) consume significantly less energy compared to the production of steel from iron ore Sanz, G. (1997). Advantages of the method for use in electric arc furnaces, in terms of recyclability and economic investments must be assessed Romelot, P., et al. (1997). This has triggered environmental improvements and economic operation of the furnaces and develop alternative methods of producing steel. And use the best technologies (such as oxyfuel burners machines fluid jet technology, working with sparkling slag, furnace enclosure, etc.) favor the introduction of plastic waste in the industrial units.

In cupola furnaces for cast - in some cases more flexibility is required production in units of less productive in principle to meet customer requirements. Is the production of waste iron in cupola furnaces. These aggregates are used SOFT exploitation upper primary fuels. Difficulties opposed to what can be done are many and are given primarily limited knowledge of data characterizing materials, as well as certain aspects of the manufacturing process. Also modern practice requires the existence of data transfer agents and recycling products.

Using plastic waste is a potential use in cupola furnaces mainly because big progress in terms of auxiliary plant especially those related to environmental protection.

The use of plastic waste in the furnace exploitation give good result in energy and material saving Nakamura, S., Kondo, Y. (2002). The method of use of plastic waste material by injecting into the industrial furnaces of waste material is a good Possibility But is necesarry to take carry for the environment problems.

In the process, theoretical calculations, and also based on comprehensive test programs in the elimination of all risk factors, the process may be extended to other industrial units.

Recovery of plastics using them at a lower value

In this direction possible variants for residues of plastics are:

- Transformation into carpet padding, Boon, J.E., et al. (2003);
- Obtaining media for batteries;
- Achieving absorbing plates;
- Developing products for waterproofing.

It can be said that recovery of plastics is dominated by laws defining industry-market correlation, imposing develop a recycling system combining the properties which determine the recyclability and recovery product. Summing these apect determine the economic character of recycling and reuse and thus the degree recycling and reuse Van Schaik, A., Reuter, M.A., (2005). It should be noted that each system activity takes place within normal limits in relation to legislation in an industrial area. Based on these intrinsic properties developed such a system as a common language to harmonize legislation recycling industry practice, physical separation and thermodynamic quality recycling (intermediate) products and industrial statistics as products. Recycling optimization model built on research, not only physical separation process description covers the physical separation of the residue of shredder closely related to its final treatment. This model brings significant new aspects can be applied to industrial recycling (in order to optimize the process) and the legislature (to demonstrate the arguments in favor of greater flexibility and reducing regulations) to achieve and assess how recycling vehicle shape, the evaluation market directions, finding the balance between disassembly, post-shredder technology (grinding) as a function of input limitations of various treatment options.

The diversity of the solutions adopted, as recent research shows the timeliness and importance of the issue, Keoleian, G. A. (1998). Currently, there is a solution "typified" or recognized as a European or global optimum.

The general objectives to develop in this area are related to:

- Develop an evaluation system to ensure harmonization of requirements and processors to achieve full recovery of organic waste technologies ferrous materials.
- Applying basic system is not only to provide precise indications on the opportunities of different materials: to highlight the usefulness of such a model to serve as a tool enabling greater knowledge of multiple aspects of the problem to be studied in while a clear overview.

The corresponding results oriented activities have developed in such a way that there is sistemici strictly necessary elements, such as:

- Studies on evaluation systems;
- Evaluation Criteria;
- Database;
- theoretical and experimental models;
- Computer programs based on factors determined: physical, inclusions, gas, IA.

What is really clear is that the limit of 85% will be difficult to achieve in the future under EU rules. Preferred route processing vehicles with minimal disassembly (only pollution) but including post-shredder technology is feasible to achieve a 85% (plus one standard deviation) Ferrão, P., et al. (2006).

However the new innovative car reducing weight, low impact benefit during phases of wear can lead boundary limit of 85% to a value of 95% after 2015, Börjeson, L., et al. (2000).

To implement a new technology may give rise to significant differences related marketing due share in the cost components (material required quality obtained by recycling deposit distances, transport costs, lack of land for storing waste, environmental regulations, etc.) Isaacs, J.A., Gupta, S.M., 1997. Therefore full analysis of the system must be customized eco-efficiency.

CONCLUSIONS

Facilities "Shredder", which are an important factor in preparing raw material competing classics are efficient by reducing waste, namely the recycling of plastics and reduce the amount of waste dumps (stored).

Material recycling should become a permanent activity, including all phases of the design of a car to its removal from service, with feedback on the results obtained in the chain of processes involved. Recycling should be flexible to accommodate the structure, although market constraints with technological and natural laws due to innovative design of cars. This will help stimulate more creative in the future and at the same time bringing recovery and recycling technology using a maximum.

Advanced recycling of materials contributes significantly to enhanced environmental management implementation that allows environment and economy to coexist harmoniously ie a sustainable development paradigm beginning of this century.

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SPECIFIED EMISSION FACTORS ESTIMATION FOR MAJOR LIGNITE POWER PLANTS IN ROMANIA

Mihaela NEAGU[1*], Daniela Luminiţa MOVILEANU[1], Ion ONUŢU[1]

[1] Petroleum-Gas University of Ploiesti, Faculty of Petroleum Refining and Petrochemistry, 39 Bucureşti Blv., 100680, Ploiesti, Romania
[*] E-mail: mpetre@upg-ploiesti.ro

ABSTRACT. Climate change is a major global issue which is assigned to the greenhouse gas (GHG) effect. Coal continues to be the most widely used fuel for electricity and heat generation in Romanian power plants. CO_2 is the main greenhouse gas emitted by coal combustion. Along with CO_2, nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) are other major combustion – generated pollutants from coal – fired power plants. Emission factors are cost-effective means for the development of emission inventories and control strategies.

The aim of the present study is to estimate the specified emission factor for several pollutants emitted from four lignite-coal power plants in Romania, namely Turceni, Rovinari, Craiova 2, and Işalniţa. The major gaseous emissions (e.g. sulphur dioxides, nitrogen dioxides and carbon dioxide) generated from lignite-fired power plants in Romania are estimated based on Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. The estimations were made for each of the four plants that produced electricity in 2010 as the fired lignite composition in these power plants is quite different from mine exploitation to another. Calculations for estimating the emission factor for nitrogen and sulphur oxides have been made. The coal composition and characteristics (i.e. the total sulphur content and lower heating value) greatly affect the emission of SO_2. The calculation procedure of the NO_2 emission factor included many factors. A short list of the factors that influence the fuel and thermal NO_2 emissions comprise: fuel nitrogen content, volatile fuel content, combustion boiler type, specific flue gas volume, reduction efficiency of primary measures, lower heating value, etc.

Key words: *lignite, specified emissions factor, carbon dioxide, sulphur dioxides, nitrogen dioxides*

INTRODUCTION

The energy supply system is the prime mover of technological and economic growth. Fossil fuels will continue to dominate the electricity generation sector for a long period during the following century. Coal will continued to be the most widely used fuel for power generation in many economies, especially where coal is the main indigenous and economically viable source of energy (Minchener and McMullan, 2007).

In 2010, about 45 percent of the generated electricity in the Romania came from power plants, followed by hydropower and nuclear power plants, as shown in Fig. 1 (Report ANRE, December 2010).

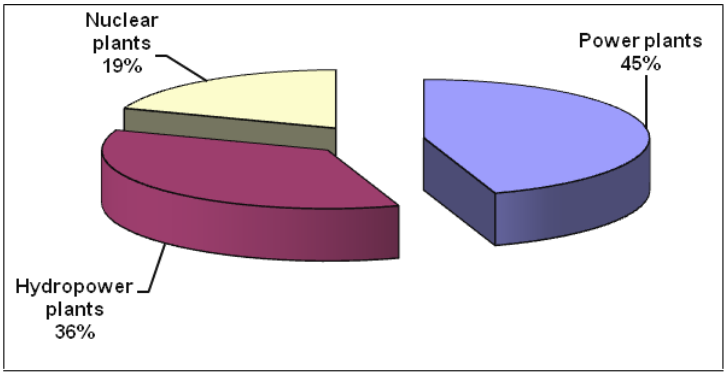

Fig. 1. *The share of the energy sources in Romanian power generation.*

The use of coal for electricity generation in Romanian power plants had the highest share in 2010, although the natural- gas-fired generation has rapidly grown in last decade. The use of oil for electricity generation in large power plants (over 300 MWh) is not a proper option. The oil is the main feedstock for thermal and electricity generation in medium and small plants, in industrial and domestic applications.

In 2010, the electricity generated in Romanian power industry was 59140 GWh. The main players and their contributions to the electricity market are showed in Table 1.

Table 1. *Individually contribution of electricity generated in Romanian power industry*

Power plant name	Electricity production, GWh	Share in electricity market, %
Hidroelectrica	21112.98	35.7
Nuclearelectrica	11473.16	19.4
CE Turceni	5914.00	10.0
CE Rovinari	5322.60	9.0
CEN Craiova	4139.80	7.0
Electrocentrale Bucuresti (ELCEN)	3548.40	6.0
Electrocentrale Deva	1774.20	3.0
Termoelectrica	1182.80	2.0
Others	4672.06	7.9
Total	59140.00	100

The data from Table 1 show that the contributions of CE Turceni, CE Rovinari and CEN Craiova (Craiova 2 and Işalniţa) of the total electricity capacity are about 15376.4 GWh. These main contributors are power plants based on lignite as fuel and are placed near the region where the lignite is extracted. The combustion plants with a thermal capacity ≥ 300 MW should be considered as point sources, according to CORINAIR90 (1991). A combustion unit can comprised of a boiler or boiler series of different sizes. In the case of many boilers the possibility of their aggregation should be taken into consideration. The configuration of the selected power plants for this study can be seen in Table 2. The design capacity of the selected lignite-fire thermal plants is obtained from GEO (2009).

Table 2. *Lignite power plants configuration and design capacities.*

Power plant	Combustion units	Design capacity per unit
CE Turceni	6	789 MWe*
CE Rovinari	4	330 MWe
CEN Craiova 2	2	150 MWe
Işalniţa	2	315 MWe

* MWe-megawatt electrical

The data presented in Table 2 show that each combustion unit from CE Turceni, CE Rovinari and Isalnita can be considered as a single point source and the entire capacity of Craiova 2 is considered as a point source, according to CORINAIR90. Our decision is to approach each of the power complexes as single point source.

Lignite-fired power plants used to generate electricity convert the coal into heat energy. Power plants are the largest individual sources of environmental pollution in Romania and around the world. A great number of researchers have focused on the environmental impacts of the coal-fired power plants used for electricity production and reported their results in the last decade.

The different types of emissions generated from power plants and their effects on the atmospheric environment and on health were investigated by Ghoniem (2011),Vardar and Yumurtaci (2010), Akimoto et al. (2010), Köne and Büke (2010), Ko et al. (2010), Minchener and McMullan (2007), Cai et al. (2007), Demirbras (2003). The number of studies regarding to emissions in energy production sector, thermal and lignite fired power plants, is very small. In this context, the energy and environmental issues relating to GHG emissions in Romania were investigated by Cârdu and Baica (2005).

The climate change due the GHG emissions and sustainable development are two major environmental issues on the entire world. Reducing the emissions can be the solution to these.

It is well known that there are the five types of greenhouse gas (GHG) emissions outlined in the Kyoto Protocol, namely carbon dioxide, methane, nitrous oxides and fluorocarbons emissions (HFCs, PFCs, and SF_6).Carbon dioxide (CO_2) is the main GHG product resulted from the combustion of all fossil fuels. Along with CO_2, other two acid gases are released from coal burning, namely sulphur oxides and nitrogen oxides, both having a significant effect on atmosphere acidification.

In the future, the using of coal depends on the strict requirements imposed by environmental legislation, which includes minimization of CO_2 as well as of nitrogen and sulphur oxides emissions, especially coming from power plants.

In the present paper the specified emission factors for some pollutants emitted from four lignite - coal power plants in Romania (Turceni, Rovinari, Craiova 2 and Isalnita) are estimated. The main gaseous emissions (e.g. sulfur dioxides, nitrogen dioxides and carbon dioxide) generated from lignite-fired power plants in Romania are estimated based on the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. Because the lignite composition is quite different from a region to another, the estimations are made for each of those four plants that produced electricity in 2010 in Romania. The emission factors for nitrogen and sulphur oxides have been estimated by calculations. The composition and characteristics of coal (i.e. the total sulphur content and lower heating value) greatly affect the emission of SO_2. The calculation procedure of the NO_2 emission factor includes more factors.

CHARACTERISTICS AND COMPOSITION OF LIGNITE USED IN THE SELECTED POWER PLANTS

Over 90% of total lignite reserves are in coal basins from Oltenia region (Dina and Popa Paliu, 2010; Rademaekers et al., 2008), and the main beneficiaries of the extracted coal are the biggest Romanian power complexes Rovinari, Turceni and Craiova with Isalnita and Craiova 2. The location of all these power complexes in Gorj County makes them the biggest power producer in Romania. About 26% of coal energy produced in 2010 in Romania comes from here. The Romanian lignite has a low quality that means a low calorific value of 1650 – 1950 kcal/kg, a high ash content 25% and a maximum total moisture content of 46% (Fodor et al., 2000). The sulphur content of lignite is 0.8 – 1.2%. The chemical composition of lignite is quite different from a coal mine to another, even if it comes from the basins located in the Oltenia region.

The coal quality is evaluated based on proximate and ultimate analysis. The first type of analysis, the proximate one, is used to determine only the fixed carbon, volatile matter, moisture and ash percentage (Sivasankar, 2008), and the ultimate one is used for establishing all the solid and gaseous elements of coal.

Table 3 shows the ultimate composition of lignite. In our next calculations, the ultimate composition in moisture and ash free basis (*maf* composition), or dry and ash free basis (*daf* composition) will be useful. The *maf* compositions are shown in Table 4.

Table 3. *Selected composition of the Romanian lignite, % wt.*

Power plant	Moisture	Ash	C	H	S	O	N
CE Turceni*	44.65	19.89	21.70	1.98	1.10	10.00	0.70
CE Rovinari**	42.69	18.60	23.94	2.00	1.35	10.70	0.72
CE Craiova 2***	39.90	23.30	22.40	1.90	1.30	9.50	1.70
CE Işalniţa****	41.50	21.00	22.00	2.00	1.30	11.00	1.20

* Source: Environmental Integral Autorisation, No. 11/2006, S.C. Complexul Energetic Turceni S.A;
** Source: Environmental Integral Autorisation, No. 12/2006, S.C. Complexul Energetic Rovinari SA ;
*** Source: Tasks Note book – Flue gas desuphurisation plant at S.E. Craiova II, 2010 ;
**** Source: Tasks Note book - Flue gas desuphurisation plant at S.E. Işalniţa, 2010

Table 4. *Ultimate lignite composition in moisture and ash free basis (maf composition), wt%.*

Power plant	**C**	**H**	**S**	**O**	**N**
CE Turceni	61.16	5.58	3.10	28.19	1.97
CE Rovinari	61.84	5.17	3.49	27.64	1.86
CE Craiova 2	60.87	5.16	3.53	25.82	4.62
CE Işalniţa	58.67	5.33	3.47	29.33	3.20

In this work, volatile matter and fixed carbon will be useful for emissions factor calculation. The volatile matter content (*VM*) of lignite can be determinate by Seyler's empirical formula which is given below (Van Krevelen, 1993):

$$\%VM(daf) = 10.61\%H(daf) - 1.24\%C(daf) + 84.15 \quad (1)$$

where: % *C* and % *H* represent the percentage of carbon and hydrogen in dry and ash free basis.

Fixed carbon (*FC*) is associated with the volatile matter (*VM*) content of lignite by the following formula:

$$\%FC = 100 - \%VM \quad (2)$$

The *VM* is calculated based on equation (1) and ultimate lignite composition in moisture and ash free basis in Table 4. The *FC* is calculated by using equation (2).

Another important characteristic of lignite is the calorific value of fuel. Fuel lower calorific value (or Net Calorific Value - *NCV*, or Lower Heating Value - *LHV*) represents the amount of heat produced by its combustion at constant pressure in "standard" conditions (i.e. to 0^0C and pressure of 1.013 bar). The combustion products contain water vapor and the heat from this is not recovered. The *LHV* (or *NCV*) is expressed in kcal/kg of solid fuel or kJ/kg of solid fuel.

The lower heating value of investigated lignite, in MJ/kg, together with *VM* and *FC* calculated with equation (1) and equation (2) are presented in Table 5.

Table 5. *LHV, VM and FC of lignite.*

Power plant	*LHV*, MJ/kg	*VM* %	*FC* %
CE Turceni	6.90	67.54	32.46
CE Rovinari	7.66	62.28	37.72
CE Craiova 2	7.61	63.45	36.55
CE Işalniţa	7.88	67.99	32.01

In next section, the lower heating value and composition of lignite used in the selected power plants are needed in specified emissions factors calculations and SO_2 and NO_2 concentrations in flue gas.

ESTIMATION OF SPECIFIED EMISSIONS FACTORS FOR THE MAJOR POLLUTANTS GENERATED FROM LIGNITE POWER – PLANTS IN ROMANIA

Emissions generated from lignite power-plants

The flue gas generated by combustion processes depends on the type of fuel and the combustion conditions. Many flue gas components are air pollutants and are covered by European and governmental regulations (Directive 2010/75/EU, Directive 2008/50/CE, Directive 2008/1/CE).

The emissions generated from coal burning include many pollutants such us: greenhouse gases (e.g. carbon dioxide, nitrous oxide and methane), sulphur oxides (SOx), nitrogen oxides (NOx), carbon monoxide, particulate matter, carbon monoxide (CO), non-methane volatile organic compound and trace of heavy metals. This work is focused on only the following major pollutants: carbon dioxide, nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

The primary greenhouse gas emitted by coal combustion is CO_2. The CO_2 emission is directly related to the carbon content of fuels. The content of carbon varies in Romanian lignite between 15 and 30 wt%.

The sulphur oxides (SOx) emissions are directly related to the sulphur content of the fuel, which for Romanian lignite varies between 0.6 and 1.35 wt%. The coal contains sulphur in the following forms: pyrite (FeS_2), organic sulphur, sulphur salts and elemental sulphur. The pyritic and organic sulphur are responsible for most part of sulphur in lignite. Both of them lead to the formation of SOx. The most important nitric oxides formed are nitric monoxide (NO) and nitric dioxide (NO_2).

Methodology

The GHG Protocol calculation tools are in accordance with those from Intergovernmental Panel on Climate Change (IPCC, www.ipcc.ch) used for the compilation of emissions at national level. They were also been refined in order to increase the accuracy of data about emissions at the company level. According to IPCC (2006), the *emissions of each greenhouse gas from stationary sources are calculated by multiplying fuel consumption with corresponding emission factor*. IPCC

considers a *good practice* the estimation of emissions based on data at the level of individual facilities, namely the fuel statistics and data on combustion technologies and specific emission factors.

The European Environment Agency's publications include the *EMEP/CORINAIR Emission Inventory Guidebook* (2006) that provides guidance on estimating emissions and calculation methodology for general and specified emission factors.

In this work, the emission factor methodology is based on the *EMEP/CORINAIR Emission Inventory Guidebook* formulas and recommendations. Some general considerations regarding lignite combustion technology are necessary for the next calculations. It is assumed that the combustion configurations are pulverized coal and dry bottom boiler (DBB) for all plants, because there are not available data about boiler types and the combustion configuration of plants.

Specified CO_2 emission factors methodology

In order to determine specified CO_2 emission factors, the following general equation can be used:

$$EF_{R_{CO_2}} = \frac{44}{12} \cdot C_{C\,fuel} \cdot \varepsilon \cdot \frac{1}{H_u} \cdot 10^6 \tag{3}$$

where: $EF_{R\,CO2}$ – specified emission factor, g/GJ; $C_{C\,fuel}$ – carbon content of fuel (in mass C/mass fuel, kg/kg); ε - fraction of carbon oxidized; H_u – lower heating value of fuel, MJ/kg.

The part of oxidized carbon to CO_2 represents the fraction of carbon oxidized (ε). A small part of carbon can remain un-oxidized. Default values are 0.98 for solid fuels according to IPCC.

Specified SO_2 emission factors methodology and SO_2 concentration in flue gas

The following general equation should be used to determine specified SO_2 emission factors:

$$EF_{R_{SO2}} = 2 \cdot C_{S\,fuel} \cdot (1 - \alpha_S) \cdot \frac{1}{H_u} \cdot 10^6 \cdot (1 - \eta_{\text{sec}} \cdot \beta) \tag{4}$$

where: $EF_{R\,SO2}$ – specified emission factor, g/GJ; $C_{S\,fuel}$ – sulphur content in fuel; α_S – sulphur retention in ash; H_u – lower heating value of fuel, MJ/kg; η_{sec} – reduction efficiency of secondary measure; β - availability of secondary measure.

In equation (4), the $C_{S\,fuel}$ values are presented in Table 3 and the values for H_u are those for *LHV* in Table 5. But, to our knowledge, some input data are not available. For example, α_S is not available for public information. In this case, default values provided by literature data can be used. The default values for the sulphur retention in ash (α_S) for pulverised coal fired boilers in DBB technology are in range of 0.05 to 0.3. In our opinion, a value of 0.2 is a feasible option.

The secondary measure was not yet implemented in investigated lignite power-plants in the investigation year 2010. The flue gas desulphurization (FGD) units, namely the wet scrubbing process (WS), are implemented today as a secondary measure in all investigated power – plant. The reduction efficiency of secondary measure is practically proved to be over 96%. In the context of the above remarks, the availability of the secondary measure is practically proved to be 0.99 values in all investigated lignite power plants.

Specified NO_2 emission factors methodology and NO_2 concentration in flue gas

Empirical relations are used to establish NOx emission factors. The forming of fuel-NO and thermal-NO is taken into account for calculating of NOx emission factors. Fuel-NO forming is based on fuel parameters. Not all the fuel nitrogen can be converted into fuel-NO. The thermal-NO is an additional formed fraction and it depends on the boiler type.

The NOx emission factor calculation procedure includes the following steps:

1. The fuel nitrogen reacts with O_2, in a stoichiometric manner, and forms the nitrogen oxide. Thus, the maximum amount of fuel nitrogen oxide ($C_{NO_{fuel\max}}$) is achieved.

$$C_{NO_{fuel\max}} = C_{N_{fuel}} \cdot \frac{30}{14} \cdot \frac{1}{V_{FG}} \tag{5}$$

where: $C_{NO_{fuel\max}}$ is the maximum attainable amount of fuel nitrogen oxide (in mass pollutant/volume flue gas), kg/m^3; $C_{N\ fuel}$ is the nitrogen content in fuel (in mass nitrogen/mass fuel), kg/kg; V_{FG} is specific flue gas volume (in volume flue gas/mass fuel), m^3/kg.

In equation (5), the nitrogen content in fuel is taken from Table 3.

As previously noted, not all the nitrogen content in fuel is converted into $C_{NO\ fuel}$. The establishing of the converted part of fuel-nitrogen into fuel-NO ($C_{NO_{fuel\,conv}}$) can be done by applying the empirical relation presented bellow. The oxygen in dry flue gas is zero percent.

$$C_{NO_{fuel\,conv}} = 285 + 1280 \cdot \left(\frac{C_{N_{fuel}}}{0.015}\right) + 180 \cdot \left(\frac{C_{volatiles}}{0.4}\right) \cdot \left(\frac{C_{NO_{fuel\max}}}{3200}\right) - 840 \cdot \left(\frac{C_{C_{fix}}}{0.6}\right) \cdot \left(\frac{C_{NO_{fuel\max}}}{3200}\right) \tag{6}$$

where: $C_{NO_{fuel\,conv}}$ is fuel NO released (in mass pollutant/mass flue gas), mg/kg; $C_{N_{fuel}}$ is nitrogen content in fuel (in mass nitrogen/mass fuel), kg/kg, (*maf); $C_{volatiles}$* represents the fuel content of volatile (in mass volatiles/mass fuel), kg/kg, (*maf*); $C_{NO_{fuel\max}}$ is the maximum attainable amount of fuel nitrogen oxide (in mass pollutant/ mass flue gas), kg/kg; $C_{C_{fix}}$ is fixed carbon in fuel (in mass carbon/mass fuel), kg/kg, (*maf*).

The $C_{volatiles}$ and $C_{C_{fix}}$ are noted above as *VM* and *FC* and their values are presented in Table 5. In equation (6) the $C_{N_{fuel}}$ in (*maf*) basis are calculated for each investigated power-plant and the corresponding values are given in Table 4. It is observed that in equation (5) the $C_{NO_{fuel\max}}$ is in [kg/m^3] unit of measure, but in equation (6) is in mg/kg unit of measure. This means that the flue gas density (in mass flue gas/volume flue gas [kg/m³]) has to be taken into account. The flue gas density is calculated stoichiometrically based on the lignite composition assuming an air excess of 30%. The calculation procedure of flue gas density is not detailed in this work.

If the amount of fuel – NO achieves a rate of 70- 90%, then the formation of fuel – NO is assumed to be more important than the thermal – NO formation, the thermal – NO content can be considered as a fraction γ of NO fuel. This fraction depends on the boiler type. The equation (7) is used to calculate the total nitrogen oxide formed in boiler, $C_{NO_{total\,boiler}}$.

$$C_{NO_{total\,boiler}} = C_{NO_{fuel\,conv}} + C_{NO_{thermal}} = C_{NO_{fuel\,conv}} \cdot (1+\gamma) \tag{7}$$

where $C_{NO_{total\,boiler}}$ is the total content of nitrogen oxide formed in the boiler (in mass pollutant/mass flue gas), kg/kg; $C_{NO_{fuel\,conv}}$ represents the fuel-NO released (in mass pollutant/mass flue gas), kg/kg; $C_{NO_{thermal}}$ is the content of thermal – NO formed (in mass pollutant/mass flue gas), kg/kg; γ is the fraction for thermal – NO formed.

The default values of γ for dry bottom boiler (DDB) is recommended to be 0.05. In order to establish total nitrogen dioxide emissions from boiler, $C_{NO2_{boiler}}$, equation (8) can be used.

$$C_{NO2_{boiler}} = C_{NO_{total\,boiler}} \cdot \frac{46}{30} \tag{8}$$

where $C_{NO2_{boiler}}$ is total content of nitrogen dioxide formed in the boiler (in mass pollutant/mass flue gas), kg/kg and $C_{NO_{total\,boiler}}$ represents total content of nitrogen oxide formed in the boiler (in mass pollutant/mass flue gas), kg/kg.

2. Considering the primary measures with the reduction efficiency η_{prim} leads to lower total boiler nitrogen dioxide content ($C_{NO2_{prim}}$).

$$C_{NO2_{prim}} = C_{NO2_{boiler}} \cdot (1-\eta_{prim}) \tag{9}$$

where $C_{NO2_{prim}}$ is the content of primary nitrogen dioxide (in mass pollutant/mass flue gas), kg/kg; $C_{NO2_{boiler}}$ represents the total content of nitrogen dioxide formed in the boiler (in mass pollutant/mass flue gas), kg/kg; η_{prim} is the reduction efficiency of primary measure(s).

In investigated Romanian lignite power-plants, the primary measure for NO_2 reduction is mainly low NOx burner (LNB), excepting the Turceni power-plant which implemented the staged air supply (SAS) measure. For LNB measure, the reduction efficiency recommended in *EMEP/CORINAIR Emission Inventory Guidebook* is 0.2 and 0.3 for SAS; both values are valid for DDB combustion technology.

The next step in specified NO_2 emission factors calculation takes into account the secondary measure for NO_2 reduction. Any secondary measure has not been implemented yet in all Romanian power-plants. This means that the third step in specified NO_2 emission factors calculation is skipped.

The obtained value of $C_{NO2_{\sec}}$ is converted into C_{NO_2} and into the emission factor EF_{NO_2} according to the following equations:

$$C_{NO_2} = C_{NO2_{\sec}} \cdot \frac{1}{V_D} \cdot 10^6 \tag{10}$$

$$EF_{NO_2} = C_{NO_2} \cdot \frac{1}{H_u} \cdot V_{FG} \tag{11}$$

where C_{NO_2} is nitrogen dioxide in flue gas (in mass pollutant/volume flue gas), mg/m^3; $C_{NO2_{\sec}}$ represents nitrogen dioxide downstream of secondary measure (in mass pollutant/mass flue gas), kg/kg; V_D is dry flue gas volume (in volume flu gas/mass flue gas), m^3/kg; V_{FG} is specific dry flue gas volume (in volume flue gas/mass fuel), m^3/kg; EF_{NO_2} means the emission factor for nitrogen dioxide, g/GJ; H_u is lower heating value, MJ/kg.

In order to convert the emission factor expressed in g/GJ into mg/m^3, the specific flue gas volume has to be established. This makes the measured data comparison easy. To determine the specific dry flue gas volume (V_{FG}) the following procedure, which is further described, is applied. To determine the flue gas volume, the ultimate lignite composition in moisture and ash free basis of the fuel (content of carbon C_C, sulphur C_S, hydrogen C_H, oxygen C_{O2} and nitrogen C_N (*maf*)) must be known (see Table 4).

The following empirical equation is applied for calculating the volume of oxygen ($V_{O_{2\min}}$) required for a stoichiometric reaction:

$$V_{O_{2\min}} = 1.864 \cdot C_C + 0.700 \cdot C_S + 5.553 \cdot C_H - 0.700 \cdot C_{O_2} \tag{12}$$

The terms significances in the equation (12) are:

$V_{O_{2\min}}$ - volume of oxygen required for stoichiometric reaction (volume oxygen/mass fuel), m^3/kg;

C_C - content of carbon in fuel (mass carbon/mass fuel), kg/kg;

C_S - content of sulphur in fuel (mass sulphur/mass fuel), kg/kg;

C_H - content of hydrogen in fuel (mass hydrogen/mass fuel), kg/kg;

C_{O_2} - content of oxygen in fuel (mass oxygen/mass fuel), kg/kg.

Equation (13) is used for calculating the corresponding volume of nitrogen in the air, $V_{N_{air}}$:

$$V_{N_{air}} = V_{O_{2\min}} \cdot \frac{79}{21} \tag{13}$$

where: $V_{N_{air}}$ is volume of nitrogen in the air (volume nitrogen/mass fuel), m^3/kg; $V_{O_{2\min}}$ represents the volume of oxygen required for stoichiometric reaction (volume oxygen/mass fuel), m^3/kg.

To calculate the specific dry flue gas volume at 0% oxygen, V_{FG}, equation (14) is used:

$$V_{FG} = 1.852 \cdot C_C + 0.682 \cdot C_S + 0.800 \cdot C_N + V_{N_{air}} \tag{14}$$

where: V_{FG} is specific dry flue gas volume (volume flue gas/mass fuel), m^3/kg; C_C is the content of carbon in fuel (mass carbon/mass fuel), kg/kg; C_S represents the content of sulphur in fuel (mass sulphur/mass fuel), kg/kg; C_N is the content of nitrogen in fuel (mass nitrogen/mass fuel), kg/kg; $V_{N_{air}}$ is the volume of nitrogen in the air (volume nitrogen/mass fuel), m^3/kg.

To convert V_{FG} values at 0% oxygen into the reference oxygen content in flue gas, equation (15) is used:

$$V_{FG_{ref}} = V_{FG} \cdot \frac{21 - O_2}{21 - O_{2_{ref}}} \tag{15}$$

In the above equation the terms represent: $V_{FG_{ref}}$ - volume of specific flue gas reference conditions (volume flue gas/mass fuel), m^3/kg; V_{FG} – volume of specific flue gas obtained (volume flue gas/mass fuel), m^3/kg; O_2 - content of oxygen in the flue gas obtained, %; $O_{2_{ref}}$ - content of oxygen in the flue gas under reference conditions, %.

RESULTS AND DISCUSSION

The emission factors are proportional to the carbon, sulphur or nitrogen content of lignite and the combustion characteristics. The estimation accuracy depends on the data reported in available papers. In this paper, the calculations of emissions were made based on the average carbon content and on the maximum sulphur or nitrogen content reported in available public reports (The Integral Environmental Authorisations), for Turceni, Rovinari and Işlaniţa power-plants. The calculations for Craiova 2 power-plant were based on the specific lignite chemical composition, taking into consideration their own desulphurisation plants design. All these considerations were the base for chemical composition presented in Table 3.

Estimation of specified CO_2 emission factors

The specified CO_2 emission factors are obtained with the EEA methodology and expressed in grams CO_2 per Gigajoule or kilograms per Terrajoule (g/GJ or kg/TJ). **Fig. 2** shows the specified CO_2 emission factors values for selected lignite based power-plants.

As can be seen in **Fig. 2**, the specific emission values of estimated CO_2 for CE Işalniţa are lower than in other plants. The explanation of this aspect can be the fact that the specific emission factors, which depended on the lower calorific value of lignite reported for this plant, are higher than those for other plants. The same explanation is valid, but inversely, to explain the higher value for specific emission values of CO_2 estimated for CE Turceni.

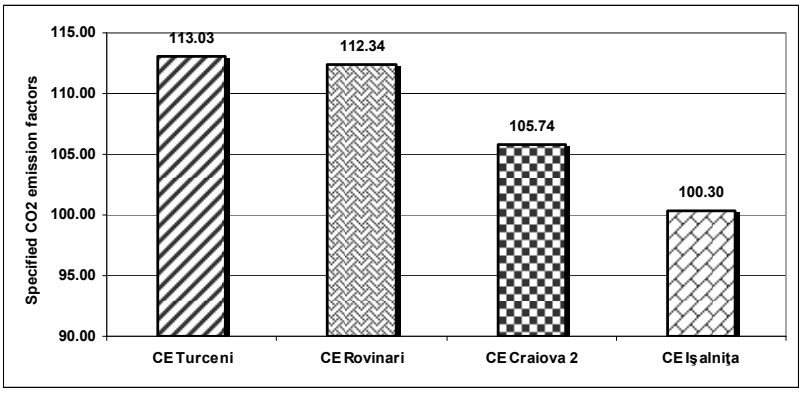

Fig. 2. *Specified emission factors for CO_2 (kg/GJ).*

Furthermore, a comparison between the estimated CO_2 specific emission values in this work and the IPCC values for stationary combustion in energy industry is useful. According to IPCC the lower value indicated for lignite is 90.9 kg/GJ and the higher value is 115 kg/GJ. The default CO_2 emission factor is 101 kg/GJ. The specific emission values of CO_2 estimated for lignite combustion obtained in this work are placed in the *IPCC*'s values range, but the default value is not relevant for CO_2 emission estimation in Romanian lignite power-plants.

Estimation of specified SO_2 emission factors and SO_2 concentration

The specified SO_2 emission factors are obtained by EEA methodology and are expressed as grams SO_2 per Gigajoule (g/GJ). In all our calculations, a value 0.2 for sulphur retention in ash (α_S) is considered. Firstly, in equation (4) secondary reduction measures will not be considered. As mentioned above, since 2011 all Romanian power plants have taken measures to implement the wet scrubbing process (WS) for flue gas desulphurization. Taking into account the reports available for public information and the fact that the lignite chemical composition and lower calorific values were not changed between 2010 and 2012, the calculations for

specified SO_2 emission factors including WS as secondary reduction measures were performed. **Fig. 3** shows the specified SO_2 emission factors values for selected lignite based power-plants without and with secondary reduction measures.

As can be seen in **Fig. 3**, the specific emission values of SO_2 with secondary reduction measures are significantly lower than those without these measures. The specific value of SO_2 emission factor in the case of the CE Rovinari power-plant is the biggest one because the lignite used in this plant has the maximum sulphur content value. The validation of our calculation is more difficult to be made if it is based only on the comparisons with literature reported values. This is due to different values of lignite sulphur content and lower calorific value. More significant comparisons can be made based on SO_2 concentrations in flue gas. The SO_2 concentrations in flue gas can be calculated with equation (10). Firstly, the specific dry flue gas volume at 0 % oxygen (V_{FG}) must be calculated according to the procedure presented above. Table 6 shows the results of V_{FG}'s procedure.

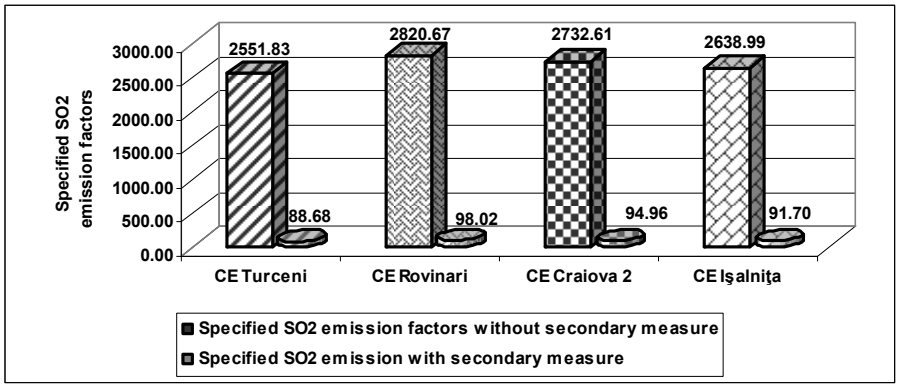

Fig. 3. *Specified emission factors for SO_2 (kg/TJ).*

Table 6. *Specific dry flue gas volume at 0 % oxygen (V_{FG}).*

Power plant	V_{O2min} from Eq. (12), [Nm^3/kg fuel]	V_{Nair} from Eq. (13), [Nm^3/kg fuel]	V_{FG} at 0 % oxygen from Eq. (14), [Nm^3/kg fuel]
CE Turceni	1.27	4.79	5.96
CE Rovinari	1.27	4.78	5.96
CE Craiova 2	1.27	4.76	5.95
CE Işalniţa	1.21	4.55	5.68

The SO_2 concentrations in flue gas calculated at 0 % oxygen are corrected at 6% oxygen according to equation (15). Table 7 shows a comparison between calculated and in-site measured values of SO_2 concentrations.

Table 7. *Calculated and in-site measured values of SO_2 concentrations.*

Power plant	Calculated SO_2 concentrations [mg/Nm^3] at 0 % oxygen without secondary reduction measures	Calculated SO_2 concentrations [mg/Nm^3] at 0 % oxygen with secondary reduction measures	Calculated SO_2 concentrations [mg/Nm^3] at 6 % oxygen without secondary reduction measures	Calculated SO_2 concentrations [mg/Nm^3] at 6 % oxygen with secondary reduction measures	Measured SO_2 concentrations [mg/Nm^3] at 6 % oxygen without secondary reduction measures
CE Turceni	2951.44	102.56	4132.02	143.59	4880
CE Rovinari	3621.78	125.85	5070.49	176.20	5752
CE Craiova 2	3496.73	121.51	4895.42	170.12	NA*
CE Işalniţa	3660.34	127.20	5124.47	178.08	5543

*Not available

The data in Table 7 show a good concordance between calculated and measured SO_2 concentrations at 6 % oxygen without secondary reduction measures. On the other hand, all calculated SO_2 concentrations at 6 % oxygen with secondary reduction measures are under the value of 200 [mg/Nm^3] imposed by European legislation such as Directive 2010/75/EU regarding industrial emissions. All measured SO_2 concentrations with secondary reduction measures are in house, but environmental authorities suggest that the emission limits for sulphur dioxides fixed by European legislation are attained.

Estimation of specified NO_2 emission factors and NO_2 concentration

Nitrogen dioxides emission factors are calculated by equations (5-11) taking into account only the prior mentioned primary measure for NO_2 reduction. Fig. 4 shows the specified NO_2 emission factors values for selected lignite based power-plants.

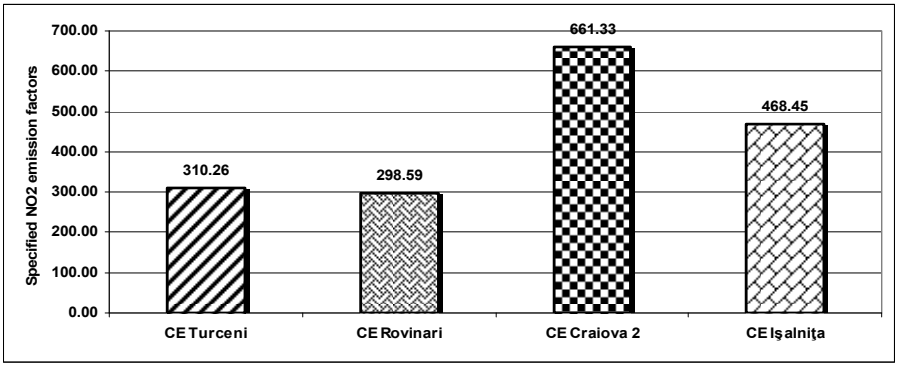

Fig. 4. *Specified emission factors for NO_2 (kg/TJ).*

As seen in the Fig. 4, the CE Craiova 2 reached the highest NO_2 emission factor. This correlates with nitrogen content in lignite, the content being the highest of all indigenous lignite, according to data presented in the current available literature. However, the range of the reported NO_2 emission factors is 156-558 kg/TJ (Complainville and Martins, 1994). It is possible that NO_2 emission factor for CE Craiova 2 be incorrect and further investigations in literature data or in-site information regarding nitrogen content are needed.

In next step, the NO_2 concentrations in flue gas are calculated with equation (10) in [mg/Nm^3] at 0 % oxygen and then the results are converted into 6 % oxygen. Table 8 shows as comparison between calculated and measured values of NO_2 concentrations.

Table 8. *Calculated and measured values of NO_2 concentrations.*

Power plant	Calculated NO_2 concentrations [mg/Nm^3] at 0 % oxygen	Calculated NO_2 concentrations [mg/Nm^3] at 6 % oxygen	Measured NO_2 concentrations [mg/Nm^3] at 6 % oxygen
CE Turceni	357.00	499.81	259-492**
CE Rovinari	383.39	536.75	863-1340***
CE Craiova 2	846.26	1184.76	863-1340 ***
CE Işalniţa	649.75	909.64	863-1340 ***

** in site measured value;

*** Literature available data for DBB with LNB as primary measure (*EMEP/CORINAIR Emission Inventory Guidebook*, 2006)

Table 8 shows a good agreement between the calculated and in-site measured NO_2 concentrations at 6 % oxygen with SAS primary reduction measures for CE Turceni. Unfortunately, for the remaining investigated power plants measured concentration data are not available. Literature available data for DBB with LNB as primary measure indicates that around the world, the NO_2 concentrations in flue gas are in range of 863-1340 mg/Nm^3. Based only on this general information, it can be seen that our calculated values are in the reported range. The final validation of our work procedure needs some in-site information.

CONCLUSIONS

The specified emission factors for some pollutants from major gaseous emissions, namely carbon dioxide, sulfur dioxides and nitrogen dioxides are estimated in this study. The concentration of sulfur dioxides and nitrogen dioxides in flue gas are calculated at 6% oxygen and are compared to available in-site data or literature data. The investigations are made for Turceni, Rovinari, Craiova 2 and Işalniţa lignite-fired power plants.

In this paper, the emission factor calculations are based on the *EMEP/CORINAIR Emission Inventory Guidebook* methodology. The emission factors are direct related to carbon, sulphur or nitrogen content of lignite and combustion characteristics. The obtained values of CO_2 emission factors for lignite combustion range between 100 and 113 kg/GJ.

These CO_2 specific emission values obtained as a result of the present study range from 90.9 kg/GJ to 115 kg/GJ, as indicated by *IPCC*. The specified SO_2 emission factors values for the selected lignite based power-plants without and with secondary reduction measures are also calculated. A good agreement is obtained between the calculated and measured SO_2 concentrations at 6 % oxygen without secondary reduction measures. The estimated NO_2 emission factors with primary measures range between 299 and 661 kg/TJ. All the calculated values are in accordance with those reported by literature, except those corresponding to CE Craiova 2 power plant. The NO_2 concentrations at 6 % oxygen with SAS primary reduction measures for CE Turceni power plant are in accordance with the in-site measured concentration. The other obtained values are in the general range reported by literature.

IPCC considers estimating emissions based on the individual specific data being a *good practice.* In our opinion, the specific emission factors obtained in the present study are useful means for the development of emission inventories and control strategies in the investigated Romanian power plants.

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***Directive 2008/1/CE concerning integrated pollution prevention and control, http://eur-lex.europa.eu.

***Directive 2008/50/CE on ambient air quality and cleaner air for Europe, http://eur-lex.europa.eu.

***Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) http://eur-lex.europa.eu.

***Global Energy Observatory (GEO) http://globalenergyobservatory.org/list.php?db=PowerPlants&type=Coal.

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MAGNETOSPHERE DOUBLE LAYERS AND AURORA BOREALIS. ACCELERATION MECHANISMS AND INSTABILITIES

Oana NICULESCU[1*], Marius Mihai CAZACU[2], Mihail Nicolae DANILA[2], Dan Gheorghe DIMITRIU[2], Silviu Octavian GURLUI[2*], Maricel AGOP[1]

[1] Department of Physics, Gheorghe Asachi Technical University of Iasi, 59A Mangeron Blvd., 700050 Iasi, Romania
[2] Department of Physics, Alexandru Ioan Cuza University of Iasi, 11 Carol I Blvd., 700506 Iasi, Romania
** E-mail: oannaniculescu@yahoo.com; sgurlui@uaic.ro*

ABSTRACT. As it was confirmed that the aurora borealis can be assimilated to laboratory plasma, a series of experiments are performed in order to emphasize the mechanisms of double layers formation and to study their properties. To this extent, in our work, the double layers are obtained in front of a positively biased electrode that is immersed in a cold, steady-state diffusion plasma, when the biasing voltage exceeds a threshold value. In certain experimental conditions, complex space charge structures are obtained in the form of multiple double layers. In this case, it was found that the potential profile is very similar to the aurora borealis stair-step diagram. Further experiments were carried out to study the influence of uniform magnetic fields on the formation and dynamics of a simple double layer, in order to simulate the conditions from the Earth magnetosphere. The results showed that, even at low intensity magnetic fields, the double layer behavior changes dramatically. Also the study of instabilities (Buneman instabilities, ion-acoustic instabilities) that arise in such plasma structures was proved to be very similar to those encountered in northern lights.

These series of experiments can provide important information about the formation of the magnetospheric double layers and their possible role in creating the aurora.

Key words: *aurora borealis, plasma double layers*

INTRODUCTION

The aurora borealis is mainly caused by high-energy electrons originating in the Sun entering the Earth's atmosphere in narrow regions centered on the magnetic poles.

These electrons collide with atmospheric atoms which are excited to higher energy levels. Auroras result from emissions of photons in the Earth's upper atmosphere, above 80 km, from ionized nitrogen atoms regaining an electron, and oxygen and nitrogen atoms returning from an excited state to ground state. They are ionized or

excited by the collision of solar wind and magnetospheric particles being funneled down and accelerated along the Earth's magnetic field lines. Excitation energy is lost by the emission of a photon, or by collision with another atom or molecule. As the brownish-red color results from oxygen atoms returning into their ground state while, the blue or red colors results from nitrogen emissions (see figure 1).

Fig. 1. *Picture of Aurora Borealis*

As proposed by Hannes Alfvén (1958), the electrons are accelerated by an electric field localized in a small volume bounded by two charged regions (double layer) which accelerates electrons Earthwards. Later, Forrest Mozer (Temerin and Mozer, 1987; Mozer, 1977) proved the presence of an electric field along the Earth magnetic field lines and the existence of electrical double layers. The particles densities measured in such structures can be as low as 33% of the background density. The structures usually have an extent of 100 m (a few tens of Debye lengths). Almost 10% of these structures fill the space in the lower magnetosphere. If one, out of 5 such structures, has a net potential drop of 1 V, then the total potential drop over a region of 5000 km would be more than the 1 kV, which is needed for the electrons to gain enough energy to create the aurora.

EXPERIMENTAL RESULTS

According to Piel (2010), the aurora borealis can be assimilated to laboratory plasmas and thus, a series of experiments are performed in order to emphasize and study the properties of multiple double layers.

The experiments were performed in a plasma diode (see figure 2), where the double layers (DLs) are achieved by positively biasing an electrode (denoted by E in figure 2) immersed in the previously obtained cold diffusion plasma. At a certain voltage applied on E, a bright spherical double layer spontaneously emerges in front of the electrode.

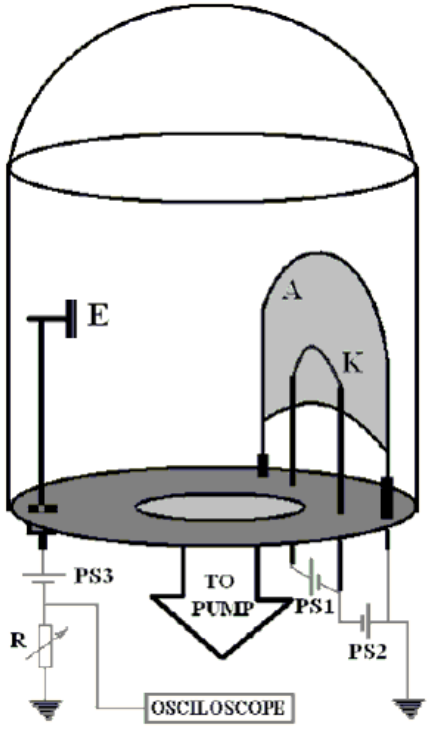

Fig. 2. *Schematics of the experimental device: A - anode with permanent magnets attached, K – cathode, E – additional electrode, PS1 – power supply for heating the filament, PS2 - power supply for discharge, PS3 – power supply for biasing the additional electrode, R – load resistor*

Under certain experimental conditions, depending on the gas pressure and electrode biasing voltage, more complex structures can appear in the form of multiple double layers (MDLs) (Ioniță, et al., 2007) (see figure 3).

As before mentioned, the acceleration mechanisms present in the aurora borealis consist also in a multitude of double layers and thus, a stair step potential profile can be expected (see figure 4) (Charles and Boswell, 2003).

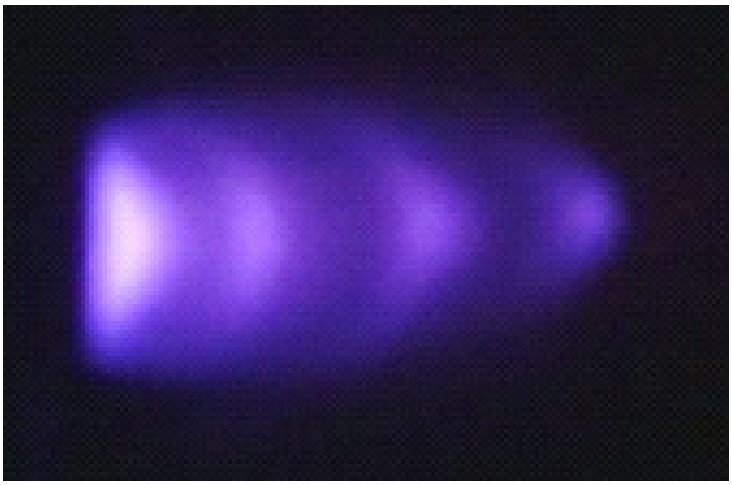

Fig. 3. *Picture of multiple double layers obtained in the laboratory*

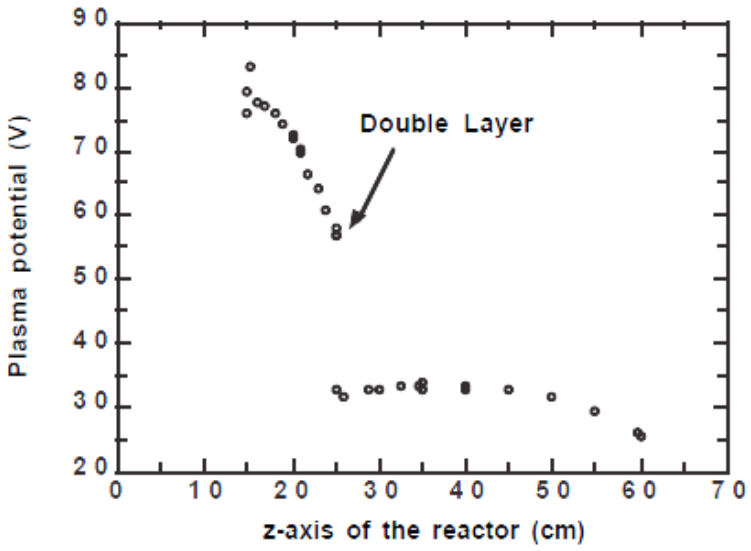

Fig. 4. *Auroral potential drop showing the double layer* [6]

Using an electrical probe that pierces through the electrode from behind, the radial potential profile of laboratory MDLs was drawn (see figure 5).

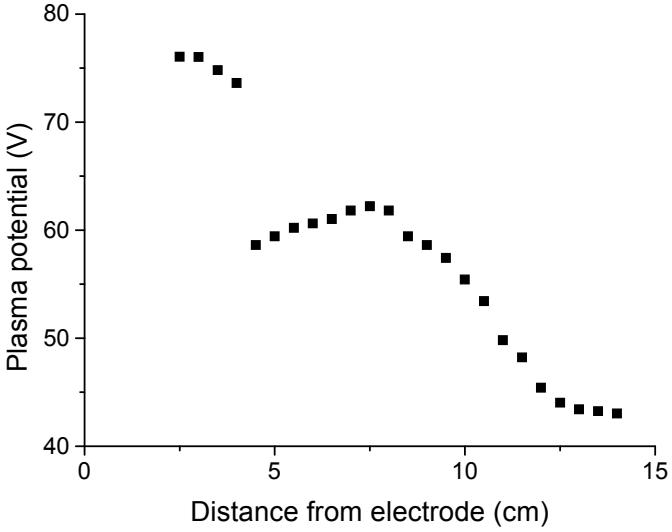

Fig. 5. *MDLs radial potential profile*

A great similarity between the potential profile from figure 4 corresponding to the aurora borealis MDLs and the potential profile from figure 5 corresponding to the laboratory MDLs is observed. Thus, we can conclude that the acceleration mechanisms in both cases are alike.

CONCLUSION

By performing a series of experiments concerning the formation process and the properties of multiple double layers, we observed that the obtained data are comparable with the date obtained for the case of aurora borealis. The mechanism of cosmic particle acceleration by such structures is similar to that encountered in laboratory plasmas.

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STUDY ON INCREASING THE EFFICIENCY OF BIOLOGICAL TREATMENT BY USE NEW MICROORGANISMS

Casen PANAITESCU[1*]

[1] Petroleum-Gas University of Ploiesti, B-dul Bucharest, No. 39, 100680 Ploiesti, Romania
** Email: c.panaitescu@gmail.com*

ABSTRACT. The industrial wastewaters from the petroleum refining industry are characterized by high amounts of organic compounds, but also contains nitrogen compounds, which justify the necessity of a biological wastewater treatment. Some substances are easily degraded by microorganisms of active sludge, other require a selected and adapted flora. In this study were followed to introduce new microorganisms in biological treatment step to observe the biological process performance; the study was performed on laboratory scale. Were analyzed microscopically samples of different microorganisms, then were selected the optimal sample and were introduced it in the biological system for observing the effects on baseline characteristics of wastewater in order to obtain a high efficiency.

Key words: *industrial wastewater, microorganisms, biological treatment, BOD*

INTRODUCTION

The biomass made up of unicellular or complex organisms must ensure the disposal of developped and colloidal material from the wastewater subjected to biological treatment. In the industrial wastewater treatment stations the main types of existing microorganisms in the active sludge are: *Sphaerotiius naians, Zoogleea Ramigeta, Sarcina Paludosa, Spirilhim Undulans, Oscillaloria limosa, Protozoare, Rhizopoda, Amoeba proteus, Amoeba radiosa, Amoeba vetwcosa, Amoeba limax., Nematodea, Diplogasier* (Frigon at al., 2002).The most important transformation which occurs in biological treatment is that of the organic nitrogen (Mulas at a., 2005).The degree of purification from biological treatment is influenced by the quality of the biomass, the residence time of water in the aeration basin, hydraulic loading as secondary treatment stage.

This paper aims to realize the efficiency growth of the biological treatment stage by introducing new types of microorganisms in aerotank of the stations of industrial wastewater treatment station with an input flow rate of 500 m^3/h, in the area of Ploiesti industrial park. The introduction of these new types of microorganisms that together with active sludge will create the biomass represents a solution to reduce the concentrations of nitrates and nitrites from the wastewater subjected to biological treatment.

EXPERIMENTAL SECTION

Monitoring the concentration of the chemical parameters and evolution of microorganisms was done in November and December 2011.

The microorganisms introduced in the biological treatment were of MICROPAN AQUA PE type. This is one of the products that are recommended for cases when it is necessary to speed up the nitrogen and phosphorus cycles and mineralization reaction of the organic substrate (Sotomayor at al., 2002). The evolution of the microorganisms introduced into the biological treatment together with the active sludge have made the biomass, they were studied for two weeks observations being made using the epifluorescence trinocular digital microscope, with built in video camera.

Monitoring was done at the initial moment (after shaking the mixture wastewater-existing sludge active-microorganisms in the aeration basin), after 24 hours of growth from the initial moment, after 5 days, respectively after 7 days of growth.

Wastewater samples were taken with the Bühler 1000 sampler according to SR ISO 5667.

The concentrations of COD-Cr, ammonium, BOD_5 and total suspended solids concentrations were determined with the DR 5000 instrument.

CBO5 concentration was determined using the VELP instrument that allowed, unlike other techniques for determination, establishing intermediate values after only 24 hours from the beginning of the analysis, so the biological treatment stage can be operated properly.

Analytical methods are in accordance with national and international standards presented in table 1.

Table1. *Standardized methods corresponding to chemical parameters determined within the experimental study*

Chemical parameters	**Standardized methods**
Ammonium	SR EN 12260:2004
Chemical oxygen demand (COD-Cr)	SR ISO 6060:1996
Total suspended solids	SR EN 872:2005/STAS 6953:1981
Biochemical oxygen demand (BOD_5)	SR EN 1899-1:2003/SR EN 1899-2:2002

RESULTS AND DISCUSSION

Activated sludge monitoring

The Active sludge constituent of initial biomass without the addition of microorganisms from the biological stage is presented in figure 1. Can be noticed that there is a tendency for the formation of zoogleal predecessor bacteria on flakes.

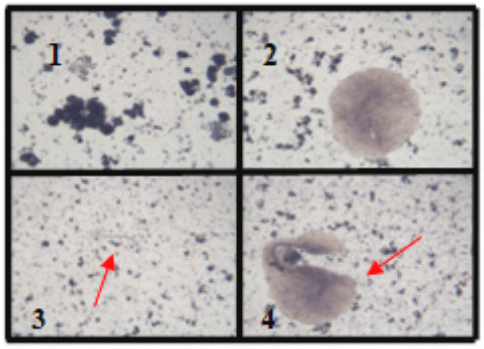

Fig. 1. *Microscopic analysis of active sludge at the beginning of the experiment (without the addition of microorganisms)*

After the initial microscopic analysis of the mixture formed after 24 hours from the beginning of the experiment have been observed numerous free bacteria (Figure 2), bacteria with tendency towards concentration forming agglomeration bacteria and small flakes, essential in the biological treatment process, traces of *filamentous bacteria* and *nematodes. Nematods* are found frequently in active sludge. Nematodes metabolism is aerobic, they can metabolize organic solid materials, even those that are not easily degraded by other microorganisms, such as cell walls polymers (Schuler, 2005).

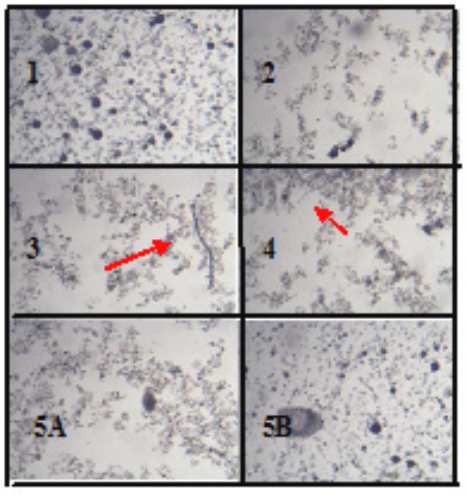

Fig. 2. *Microscopic analysis of the active sludge-microorganisms mixture after 24 hours from the beginning of the experiment: 1. Free bacteria; 2. Bacteria in agglomerations; 3. Filamentous Bacteria; 4. Nematode; 5. The tendency to form small flakes (A, B)*

On the microscopic analysis after 5 days, could have been observed the formation of large flakes, well defined, (figure 3), significant reduction of the population of *filamentous bacteria* and disappearance of the tendency to form open flakes, and stability in what concerns the *nematodes*-microorganisms density whose presence is an indicator of efficiency in wastewater treatment. Can be observed the emergence of ovoid form bacteria, singular, but also in the process of division, that can indicate the stage of development of the nitrification bacteria, because it is known that they (*autotrophic bacteria*) have a slower development, so a great generation time, compared to other types of bacteria (heterotrophic).

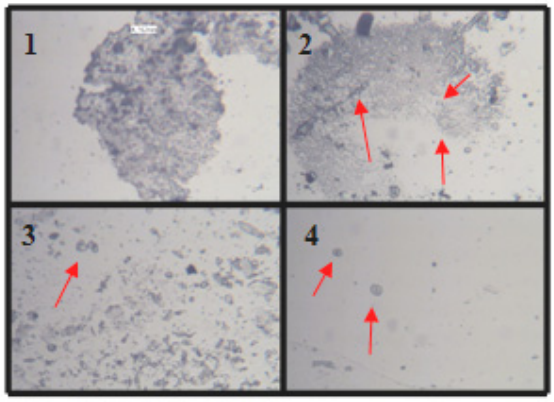

Fig. 3. *Microscopic analysis after 5 days of development in the bioreactor of sample number 1at the beginning of the experiment: 1-Well developed flakes; 2- Micrococcus linear structures Nitrosomonas/Nitrobacter bacteria; 3- Micrococcus tetrade; 4- Nitrosospira individual bacteria*

The addition of microorganisms in the aeration basin, led to the formation of small floaters, with diameter ranging between 2,013 mm and 2,400 mm. Also, were observed individual microorganisms of *metazoa* - *nematodes* category and *protozoa* – *amoeba*, indicators of a good performance of the active sludge facility. Viewed under a microscope, the flake presents a complex image, characterized by a jelly-like mass produced by the bacteria (zoogleal mass) in which are included numerous bacteria, also organic and inert inorganic substances; among the flakes live *protozoa* and some *metazoa* (Raducan at al., 2006, Vasiliadou at al., 2006).

After the microscopic analysis of water from biological stage, at 7 days after adding the microorganisms, after aeration, was observed the formation of well defined active sludge (figure 4), and other microorganisms like *rotifers* and *ciliates*, the components of a diversified biocenosis indicates a good performance in the purification process. Also, can be observed that the population of filamentous bacteria is balanced, mixing among active sludge flakes without forming with them typical flake structures, deficiencies predecessor in working with active sludge (sludge swelling, foaming).

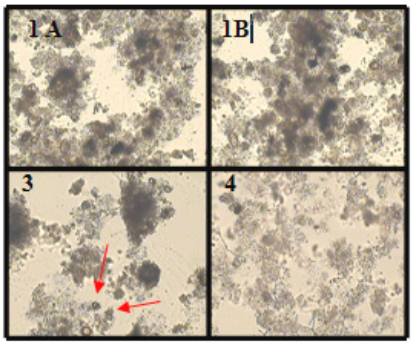

Fig. 4. *Microscopic analysis at 7 days after the addition of microorganisms selected in the biological stage, after aeration: 1. Formation of active sludge flake (normal sizes) (A, B); 2. Rotifer and ciliate; 3. Traces of filamentous bacteria*

The *rotifers* appear only in active sludge with high capacity to stabilize wastewater, so in environment with low content of organic substances, being indicators of this sludge; they are strictly aerobic organisms, having bacteria as food source, also organic particles. Because the emergence of *protozoa* and *metazoa* in the biomass is proof of good conditions for aerobic life, these microorganisms became purification indicators for different industrial wastewaters (Otawa at al., 2007).

Chemical characteristics of wastewater before and after the addition of microorganisms

After the conducted experiment were analyzed the chemical characteristics at the inlet and outlet of the biological stage. The results obtained are presented in figure 5-figure 12.

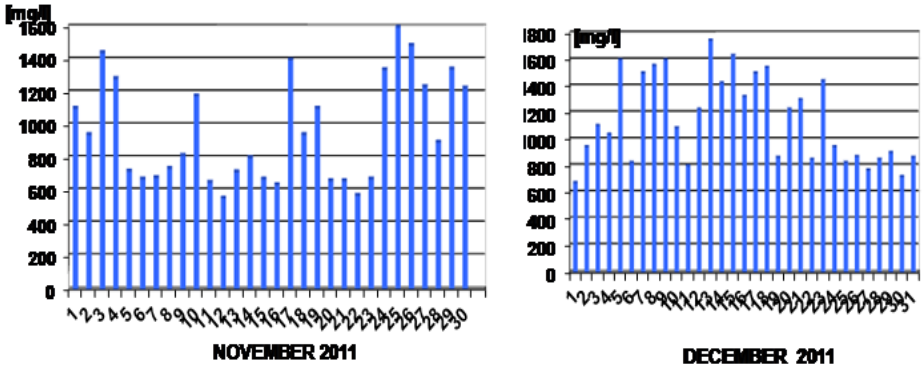

Fig. 5. *COD concentration at the inlet in the treatment station in November and December 2011*COD values ranged between 580 and 1600 in November 2011 and the maximum value was in December 2011 namely 1710 mg/l.

The maximum BOD5 concentration was of 380 mg/l in November 2011.

Nitrogen reached a maximum value of 42 mg/l in December 2011, which lead toe disturbance in the operation of the biological treatment stage.

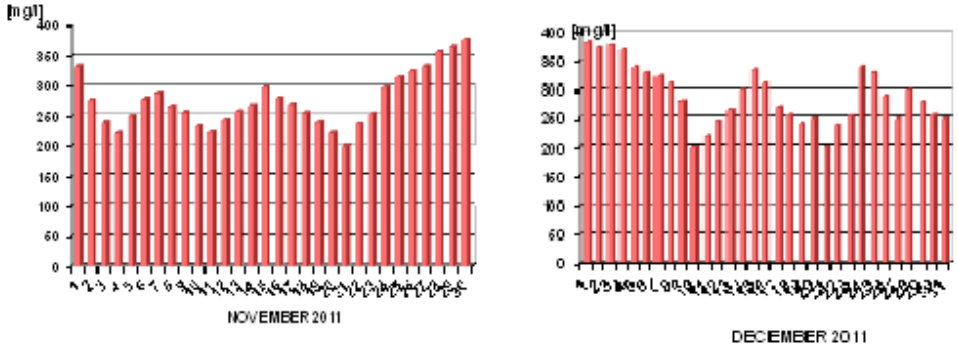

Fig. 6. *BOD5 concentration at the inlet in the treatment station in November and December 2011*

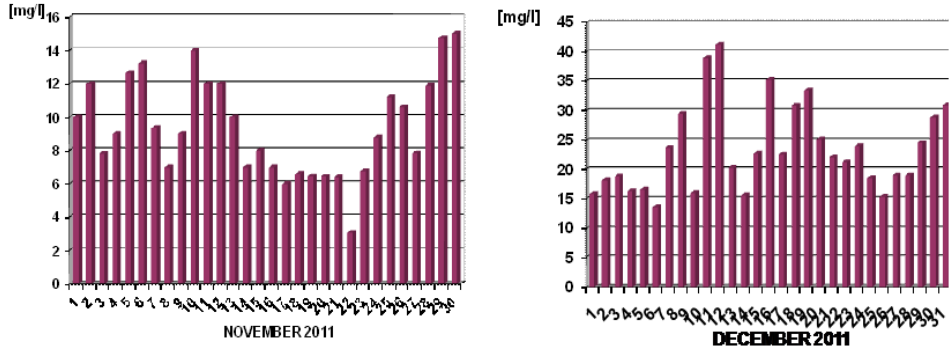

Fig. 7. *Ammonium concentration at the inlet in the treatment station in December 2011*

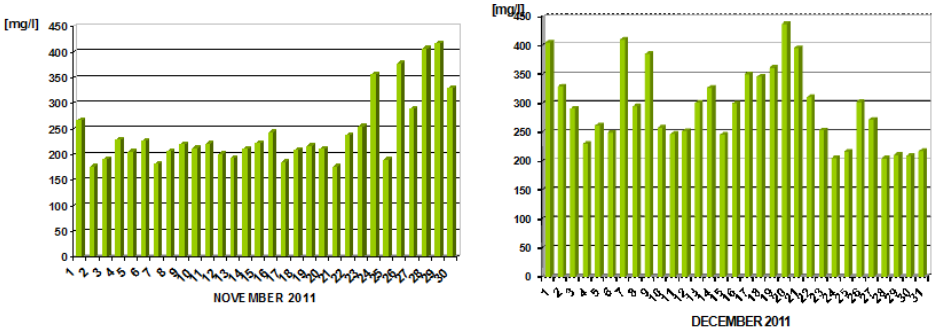

Fig. 8. *Total suspended solids concentration at the inlet in the treatment station in December 2011*

Total suspended solids have a special importance in terms of organic pollution of the aeration basin. The maximum concentration of 440 mg/l from December 2011 shows a high load.

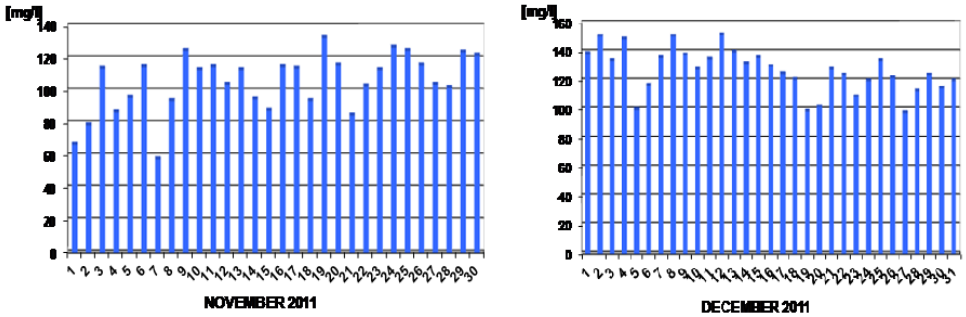

Fig. 9. *DOC concentration at the outlet in the treatment station in November and December 2011*

COD at the outlet from the biological stage has variable values based on the development of culture of studied microorganisms, so that at the end of December 2011 value goes below 124.76 mg/l.

In these conditions the biological treatment process must be done with maximum efficiency, which is difficult if we take into consideration that water residence time in the installation is about two hours.

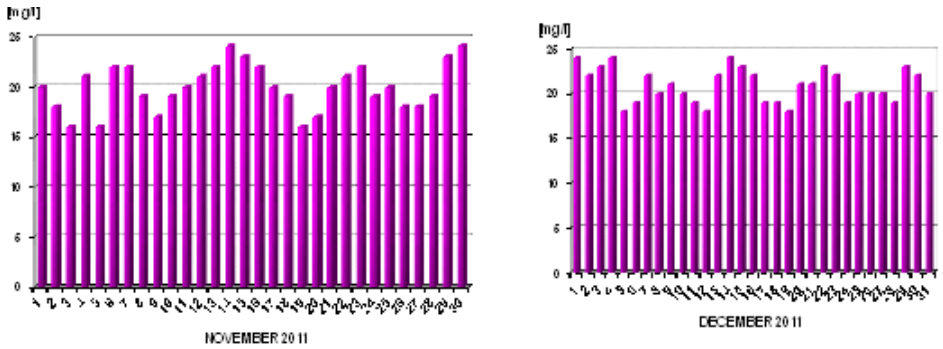

Fig. 10. *BOD 5 concentrations at the outlet in the treatment station in November and December 2011*

BOD_5 variation decreases during the experiment, less in the first part, more in the second one, after a longer time span of biological treatment, reaching in the end a value close to the maximum accepted limit according to NTPA 001/2005, de 25.12 mg/l.

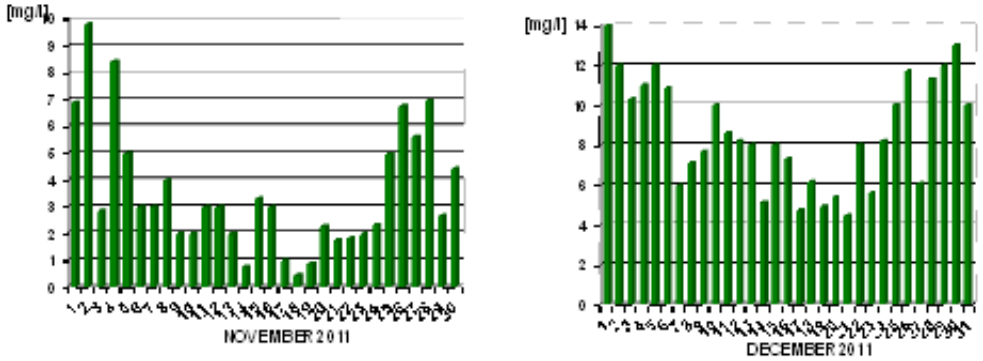

Fig. 11. *Ammonium concentration at the oulet in the treatment station in November and December 2011*

After adding the microorganisms in the biological stage is noticed a significant decrease of the concentration of ammonium, up to values of 0.5 mg/l which shows a development of the performance of the biological stage from the point of view of nitrogen transformation, the oxidation of ammonia to nitrites, then into nitrates and subsequently in molecular nitrogen (interfere processes intensive of nitrification-denitrification).

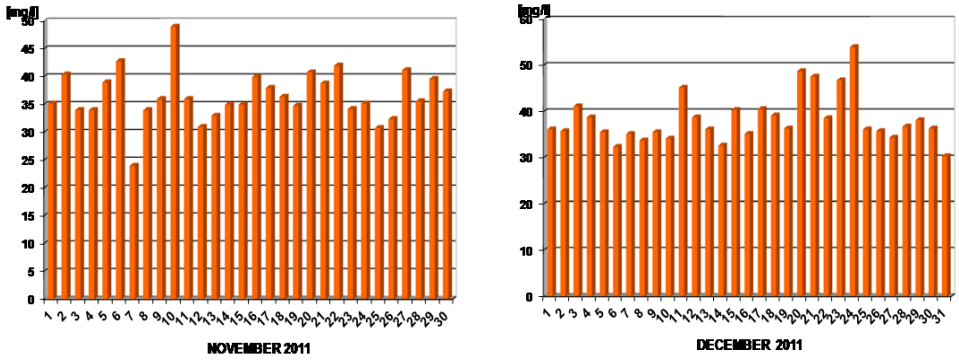

Fig. 12. *Total suspended solids concentration at the outlet from the treatment station in November and December 2011*

Total suspended solids concentration at the outlet from the treatment station does not vary very much from the inlet one, in December were registered lower values, the minimum value being 30 mg/l.

CONCLUSIONS

In the paper was studied the behavior of new microorganisms of MICROPAN AQUA PE type inserted in the biological stage in order to increase the degree of purity.

The drawbacks which may occur in the operation process with active sludge are: flake formation problems and their irregular development, swelling, respectively sludge foaming problems due to zoogleal and filamentous bacteria, and problems connected to nitrification-denitrification and toxicity (Mussati at al., 2002).

Poor sedimentation of biomass continues to be a problem in many systems that use active sludge and is well known from many researches that filamentous bacteria are a major cause of this problem, at basis of which is sludge swelling.

Were used in the experimental study Micropan AQUA PE products, they being compound of the selected enzymes and of the microorganisms able to act in aerobic environments, and anaerobic and in the presence of different pollutants. After microscopic monitoring they presented optimum characteristics in order to be inserted in the system (good capacity to form flakes, diversified biocenosis balanced quantity of filamentous bacteria).

Because was registered a good efficiency of biological treatment (the values of the pollutants concentrations - CBO_5, CCOCr, ammonium - at the end of the experiment getting close to the maximum accepted value according to NTPA 001/2005, some even below the limit) it was concluded that the selected microorganisms have adapted perfectly to the initial characteristics of the water, which is an advantage.

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COMPARISON MEASUREMENT OF RADON IN SOIL GAS AT RADON REFERENCE SITES IN THE CZECH REPUBLIC (RIM 2010)

Botond PAPP[1] *, Constantin COSMA[1], Alexandra CUCOŞ (DINU)[1], Robert BEGY[1], Tiberiu DICU[1], Mircea MOLDOVAN[1], Dan C. NIŢĂ[1], Betty BURGHELE[1], Ciprian CÎNDEA[1], Dan FULEA[1], Carlos SAINZ[1,2]

[1] Faculty of Environmental Science and Engineering, „Babeş-Bolyai" University, Fântânele Street, no. 30, 400294 Cluj-Napoca, Romania
[2] Department of Medical Physics, Faculty of Medicine, University of Cantabria, Santander, 39011, Spain
** E-mail: papp.botond@ubbcluj.ro*

ABSTRACT. In the frame of the 10th International Workshop on the Geological Aspects of Radon Risk Mapping which held in September 2010, was organized and held a Comparison measurement of radon in soil gas at Radon Reference Sites (RIM 2010). The Radon Group of the Faculty of Environmental Science and Engineering from Babes-Bolyai University was an active participant at the intercomparison, obtaining good results in accordance with other participants. We intend to test our equipment and measurement method of radon gas in soil with LUK3C radon detector. The results of the comparisons give a ratio of 0.997 between our data and the data of the other participants, which fulfill the test criteria and the estimation of the radon concentration in soil gas by our group are very well acceptable. The procedure of radon estimates accords with requirements of radon risk mapping at building sites in the Czech Republic.

Keywords: *radon, comparison measurement of radon in soil gas, radon reference site.*

INTRODUCTION

Radon in soil intercomparison measurements at radon reference sites serve for verification of field radon measurements, performed by the participant groups. Radon comparison measurements tests the calibration of the instruments, the techniques of soil gas sampling, soil gas transfer into the detection chamber, radon-measuring procedures, stability of field measurements, elimination of thoron and data processing (Neznal et al., 2004). Tests are based on the comparison of reported radon activity concentration in soil gas with other participant groups of intercomparison and with the database of the three natural radon reference sites. Since 2000, three radon reference sites have been established in the Czech Republic (Cetyne, Bohostice and Buk), located at 60 km SW of Prague. Administrator of the three radon reference sites

is the Faculty of Science, Charles University, Prague. Each reference site implies 15 stabilized stations of measurements in a grid of 5x5 m, which differ in soil gas radon activity concentration. The distribution of radon concentrations within each reference site is relatively homogeneous, also the rock type of the reference sites was very homogenous (ortogneiss for Cetyne and Bohostice and granodiorite for Buk) and soils were clayish and sand. The thickness and the permeability of soils enable sampling of soil gas from a reference depth of 0.8 m. The mean radon concentrations estimated by the administrator of the three reference sites are: 32 kBq·m^{-3} for Cetyne, 47 kBq·m^{-3} for Bohostice and 146 kBq·m^{-3} for Buk, depending on the uranium content of the soil and rocks (2.0 ppm for Cetyne, 2.3 ppm for Bohostice and 3.6 ppm for Buk) (Matolín and Koudelová, 2008).

Comparison measurement of radon in soil gas at radon reference sites in the Czech Republic (RIM 2010), was organized and held on 20-21th of September, 2010, in the frame of the "*10th International Workshop on the Geological Aspects of Radon Risk Mapping*", 22-25th of September 2010, Prague.

Fig. 1. *Participating group from Babes-Bolyai University, at RIM 2010.*

MATERIAL AND METHODS

Measurement technique

The applied method of radon measurement in soil gas, which was verified at the RIM 2010, was based on the sampling of soil gas and the detection of radon gas. Radon activity concentration was measured using a LUK3C radon and thoron detector, which was developed for radon measurements in soil and determines the concentration of the radon gas relatively quickly (directly from the alpha decay of radon and progenies). The measurement technique of this detector was based on a scintillation technique with

Lucas cells, by volume 145 mL. The scintillation material of the Lucas cell (deposited on the interior wall of the cell) was ZnS. The efficiency of this technique was (2.2 counts/sec) at 1 Bq radon activity, deposited in the Lucas cell, when radon is in equilibrium with its daughters (Plch, 1997).

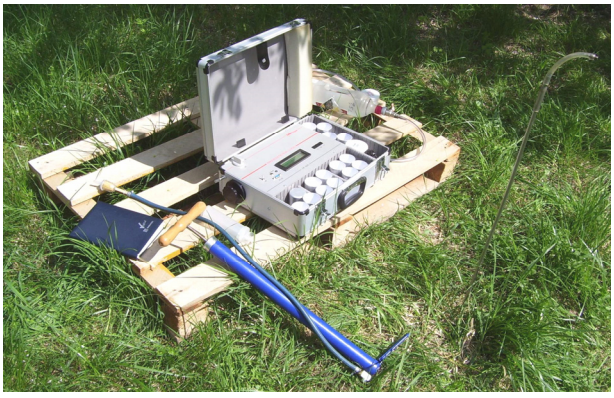

Fig. 2. *The LUK3C detector and accessories for radon concentration measurement in soil gas.*

For sampling the soil gas a "*Neznal probe*" was used (a steel pipe with the length of 1m and diameter of 1cm), which was inserted into the soil at the reference depth of 0.8 m. To create an active volume at the end of the probe in soil, it should remove a few cm (Neznal et al., 2004; Barnet et al., 2008). For soil gas sampling was used a Janet Syringe, with a volume of 145 mL (equal with the volume of the Lucas cell). The syringe is connected to the upper end of the sampling probe. Before measurement, radon gas from soil must forced by three subsequent extractions, to avoid contamination by atmospheric air. After the third extraction (by the volume of the syringe equal with the volume of the cell) the soil gas probe was introduced into the detector cell with the help of a preliminary vacuum technique (Cosma et al., 2010). The scheme for the soil gas sampling and its insertion into the detector is shown in fig.3.

The principle of the measurement method by LUK3C is in separation of the counts come from the alpha decay of Rn, from the total incoming alpha counts (Rn+Tn). Since the half-life of Tn (55.6 sec) is much shorter than the half-life of Rn (3.82 days), Tn effectively decays in ~ 5 minutes. During this time, the detector does not measure, which called delay time. Following the delay time, the detector performed several countings that comes from the decay of the Rn atoms in the scintillation cell, and it finished when the statistic errors get under 5 %. Finally, the detector determines an average Rn concentration (corrected from the background of the cell) and an estimation for Tn concentration, that is determined from total (Rn+Tn) counts minus the average Rn counts (corrected from the background of the cell). The total time of one measurement is no more than 10 minutes (Plch, 2007; Cosma et al., 2010).

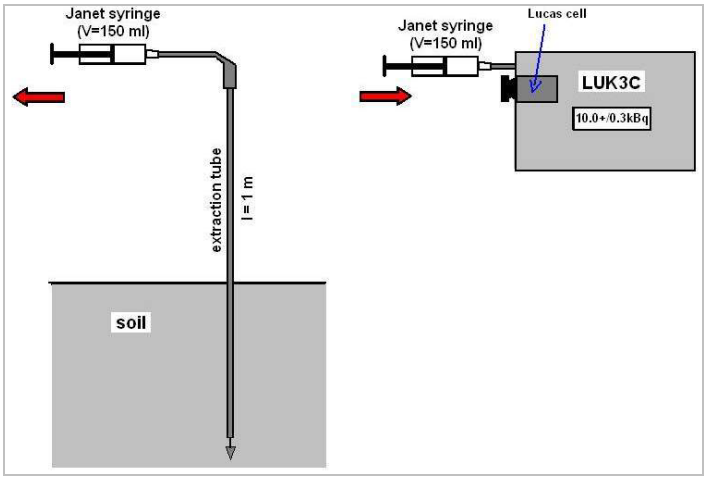

Fig. 3. *The scheme for soil gas sampling and insertion of it into the Lucas cell of the LUK3C detector, for radon activity concentration measurement.*

Test assessment

Evaluation of radon comparison measurements at radon reference sites in the Czech Republic serves for the participant as an significant information on the level of his reported radon activity concentration in soil gas. Measurement results of each participating groups at the intercomparison was assessed by the organizers, and the results was included in a certificate sent to participant groups, entitled: „*Protocol on the evaluation of comparison measurement of radon (^{222}Rn) activity concentration in soil gas at reference sites Cetyne, Bohostice and Buk (Czech Republic)*", (Report, 1). These assessment protocol contains results of three tests, which are based on comparison of radon data reported by participant group with radon data of all the groups, and with radon data of a database of the respective reference site. The evaluation of the reported data was performed by a statistical computer software (TestMOAR), developed by the Institute of Applied Mathematics and Computer Technique, Faculty of Science, Charles University in Prague. Tests 1 and 2 compare the results of a participant group with the results of the other groups, which performed measurements in the same day and climatic conditions. Since the number of participant groups is limited and their selection is random, the tests is orientative. *Test No. 1* of the program calculates differences between radon activity concentration at single stations (N = 15) of a reference site, reported by a participant group, and the median of radon data reported by all the groups, which measured radon at the same station in the same day of measurement. *Test No. 2* determines the regression y = a + b*x between radon activity concentration at all measured stations of the three reference sites (N=3*15=45 stations) reported by a tested group (y), and the median (x) of radon data for relevant stations reported by the administrator and all other groups measuring in the same day. *Test No. 3* makes comparison of the mean soil gas radon concentration reported by a participant group with the radon database of

a single radon reference sites. The database of each radon reference site is gradually formed using radon data of the groups which passed the test since 2000. At present, the data of 180 groups form the databases of reference sites. It is mention that the database eliminates temporal variation of soil gas radon activity concentration (Report, 1).

RESULTS AND DISCUSSIONS

The mean values of radon concentrations obtained by our group (A10) at the three reference site (in all 15 stations of each) are: 37.8 ± 3.8 kBq·m^{-3} for Cetyne, 52.3 ± 4.9 kBq·m^{-3} for Bohostice and 132.8 ± 23.9 kBq·m^{-3} for Buk.

Test 1 calculating differences of radon concentration determined by a participant group and the medians of concentrations reported by all groups, at single stations of three reference sites, the differences is significant, if the interval of confidence does not include zero. Level of significance α = 1 %. After test 1, values outside of the confidence interval at the reference sites are: 4/14 for Cetyně, 5/15 for Bohostice, and 6/15 for Buk.

Test 2 making linear regression (y = a + bx) and correlation of radon data determined by a participant group (y) and the median of all the groups (x) at single stations, an ideal case of data agreement is a = 0, and b = 1. After test 2, the values of the parameters from linear fit for our group are: a = 0.599 and b = 0.984, by the correlation coefficient R^2 = 0,982.

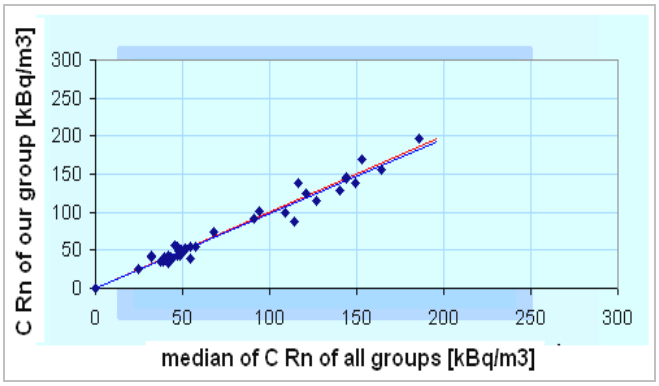

Fig. 4. *Linear regression (y = a + b·x, blue line) between radon activity concentration (CRn) reported by our group (y) and medians of CRn of all groups (x). Ideal regression line (a=0, b=1) is marked red.*

Test 3 calculating differences between averages of radon data reported by a participant groups and averages of radon data of all the groups in the database of single reference sites. The ratio of the means of radon data of our groups to the means of radon data estimated by the administrator for the three reference sites are: 0.89 for Cetyně, 0.96 for Bohostice, and 0.99 for Buk, and the results of the comparison between the mean of the radon data of our group and the data of all the participating groups including the database since 2000, for the three reference sites are: 0.96 for Cetyně,

0.99 for Bohostice, and 1.041 for Buk. The average of these values is 0.997. A relative deviation of ±30% is admissible for the Test criterion no. 3 from ideal value, ratio = 1. Thus, admissible values for the ratios are within the interval < 0.7; 1.3 >.

CONCLUSIONS

The international comparison measurement at radon reference sites in the Czech Republic has been performed in the frame of the 10th Workshop on Geological Aspects of Radon Risk Mapping, 20 - 24 September 2010, Prague.

After the evaluation of radon data, Test no. 1 and test no. 2 (orientation tests based on the comparison with participating groups) show a good agreement of the results of our group with other groups in comparison measurement. Test no. 3 (the decisive test based on comparison with the databases of radon reference sites) shows good agreement of our mean values with radon data of all successful participant groups (N = 180) who measured at radon reference sites since the year 2000 and form a database. After the decisive test 3, the results of the comparisons fulfil the test criteria and the estimation of the radon concentration in soil gas by our group are very well acceptable, with an average of 0.997 between our data and the data of the other participants, including database.

The procedure of radon estimates accords with requirements of radon risk mapping at building sites in the Czech Republic.

Acknowledgment

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COMPARISON BETWEEN THE MAIN HIDROLOGICAL CHARACTERS OF SÉD STREAM IN VESZPRÉM AND SEBES-KÖRÖS TOGETHER WITH HOLT-SEBES-KÖRÖS IN BÉKÉS AS SIMPLE AREAS OF THE WATER FRAMEWORK DIRECTIVE

Csilla SZALKAY[1*], Zsófia KOVÁCS[2], Zoltán ZSILÁK[3], Ákos RÉDEY[2], Károly PENKSZA[1]

[1] Szent István University, Department of Landscape Ecology, H-2103 Gödöllő, 1 Páter Street, Hungary
[2] University of Pannonia, Department of Environmental Engineering, H-8200 Veszprém, 10 Egyetem Street, Hungary
[3] University of Pannonia, Department of General and Inorganic Chemistry, H-8200 Veszprém, 10 Egyetem Street, Hungary
** E-mail: szalkay.csilla@chello.hu*

ABSTRACT. South East European countries increasingly appear to environmental problems, the disasters will intensify, which greatly influenced by human activities and management. The most essential purpose of the modern society is that it's able to handle and find solution for environmental problems especially water pollution which is serious problem not only for present but future generation as well. As the load to our surface water has become more significant consequently a continuously increasing demand has been created for adequate water quality and quantity. The Water Framework Directive (WFD) is a long-term water policy of the European Union. Aim of WFD is the classification and protection of the water according to consistent viewpoints. Objectives of the researches are ccomparing the main hydrological characteristics of the plots and the identification and testing of the effects of the potential pollutants sources and critical sites in Séd (Veszprém) and in Sebes-Körös just as Holt-Sebes-Körös in Békés.

Key words: *Water Framework Directive, Séd stream, Sebes-Körös, Holt-Sebes-Körös, physical and chemical parameters*

INTRODUCTION

The Water Framework Directive (WFD) is designed to estabilish a legal framework for an uniform system, which based on that waters, particularly fresh water usage is one of the most important – but also costs associated – element in our lives. Surface and ground waters carry not only natural but also social, economic values. It provides the solution and one of the most significant manifestations of water management (Zikos and Bithas, 2006). WFD (2000/60/EC) was created as a long-term water policy of the European Union. Member States are required to achieve good ecological and chemical status in all bodies of surface water by 2015 (Directive 2000/60/EC). It provides a framework for Member States and to be applied taking into consideration local features.

Hungarian typology based on four parameters altitude, geology, structure and substrate of bed material and size of the catchment area (Simonffy, 2001). A further requirement of WFD Water Management Plan has to be presented by all Member States. By 2009 standard Water Management Plan has to be developed for the whole territory of Hungary. In WFD cooperation with neighbour countries are essential. The goal of water managment is integrated and harmonized water balance on the entire state territory and in each individual river basin district, which means care for spatial distribution and for status of water quantity and water quality in a manner that is best suited for a particular area.

The competent Hungarian authorities started to examine the exact factors of the balanced ecological systems of the wetlands and the freshwater ecosystems and they according to the instructions of the WFD in Hungary marked out for reference areas. The reference area in particular, was the biggest lake in Hungary, Balaton and its surrounding, and the other was Holt-Sebes-Körös (one of the most endangered backwater) and Sebes-Körös (figure 1). In 1997 than in 2002 they made a study of the water state of the territory. The monitoring of the water's conditions is started in 2004 with the examination of the values of the ecosystems, like examining the physical and chemical factor of the water and study the toxicological condition of the freshwater.

Examination units have been defined in Water Management Plan. According to this Hungary has been divided into 42 units. Séd situate in Veszprém county is included within category 1-13. This called Észak-mezőföld és Keleti-Bakony. Holt-Sebes-Körös just as Sebes-Körös in Békés county is included within category 2-14 (Schedule of W, M. P. 2006-2009). This called Sebes-Körös.

The Stream Veszprémi-Séd runs through limestone area in Transdanubian region. Its length reaches the 70 km. It originates in Bakony Mountan, flows through in Veszprém city, Veszprém Plateu, Sárrét and leads into Sárvíz. Séd stream is the most dominant surface water flow of Veszprém city, and it has a high priority in the area of underground water resources. The stream is the recipient of the cleaned waste water streams and storm waters, which is partly from a densely populated area of the city.

Körös that comes from the Transylvanian mountains has been formed the surface of the area for thousands years. The infilling could not balanced everywhere the sinking of lithosphere, therefore we can find marshlands in a huge territory.The area of the marshlands that is covered by water increased in the years when there was more precipitation and shrank those years that had less precipitation. Those areas that did not have permanent water cover but effected by the change in the level of groundwater went through a salinization because of the leaching of sodium ions. In addition these days the effects of the human impacts also influence the ecosystem. The biggest environmental change – because of the spread of agriculture – started with the water regulation of the Körös in the 18-19th century.

The primary objective of our project, we also examine whether the main physical and chemical characters of two reference areas (Séd and Holt-Sebes-Körös just as Sebes-Körös) have been improved from 2008 to 2012. Measurements were made in spring and in autumn, so the average of these results is the basis of for our comparison.

The water capacity of Séd has been decreased year by year although the volume of incoming sewage water has been increased. At summer times several part of the stream has become dried which means it's favourable to entering the sewage water into dolomitic water.

Fig. 1. *Catchment area of Séd and Sebes-Körös together with Holt-Sebes-Körös*

Marshy areas can be found in large numbers in the area of Holt-Sebes-Körös and Sebes-Körös. Those areas that did not have permanent water cover but effected by the change in the level of groundwater went through salinization due to leaching of sodium ions (WFD, 2010). We started our investigation of chemical and physical parameters of Séd stream in 2008 5 measures points were investigated on several occasions in 2008, 2009, 2010 and 2012.

Our measures of the Sebes-Körös and Holt-Sebes-Körös were started in 2007 with the help of water specialist We marked 5 places to take samples with their help along the water where we did some important physical, chemical measurements so far. To fully describe the state of the Sebes-Körös and Holt-Sebes-Körös we used the data that are made earlier by specialists of the competent authority. Impacts of sewage and animal farms have to be taken into consideration in these areas. Furthermore the effects of the human activitie exercise also significant influence on the ecosystem.

According to the results of the examined water the followings were determined: Séd and Sebes-Körös together with Holt-Sebes-Körös are different hydrological characters. According to typological categorization (WFD) Séd belongs to high altitude calcareous stream with coarse bed material while Körös area belongs to lowland calcareous medium sized stream with moderately fine bed material.

Both tested area are loaded by direct and diffuse pollutants. Water pollution comes from close gardens, cultivated lands, sewage water treatment plants where sewage and cleaned water contain high concentration level of nitrate, nitrite, ammonium ion and orthophosphate. An additional pollutant source is the urban drainage water.

Séd and also Sebes-Körös run through water bases so they have their effects on subsurface water. It is important to measure the pollutants regularly in order to be able to follow the quantity and quality of pollution tendency.

MATERIAL AND METHODS

Physical and chemical tests were taken at urban part of Séd from 2008 to 2012. At selection of the 14 sampling sites the following direct pollution sources have been taken into consideration. 5 of them were appointed along the stream that have strong effect to water quality. These polluted locations are in front of Veszprém city (1. samplig site), Veszprém-Séd (2. sampling site), output pipe of the ZOO (3. sampling site), output of urban drainage (4. sampling site), output pipe of sewage treatment (5. sampling site) (figure 2).

Two villages were marked (Okány and Mágor) at part of Holt-Sebes-Körös and three villages (Körösszakál, Körösladány and Komádi) at part of Sebes-Körös, where some important physical, chemical measurements (Szalkay, 2001) were taken from 2008 to 2012 (figure 2).

Fig. 2. *Sampling sites in Veszprém (left) and in Békés (right)*

Following physical and chemical parameters were taken: Calibrated and portable devices were applied to take outside measurements like temperature, pH-value, conductivity. Alkaline and COD_{ps} were analyzed by titrimetry.

The SO_4^{2-}, PO_4^{3-}; NH_4^+; NO_3^-; NO_2^- were analyzed by spectrophotometer (Incédy, 1981). Na^+; K^+; Ca^{2+}; Mg^{2+} concentrations were defined using AAS methods (Welz and Sperling, 1999).

RESULTS AND DISCUSSIONS

Measurements taken on field

Along downstream pH-level is between (7,5-8,5) so the water is defined as smoothly alkaline (Fig. 3.a-b).

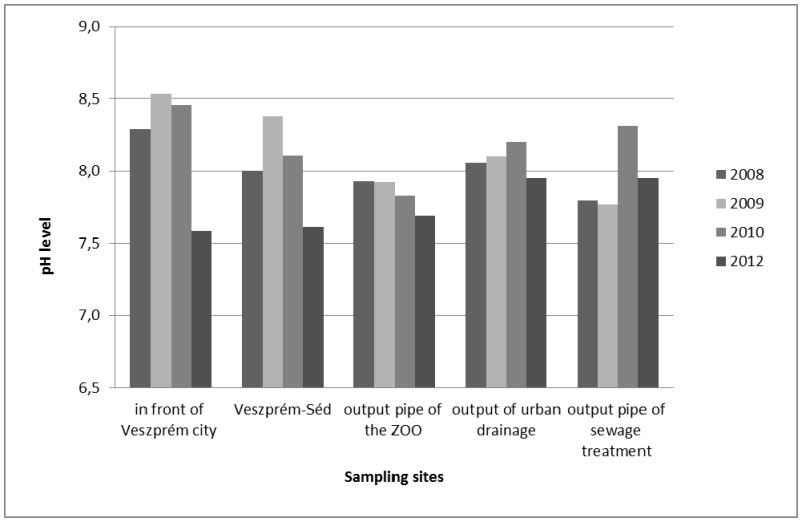

Fig. 3a. *pH - level in Séd*

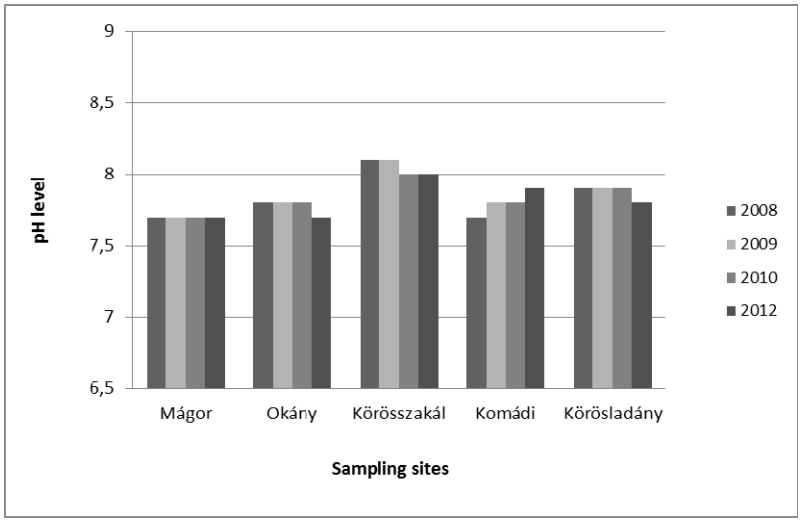

Fig. 3b. *pH - level in Körös*

Tendency of conductivity of sampling sites was similar, extremely high values (940 μScm^{-1}) were taken in 2008, low values were measured in 2010 (635 μS cm^{-1}). Average value of the conductivity is 750 μS cm^{-1} (Fig. 4a.).

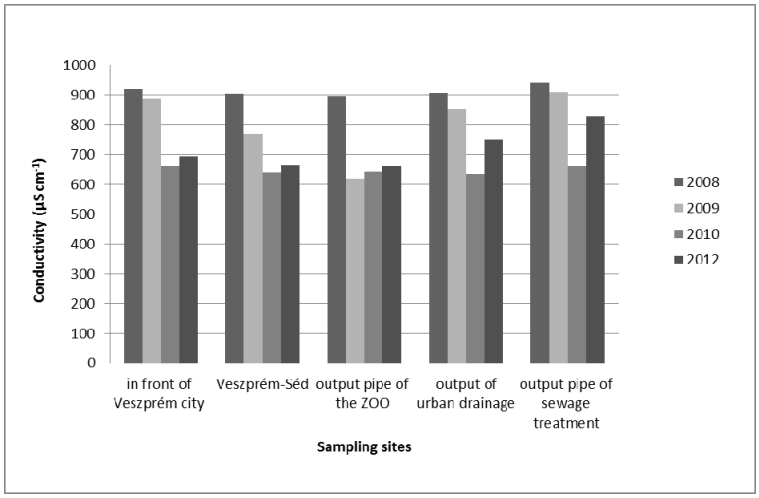

Fig. 4a. *Changeability of the conductivity in Séd*

Tendency of conductivity in Körös was also permanent, but lower than in Séd (360-800 μS cm^{-1}). The highest values (800 μS cm^{-1}) was measured in Mágor in 2009 (Fig. 4b.).

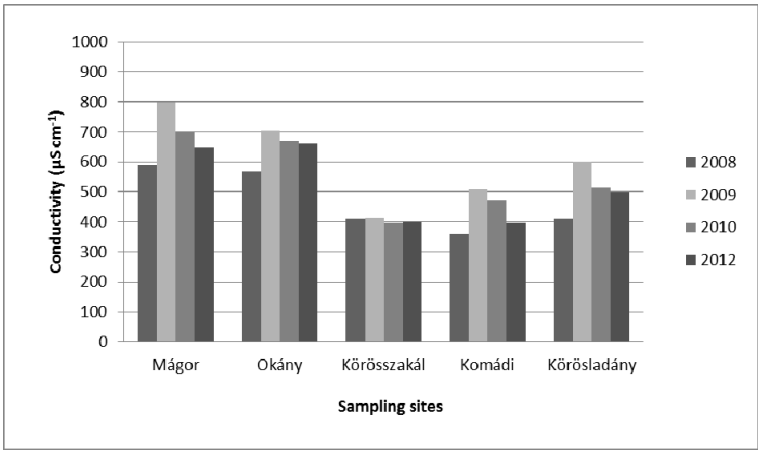

Fig. 4b. *Changeability of the conductivity in Körös*

The reason of the different values of conductivity between Séd and Körös is due to different bed material (calcareous or salinated).

Measurements taken in laboratory

The ammonium ion concentration was measured between 0,20-0,32 mg l^{-1} in Séd. Fig. 5a shows the high concentration values taken in Veszprém-Séd in 2012 (0,32 µg l^{-1}) and in front of Veszprém city in 2008 (0,28 µg l^{-1}).

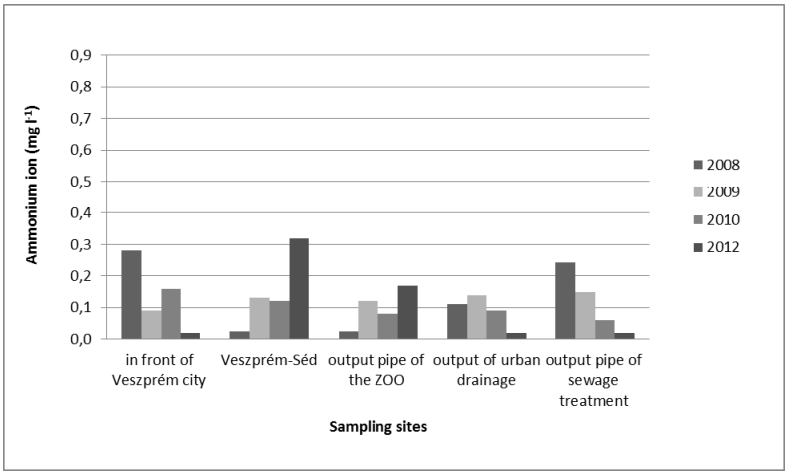

Fig. 5a. *Concentration of ammonium ion in Séd*

Figure 5b. shows the highest concentration values measured in Mágor (0,82 µg l^{-1}) due to direct pollution (Szalkay, 2001).

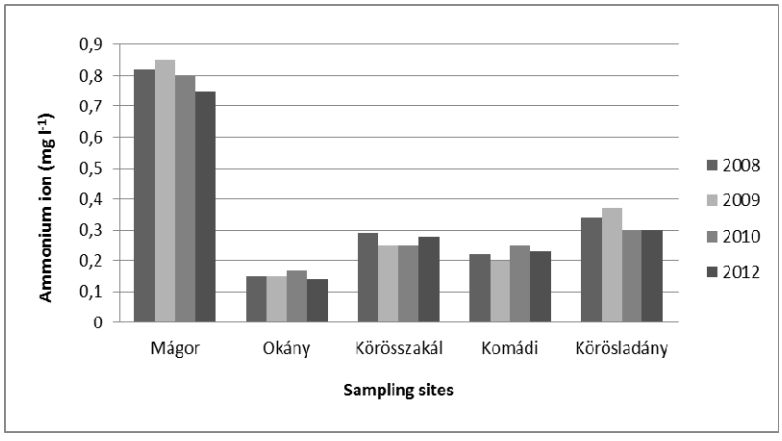

Fig. 5b. *Concentration of ammonium ion in Körös*

Nitrate concentration levels are higher in 2008 in Séd. After this year the nitrate concentrations decreased. in every sampling sites (Fig. 6a.).

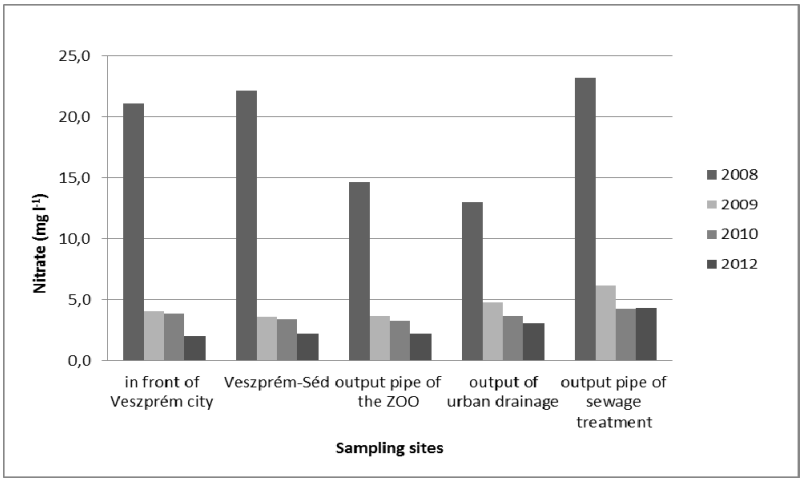

Fig.6a. *Range of nitrate concentration in Séd*

In case of Mágor always higher nitrate concentration was measured (10 mg l^{-1}) than other sampling sites (2-6 mg l^{-1}) (Fig. 6b.).

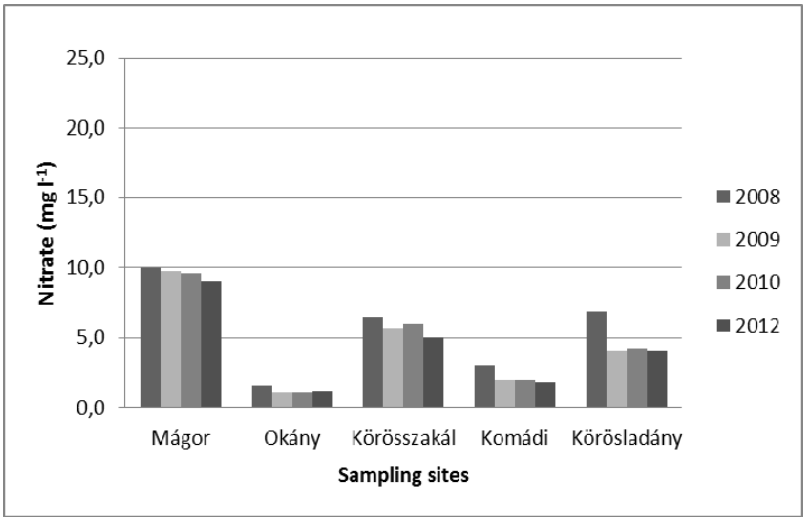

Fig. 6b. *Range of nitrate concentration in Körös*

Level of the orthophosphate concentration in Séd in Veszprém was changed between 0,09-4,0 mg l^{-1}. High concentration (4,0 mg l^{-1}) was measured in front of Veszprém city in 2010. The lowest concentrations of orthophosphate were in every simpling sites in 2012 (Fig. 7a.).

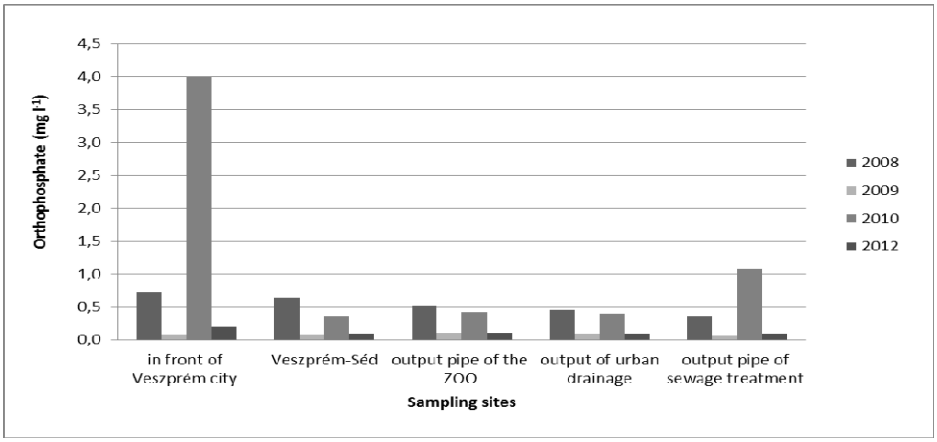

Fig. 7a. *Orthophosphate concentration in Séd*

Average orthophosphate concentration level in Körös is higher than in Séd because of fertilizer and animal husbandry. High concentration (0,70 mg l^{-1}) was measured at Sebes-Körös stream (Körösszakál) (Fig. 7b.)

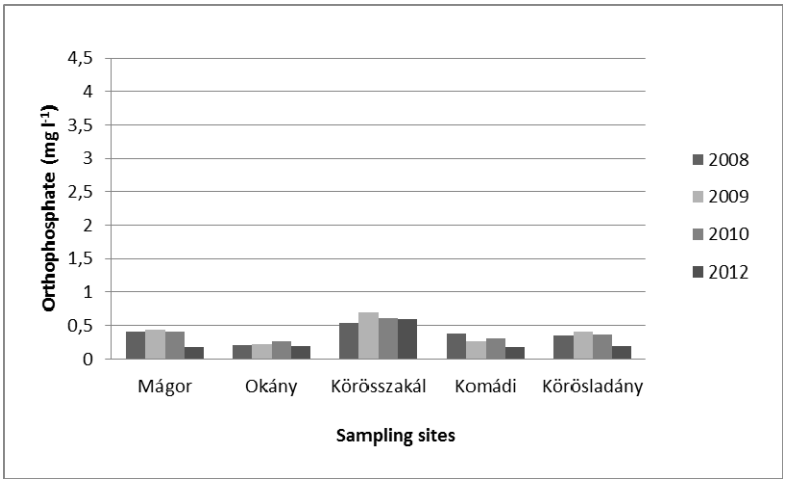

Fig. 7b. *Orthophosphate concentration in Körös*

Results of the measured 8 main ions have supported that Séd runs through calcareous and karstic base rock and Körös is in salinated area. Maucha diagram represents the concentration level of the 8 main ions in Séd and Körös. Fig. 8a presents clearly the high concentration of HCO_3^-, Ca^{2+}, Mg^{2+}. High concentration of Na^+, HCO_3^-, Cl^- was measured in Körös (Fig. 8b.).

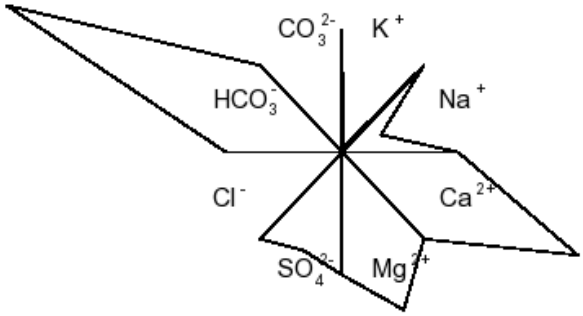

Fig. 8a. *Maucha diagram referring to Séd*

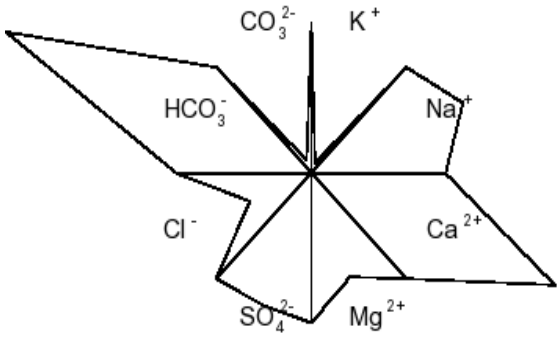

Fig. 8b. *Maucha diagram referring to Körös*

Water classification

Qualification of surface water was performed according to MSZ 12749:1993 Hungarian standards (MSZ 12749:1993). In general the measured areas are moderate stream by the way of pH level with the exception of 2009. Because the pH level of the water in front of Veszprém city was higher than 8,5.

In point of conductivity the tested part of Séd can be classified as tolerabre stream in 2008, 2009 and 2012, but moderate stream in 2010. Sebes-Körös and Holt-Sebes-Körös have been ranked as moderated stream in 2009, 2010, 2012 but tolerable stream in 2008 according to water classification. Ammonium ion concentration of measured waters category have been changed between moderate and tolerable. In Séd the most critical concentration level was indicated at Veszprém-Séd where the ammonium ion concentrate was 0,32 mg l^{-1} in 2012. The water in Mágor is different from the other points in Körös, due to pollutants caused by an animal farm and sewage treatment transmitted into freshwater. It has been ranked tolerable stream

because of ammonium ion concentration was 0,82 mg l^{-1} in 2009. In most cases ion concentration of water in Okány is the lowest, because this point was situated far from the town. The nitrate concentrations of Séd stream were highest in every simpling sites in 2008. The water quality of output pipe of sewage treatment is polluted because the nitrate concentration were near 25 mg l^{-1}. The highest nitrate concentration of Körös stream was in Mágor in 2008 (10 mg l^{-1}), so the water can be classified moderated. In other case Körös has been ranked as moderate. The ortophosphate concentration of water was the highest in front of Veszprém city (4,0 mg l^{-1}), so it can be classified extremely polluted. In 2012 Séd can be classified as moderate or tolerable stream. The water quality of Körösszakál was extremely polluted and the water quality of Mágor was polluted in 2009. In 2012 Körös can be classified as tolerable stream.

Basis of categorization of Hungarian standard the worst water quality of Séd was in 2010 because of high concentration of ortophosphat in front of Veszprém city. In case of ortophosphate concentration polluted and extremely polluted categories were distinguished (Körösszakál and Mágor). In both cases polluted water have been likely emitted. Furthermore moderate water quality was determined in Okány and Komádi and water quality measured at other sampling sites were ranked as tolerable.

Apart from the Hungarian standard water quality is regulated by ministerial decree (VM decree, 2010). The surface waters are categorized by the type of it (for example flows or streams of mountainous, hilly country and lowlands area). The water quality of waters could be 5, 4, 3, 2, 1 (excellent, good, tolerable, weak and bad).

In general the measured areas are excellent or good by the way of pH level. The category of conductivity of sampling sites are good or moderate. Because of high ammonium ion, nitrate ion and ortophosphate concentration Körös and Séd can be classified as moderate or bad quality stream.

CONCLUSIONS

According to our measurements taken on field and laboratory the water quality of Séd and Körös is classified tolerable and moderate but in some cases water quality is categorized as polluted. Several parameters refer to direct flowing of sewage that requires further detailed measurements. Five sampling sites are emphasised according to volume of pollutants. Sewage treatment are the only public utilities that possess unique permission in case of water limit values.

A project of the water samples during all four seasons for several years and we have investigated the several number of measurement points. Characterization of water bodies where necessary, previous test results were used. In Séd stream was spread 14 the measuring point, which is essentially characterized by water quality, and the factors affecting the water quality track. The current case studies are longitudinal Sebes-Körös together with Holt-Sebes-Körös were made simply, but to the entire length of the body and classified according to the sources of pollution can be traced further development of measurement points we make the appointment.

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(RECOMMENDED CITATION)

ALERT AUTOMATION SYSTEM OF OZONE MONITORING BY LABVIEW GRAPHICAL PROGRAMMING PLATFORM

Florin UNGA[1*], Ioana POPOVICI[1], Silviu GURLUI[1*]

[1] Alexandru Ioan Cuza University, Faculty of Physics, 11 Carol I Blvd., 700506 Iasi, Romania
** E-mail: florin.unga@yahoo.com ; sgurlui@uaic.ro*

ABSTRACT. The most used method for measuring ozone concentration is ultraviolet photometry. The continuous analyzer Horiba APOA 370 corresponds to legal standards, determining the ground-level ozone concentration. From scientifically point of view we identified the dependence of atmospheric ozone by certain meteorological parameters. From first observations, we found a diurnal variation of the ozone quantities, during night time low values of ozone concentrations (under 40 ~ 50 ug/m^3) and during day time higher concentrations (above 50 ~ 60 µg/m^3). Knowing that the target for human health protection is 120 ug/m^3 (the maximum daily value on 8 hours average) and an alert value is 240 ug/m^3 (average per 1 hour). Keeping in mind that Horiba APOA 370 is a ground monitoring instrument, the humidity and temperatures in the atmosphere also influence the ozone concentration. The link between LabView graphical programming platform and ozone monitoring system, Horiba APOA 370, made possible a fast and real-time acquisition of data regarding atmosphere-level ozone concentration. To simplify, we used the Ethernet port of the device for transmitting data, with the mention that the device uses its own protocol. Performances of LabView virtual instrumentation helped at increasing the monitoring system efficiency.

Key words: *LabView, Horiba, ozone, automation*

INTRODUCTION

The ozone molecule consists of three oxygen atoms that are bound together (triatomic oxygen, or O_3). Unlike the form of oxygen that is a major constituent of air (diatomic oxygen, or O_2), ozone is a powerful oxidizing agent. Ozone reacts with some gases, such as nitric oxide or NO, and with some surfaces, such as dust particles, leaves, and biological membranes (Ozone Chemistry, 2012).

An ozone monitoring system is used to determine the amount of ambient ozone at ground level, being an useful tool in monitoring the ozone values and determining whether they violated the National Ambient Air Quality Standards (240 µg/m^3 / 1 hour, 120 ug/m^3/8 hours) (Horiba, 2012) (Environmental Protection Agency, 2012).

Horiba APOA-370 is such equipment for ozone monitoring that continuously measures atmospheric ozone concentrations using a cross flow modulated ultraviolet absorption method. The ultraviolet absorption method works on the principle that ozone absorbs ultraviolet rays in the area of 254 nm from a mercury vapor light source. The

sample gas and the reference gas are continuously injected into the measurement cell controlled by a solenoid valve (Horiba, 2012). During a cycle, the system takes one air sample and scrub the ozone from it and in the next cycle a sample of air bypasses the scrubber. The difference between the two samples determines the actual ozone value (Environmental Expert, 2012).

For calculating the ozone concentration the system uses the Beer-Lambert law that says that the absorption of light is proportional to the concentration (McElroy et al., 1997):

$$I = I_0 \exp(-\alpha LC) \quad (1)$$

where: I = light intensity after absorption by ozone, I_0 = light intensity at zero ozone concentration, α = specific ozone molar absorption coefficient, L = path length and C = ozone concentration.

The advantages in using Horiba APOA-370 are the minimal maintenance requirements and the capability of continuously monitoring and instantaneously analyzing gases in their unaltered state, making it a preferred device in monitoring the atmospheric pollution (Environmental Expert, 2012).

For data aquisition and processing it has been used the LabView programming environment. Monitoring the acquisition process is very important when measurements are taken for a long period of time, especially for a remote operator.

LabView is a graphical programming environment that helps scientists to develop measurements, test and control systems. It is a language in which the user can set up the program to manipulate and store data, it reduces the implementation time and is more flexible than any other graphical programming software (National Instruments, 2012).

DISCUSSION

Ambient ozone concentrations depend on the sources that emit ozone and their location. Thus concentrations can fluctuate in the range of non-detectable near combustion sources, where nitric oxide is released into the atmosphere to several parts per billion of air in areas downwind of VOC/NO_x emissions. Ozone concentrations in urban areas are very high, but record a decay when a peak for at most a few hours before deposition and reaction with NO emissions is registered (Finlayson - Pitts and Pitts 2000, Seinfeld and Pandis 1998, Chameides et al. 1992, Smith et al. 1997).

Another variations of ozone concentration are caused by its photochemical formation, its rapid dissociation by NO, and the effects of differing VOC/NO_x ratios in air. A consequence of high ratio of NO_x emissions to VOC (Volatile Organic Compounds) emissions consists in higher peak ozone concentrations and lower minimum concentrations, compared to background conditions. The highest peak ozone concentrations are downwind from urban centers. Light winds transport ozone from urban centers, and photochemical reactions take place and create ozone from VOC and NO_x emissions. Also, far from sources of NO_x emissions, less NO is available to destroy ozone. Because the time of transport is larger, these peak ozone concentrations in downwind areas tend to appear later in the day compared to peak ozone concentrations in urban areas (Ozone Chemistry, 2012).

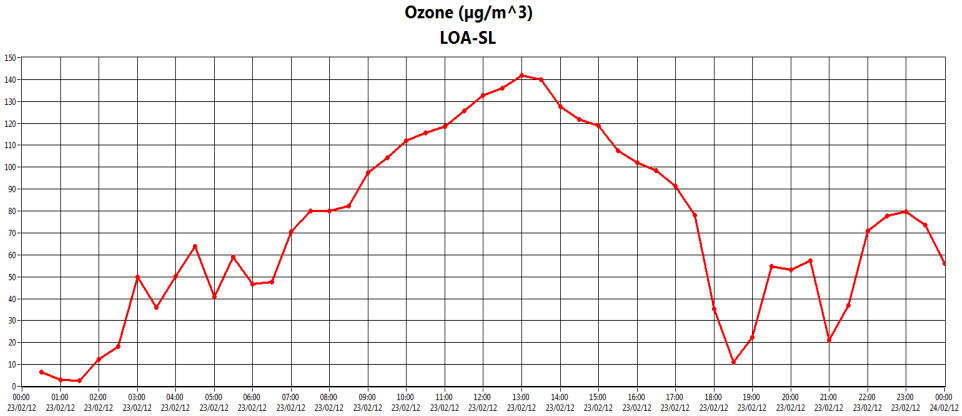

Fig. 1. *Ozone measurements (µg/m^3) from 23.02.2012*

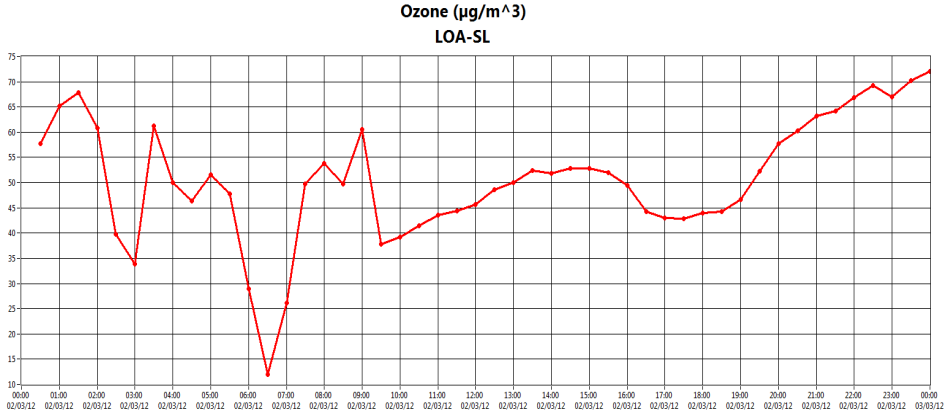

Fig. 2. *Ozone measurements (µg/m^3) from 02.03.2012*

Ambient ozone concentrations also record temporally variations in phase with human activity patterns, increasing the resulting adverse health and welfare effects. Ozone concentrations increase during the day when the rates of formation exceed the rates of destruction, and decrease at night when formation processes are inactive. This ozone variation during the day depends on location, with high peaks for brief periods of time (an hour or two) in urban areas, and low peaks with relatively little diurnal variation in remote regions. In urban areas, peak ozone concentrations normally occur in the early afternoon, at short time after solar noon when the sun's rays are most intense, but persist into the later afternoon, where transport is involved (The Physics and Chemistry of Ozone, 2012).

RESULTS

The performance of LabView virtual instrument helped creating an application for real time data acquisition regarding the atmospheric ozone concentrations. The application algorithm consists in three parts: 1) accessing Horiba system for gain data; 2) pre-processing and processing data; 3) transmitting information.

1) Horiba is an instrument that uses his own protocol for real time transfer of numerical data, the GESYTEC GmbH protocol. Communication using TCP/IP, UDP is used. A command/response is included in UDP datagram by the specified data format, including an Equipment ID (each equipment should respond to its own ID and this equipment ID is the global ID used for equipment ID setup), IP address, a SendID, dummy transmitter equipment ID (shown by HEX number of 2 digits), a RecvID, dummy receiver equipment ID (shown by HEX number of 2 digits).

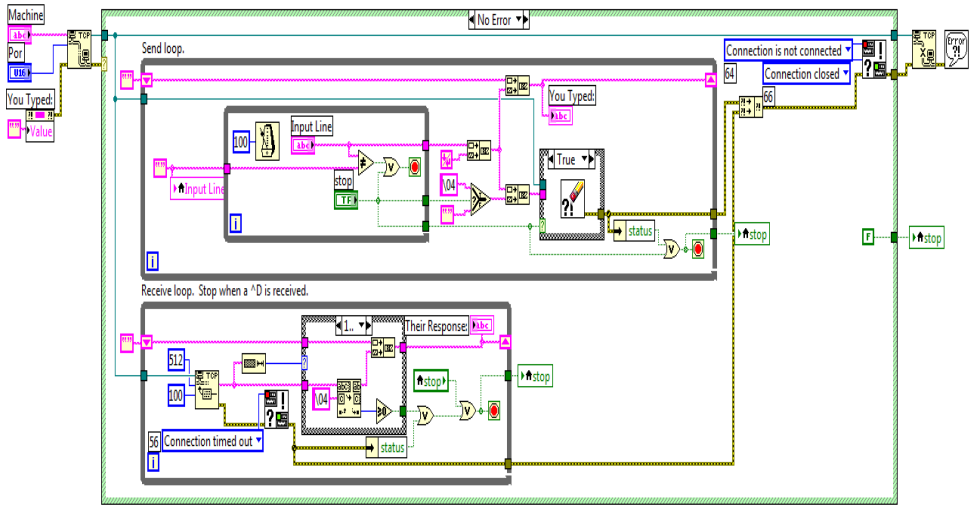

Fig. 3. *Diagram Block for TCP/IP connection*

When the communication partner is only connected to the equipment which has the IP address and the equipment that sends command doesn't know the communication partner's equipment ID, this value can be FF (255). After the connection is made, files are gained and transformed in ASCII format (HORIBA ltd., 2008).

2) Using LabView functions in Block Diagram such as Invoke Nodes, Structures (For Loop, Flat Sequence Structure, Case Structure, etc), Booleans (Select, True or False, etc), Clusters (Bundle, Bundle by name, etc.), Strings (Concatenate Strings, Search and Replace Strings, Format Strings, String Constant, etc), Comparison, Graph Indicator, etc., the pre-processing part stands in preparing information for a better access to data, converting the ASCII files to Excel format. The processing part consists in creating a Waveform Graph, plotting the ozone measurements as a time function and save it on computer, with a high resolution, as *.JPEG (1428 x 538) and *.BMP (1572 x 603).

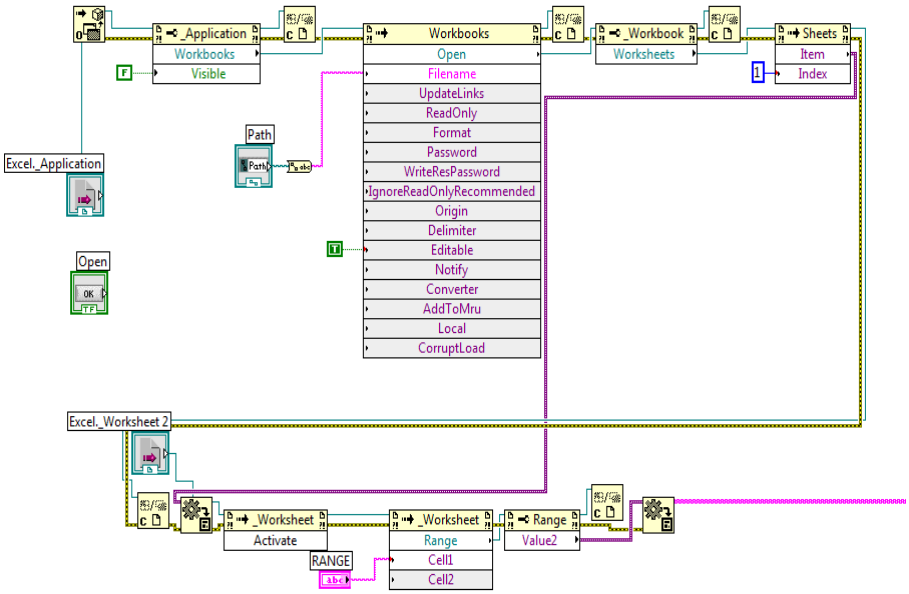

Fig. 4. *Diagram Block for reading Excel files*

The processing part consists in creating a Waveform Graph, plotting the ozone measurements as a time function and save it on computer, with a high resolution, as *.JPEG (1428 x 538) and *.BMP (1572 x 603).

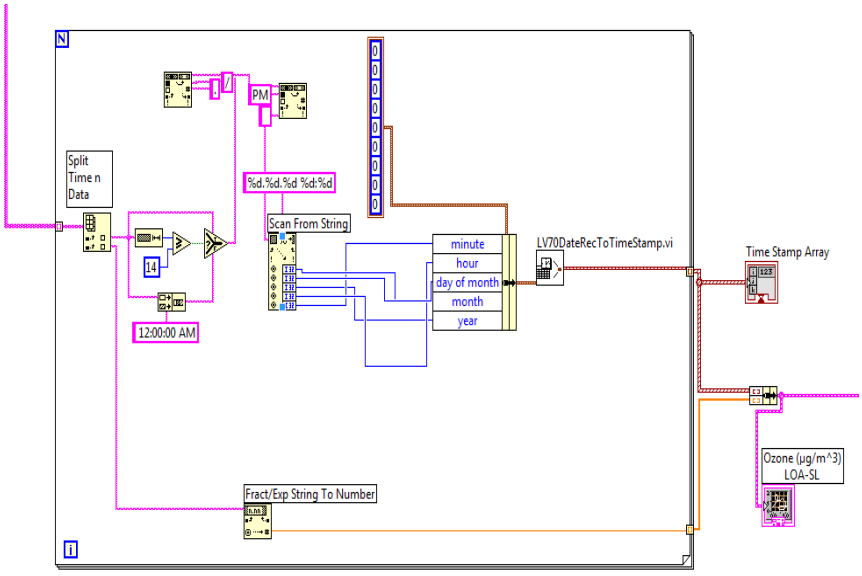

Fig. 5. *Diagram Block for creating graphs*

3) For transmitting information there are used two methods: transmitting graphs on a server which are uploaded on a specific website where daily and monthly reports are created, and informing the operator about alarms.

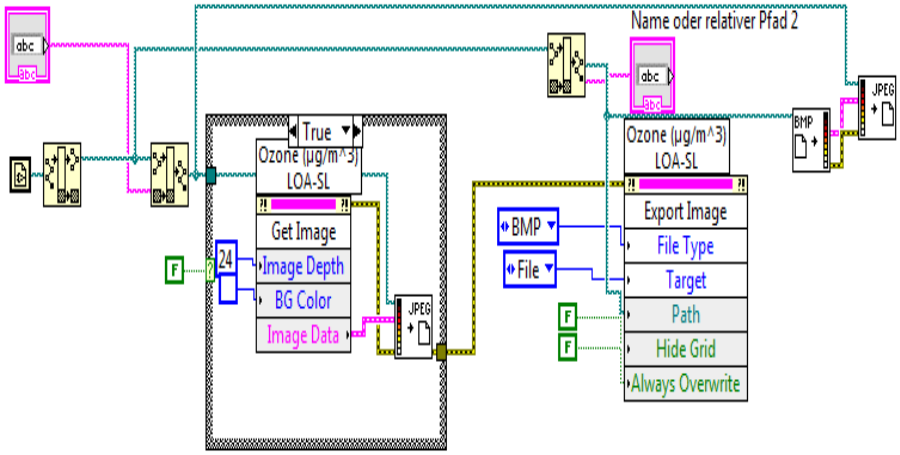

Fig. 6. *Diagram Block for saving graphs*

In the program it is also integrated an email function that allows the operator to monitorize data status and danger alarms. This danger alarm is set to alert the operator when ozone values exceed the limits of 120 ug/m^3 (the maximum daily value on 8 hours average) and 240 ug/m^3 (average per 1 hour) (National Network of Monitoring the Air Quality, 2012). In LabView environment there are two methods to implement these options: by using the ActiveX plug-in from Microsoft, or by SMTP - Simple Mail Transfer Protocol, tools that have specific tasks: sending email, sending message, sending data or sending attachements, options useful for making a complete report (National Instruments, 2012). This module makes data acquisition safer and more efficent.

CONCLUSION

This paper presents the approach between LabView graphical programming platform and ozone monitoring system, Horiba APOA 370. The program made possible the automation of ozone monitoring system and implemented an alert part that was successfully used for real time monitoring of data acquisition.

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