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Cover 1: *Taxodium distichium* with *Tillandsia usneoides* (moss).
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PHYTOREMEDIATION PLANNING IN THE CASE OF FORMER INDUSTRIAL SITES

Melania-Nicoleta BOROŞ*, Valer MICLE[1], Lazăr FLĂMÎND[1], Ioana Monica SUR[1]

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ABSTRACT. Contaminated soils from former industrial sites need urgent measures of treatment in order to be used for other purposes. Because of the large spaces that industrial sites usually occupy, green technologies have to be chosen to treat the soil while protecting the environment. Phytoremediation is an environmentally friendly technology that uses plants to decontaminate soils. The main advantage is the low cost compared to other techniques and the main disadvantage is the time factor because phytoremediation requires long period of time to treat the polluted soil. This paper presents specific features that must be taken into consideration when planning and implementing phytoremediation projects. Pollutants concentration and soil properties limit the application of phytoremediation. A clean-up plan is prepared taking into consideration limiting factors and then the remediation measures are implemented. The project needs long-term monitoring to determine the quantity of contaminants in soils during its implementation. The main purpose is to provide a safe environment for humans' health while improving the ecological situation of the former industrial sites.

Key words: *phytoremediation, planning process, former industrial sites, soil contamination*

INTRODUCTION

The population of the world is increasing and more and more land is required in the urbanization process. This has a detrimental impact on the expansion into the wilderness, forests and agricultural lands, so treating and using contaminated sites must play an important role in ensuring a sustainable development. Soil as a non-renewable resource represents a valuable asset and its clean-up in polluted areas can support biodiversity and create new ecosystems (Macek et al., 2002; Marcotullio et al. 2008; Zhang et al., 2011; Surriya et al., 2015).

Historically speaking, the industrial era meant the development of different branches of industry correlated with economic prosperity. After 1990, because of switching from manufacturing to services or because the industries moved to countries with lower labour costs, a lot of industrial sites were abandoned usually with a specific level of contamination. The redevelopment of formal industrial sites is necessary and some of the local authorities converted this type of sites for commercial, residential, industrial or even recreational functions (Loures and Panagopoulos, 2007).

Former industrial sites represent sources of contamination that can spread and affect the health of population. The routes of exposure are determined according to the site conditions (see figure 1).

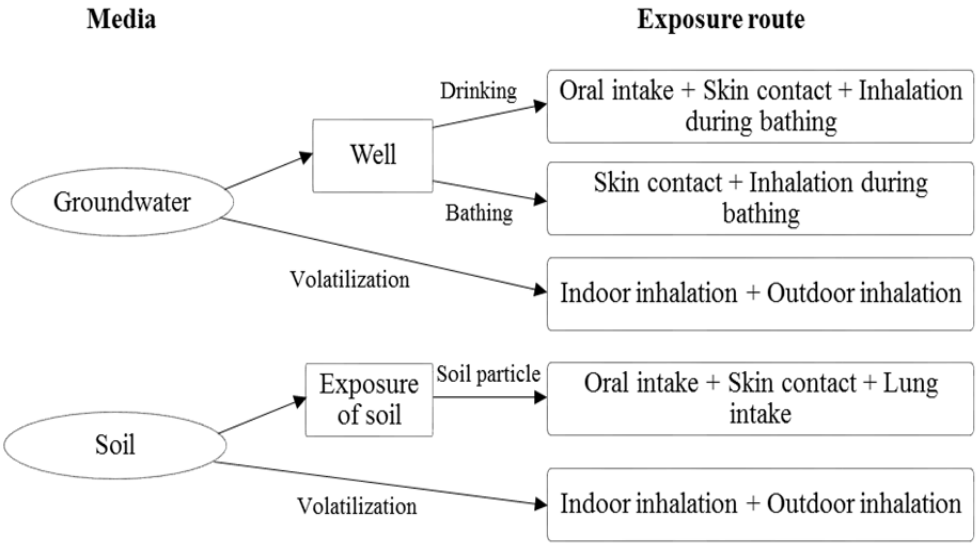

Fig. 1. *Exposure routes of dangerous compounds in the case of contaminated sites (Fujinaga, 2016)*

Contaminated sites can be treated using phytoremediation which is a technology that exploits plants to remediate dangerous compounds (Simeonova and Simeonov, 2006). Depending on the method and the remediation purposes, phytoremediation has been categorized into phytoextraction, phytodegradation, phytostabilization, phytovolatilization, rhizofiltration, rhizodegradation (EPA, 2001; Kvesitadze et al., 2006; Ali et al., 2013; Boroș and Micle, 2014; Filippis, 2015).

The aim of this paper is to present the most important factors that must be taken into consideration for the planning process of treating contaminated sites using phytoremediation. Former industrial sites can be integrated completely in the landscape after a well-documented evaluation of the present situation and the study of the most appropriate method.

LIMITING FACTORS IN IMPLEMENTING PHYTOREMEDIATION

The application of phytoremediation is not generally applicable because the conditions are different from case to case. So it is difficult to draw up a project plan that can be applied to more than one site. Every plan has to be designed for a specific case study and adapted to the local requirements for the best integration of the entire contaminated area (EPA, 2008).

In order to study the contaminated sites, three phases of diagnostic assessment procedure were identified. In the first phase, a preliminary site assessment is made which includes the site inspection and collection of data regarding maps, photos, literature, reports, articles etc. The second phase represents the comprehensive site assessment and implies sampling and analysis of media of interest to determine the exact contamination. The investigation and implementation of remedial measures are part of the third phase when the contamination is studied in detail and the plan and its actions are applied (Asante-Duah, 1995).

Former industrial sites are usually located in the vicinity of city centre or in the outskirts with good infrastructure which is an important advantage for stakeholders. They can decide to invest in the remediation process or not, depending on how huge the expenses are and how big the profit can be, according to the A-B-C model. Type A of economic opportunity states that the private sector can finance totally the reclamation of the land and the treatment of it if a safe profit is assured. A public-private cooperation can be necessary to implement the redevelopment of a polluted area in order to increase the value of the site and make profit (type B). Usually if the costs of site rehabilitation are very high, only the public sector invests in this case and only if it is for the public benefit (type C) (CARBERNET, 2006).

There are many parameters that must be taken into consideration when phytoremediation is applied at full-scale. Some of them are related to soil properties like texture, organic matter and pH and also to soil protection. An important issue is the contaminants' type and composition, which is relevant further in the process of selecting the most adequate plants. Another decisive element is the future use of land which determines directly the method that is applied on site and how intensive the remediation must be. The equipment that is used, the safety environment for workers, monitoring of the area, period and costs of remediation and also the inhabitants involvement are factors that cannot be neglected. In order to evaluate the feasibility of phytoremediation, a summary of these important parameters is presented in table 1.

Table 1. *Factors that limit the implementation of phytoremediation plan at field scale (after EPA, 2000; Mudgal et al., 2010; Meuser, 2013)*

Planning factor	Criteria	Evaluation of technical feasibility
Soil properties	Texture	Medium to fine sand, loamy sand, sandy loam and sandy clay loam soils are recommended and offer a high efficiency; Gravel, coarse sand and cohesive soils have limited applications

Planning factor	Criteria	Evaluation of technical feasibility
	Organic matter content	The best treatable concentration is 1 – 5 %; Concentrations less than 1 % and peaty soils offer strong limitations; High humus content of more than 5 – 30 % is less favorable
	pH value	Phytodegradation is not recommended in acidified soils, but is highly recommended for phytoextraction (pH <5,5); Soils with a pH of 5,5 – 7,5 are well treatable in the case of phytovolatilisation and rather not recommended for phytoextraction; Alkaline soils offer strong limitations (pH > 7,5)
Soil protection	Structure	Phytoremdiation has no negative impact on soil; Offers improvement of nutrient capacity, organic matter content and edaphon; Reduces impact on horizonation; Soil conditions can be improved by adding fertilizers
	Biological activity	
	Nutrients	
	Humus content	
Level of contamination	Scientific investigation methods	Cd, Cu, Ni, Pb, Zn are treatable by phytovolatilisation; Cd, Ni and Zn are pollutants preferred in phytoextraction; Cr and As treatment is restricted; Treatment of Hg is limited; Phytoextraction presents a low solubility of the organic pollutants; Phytodegradation can be used to treat organic pollutants like TPH, BTEX, Phenols, VCHC, PAH, PCB and free cyanides
	Type of pollutants	
	Pollutants concentration	
Sensitivity of the land use in future	Highly sensitive	The future use of the land is highly important to establish the remediation strategy; As a general rule, the higher the sensitivity of the land is required, the more intensive has to be the applied the remediation technique
	Sensitive	
	Low sensitive	
	Non-sensitive	
Plant selection	Type and depth of roots	For a proper selection of plants, lots of information must be gathered to choose the best characteristics of a plant for the specific site, climate, soil, pollutant, costs and biomass depending on the designed objectives
	Plant growth rate	
	Transpiration rate	
	Seed and plant source	
	Type of plant	
Time	Schedule	It requires longer remediation period than other techniques, even decades; The remediation plan should follow a step-by-step schedule with complete details about the processes and operation charts.
Costs	Mass to be treated	Costs can reach 25 – 50 € m^{-3}, exceptionally > 50 – 75 € m^{-3}
	Materials needed	
	Chosen method	
Long-term monitoring	Sampling procedures	Sampling and analyzing plants, soil, groundwater and vapors is part of the cleaning strategy
	Analyses	
	Immision control	

Planning factor	Criteria	Evaluation of technical feasibility
Citizens involvement	Raising awareness	The plan should involve the inhabitants from the beginning of the process; An advisory council can be established to hold meetings where the opinion of the members should be taken into consideration
	Presenting information	
	Participation in council meetings and decisions	
Equipment	Operating	The clean-up plan requires different type of equipment and trained personnel
	Maintenance	
Working safety	Sources of danger to human health	Special attention is needed for mechanical and chemical hazards; Ruined building can collapse; Chemicals can penetrate skin and be absorbed into the organism, there is also danger of asphyxiation and oral ingestion/inhalation; Fire and explosion are present risks on site
	Safety measures	A health and safety plan is developed prior to starting the remediation process

It is very important to monitor the plans that have been developed for soil treatment. Periodic monitoring is necessary to ensure optimization of remediation process and it is very important to record the decrease in concentration of constituents and also the quality of groundwater (Kondolf and Micheli, 1995; Finger et al., 2007).

Local communities need to be involved in every important step that is part of the redevelopment project. The success of the programme can be associated with the public participation and the future use of the area. In this way, the conflicts and the refuse of area rehabilitation generated by the noise, vibration due to the equipment used, dust created during the process and other unpleasant activities, are removed. The whole area is accepted easily by the citizens and represents a reference area of local identity (Soesilo and Wilson, 1997; ITRC, 2006).

PLANNING PHYTOREMEDIATION

One of the easiest ways to have best results in the phytoremediation plan is to prepare a detailed programme for the contaminated site. It should contain a list of all the information which has to be collected and all analytical tests, methods and research techniques that will be used. The site remediation program consists of several parts and includes health and safety of staff on site, staff requirements, equipment used, preservation of collected samples and analytical techniques. Remedial program also includes a presentation of the chosen method with the complete motivation for its choice. When it is necessary, standard procedures must be establish, otherwise, the documentation of the whole plan should not be unreasonably long (Russell, 2012).

It is important to plan carefully the phytoremediation studies and the soil treatment. Successive stages of phytoremediation planning and implementation are presented in figure 2.

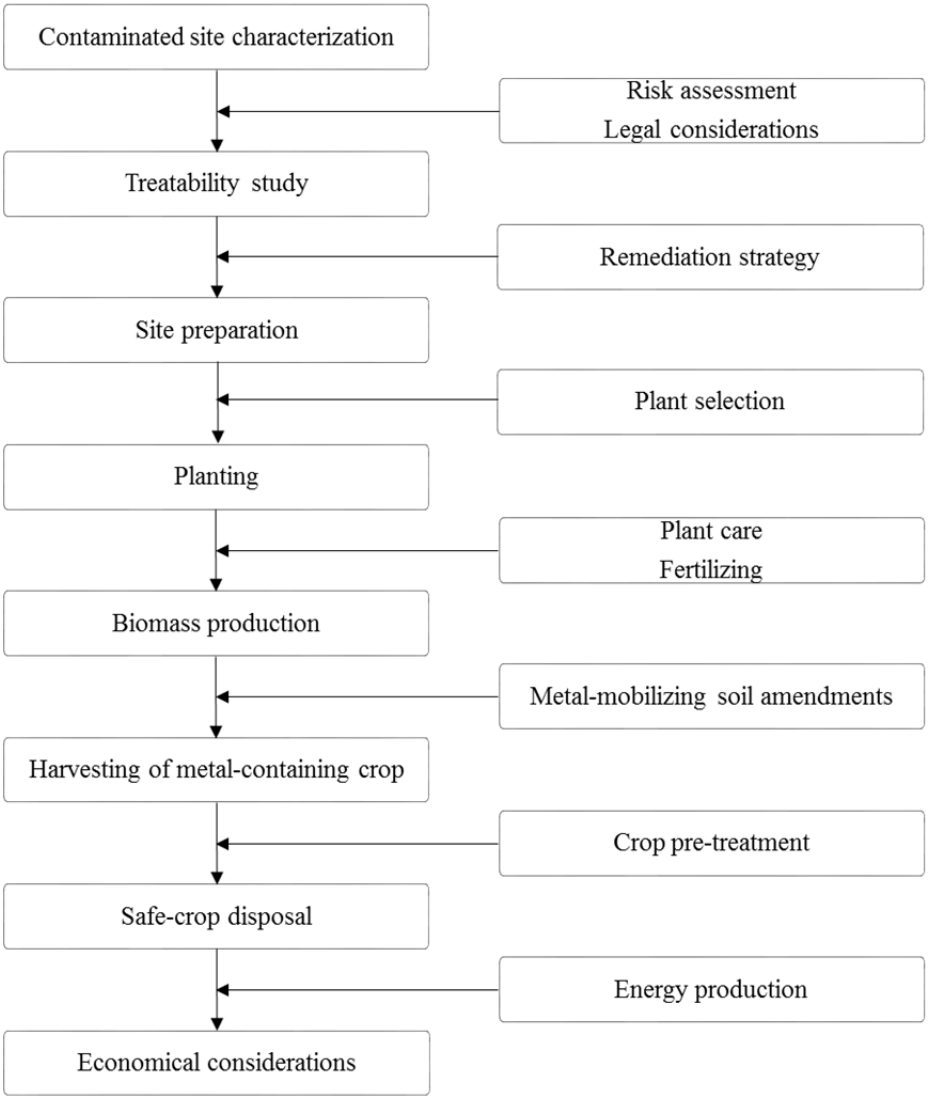

Fig. 2. *Scheme of the phytoremediation programme plan (after Sas-Nowosielska et al., 2005; Ibrahim et al., 2015)*

Site remediation cannot be carried on if the initial information is not obtained. The following details and documents have to be obtained in order to decide on the methods and proper solutions that can be implemented on site (Russell, 2012):

- Introduction and objectives;
- Site description, location and maps;
- Historical information;
- Information about the surface soil;
- Geological information, including national and local information about geological exploration;
- Utilities on site - streets, sewer, electric lines, buried water pipes, gas pipelines and telephone lines;
- Site maps and photos - including aerial photos, zoning and maps of property, where it is the case;
- Research plan of the site;
- Sampling plan - how many and which type of samples will be collected;
- Plan analysis - how samples should be preserved, handled, stored and analysed;
- Safety and health plan for staff on site, which includes information on exposure to contaminants while performing the necessary tasks.

The former industrial sites redevelopment can integrate landscape design in order to integrate parks in the scenario. The advantage of planning the future landscape concept is that it protects the valuable existing vegetation and increases biodiversity. These measures allow nature conservation and environmental protection for a sustainable development and increasing of quality of life in the surroundings.

On some of the contaminated sites, a mixture of wild plants grew, spreading on polluted soil and combined with the industrial ruined buildings and artefacts a special and unique landscape was created. In some of the places, architects, town planners and artists were interests in this type of scenery and identified new symbols for human history and industrial value. Their alternative in site redevelopment is to leave some areas in their actual state in order to permit natural succession of species so that artistic monuments can be created (USEPA, 2010).

CONCLUSIONS

Former industrial sites that are contaminated with various types of pollutants can be treated using green technologies like phytoremediation. Even though it is a technique that needs a long period to remediate the area, it is well accepted by the public that can take benefits from the site rehabilitation. Compared to other techniques, implementation of phytoremediation is cost-effective, which is a great advantage when there are very large areas that need remediation.

The entire phytoremediation design and implementation at full scale is a well-documented process and requires an evaluation of technical feasibility. Planning phytoremediation should take into consideration many factors that are

decisive in the efficiency of the implemented solution. To control the spread of contamination, but also to record the progress of remediation, a long-term monitoring must be prepared in detail.

Because the application of phytoremediation is a site-specific process, standard procedures cannot be establish, but the general guidelines can be taken into consideration for every location and every step has to be particularized.

The main objective of every site remediation is to improve the current situation of each contaminated area in order to provide a safe and healthy environment for every citizen.

Acknowledgments

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ORGANIC FARMING AND THE GREENING OF THE COMMON AGRICULTURAL POLICY MADE WALLOON AGRICULTURE BECOME MORE ENVIRONMENT FRIENDLY IN 2015

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ABSTRACT. In Wallonia, organic farming continues to increase its share of agricultural activities, the number of organic farmers exceeding for the first time 10% of the total number of farmers in 2014, with 8.6% of the total agricultural area. Meadows represent 83% of the organic areas, general crops 15% and vegetables 1%. The number of cattle heads is still increasing, while poultry and laying hen recorded a significant progress during the last years. Organic products consumption is also increasing and the market share of organic products in food products reached 2.3% in 2014. On the other hand, the implementation of the new Common Agricultural Policy, and particularly its green payment, obliges 50% of Walloon farmers to practice crop diversification and 46% to have at least 5% of ecological focus area within their arable land in 2015, which represents more than 24,000 ha. So, organic farming and ecological focus areas do have today a significant share of the Walloon agricultural area, leading to a more sustainable agriculture.

Key words: *Wallonia, organic farming, green payment, ecological focus areas*

INTRODUCTION

The pollution due to intensive agricultural practices and risks for human health have led to changes in the goals and tools of agricultural policy during the last decades. On one hand, organic farming, duly controlled as such, was defined at the European level in 1991 and became a significant new method of production during the first years of the 21st century. On the other hand, environmental considerations and measures were more and more taken into account in the

Common Agricultural Policy (CAP) since 1985. After three years of negotiations (Bureau, 2012), the European Parliament, Commission and Council of ministers defined, in June 2013, the new CAP for the period 2014-2020. One of the main characteristics of the new rules is that they go further in favour of the environment (Matthews, 2013), defining the so-called "green payment" which must represent, in each Member State/region of the European Union, 30% of the national/regional envelope for direct payments to farmers, the most important expenses of the CAP.

This paper examines the situation of organic farming, organic products consumption and the implementation of the green payment in Wallonia, the Southern part of Belgium, a founder Member State of the European Union where agricultural policy is nowadays regionalised. It shows to which extent organic farming and the green payments contribute in 2014-2015 to a more sustainable management of natural resources in a small region where high yields are obtained and large quantities of inputs (fertilizers, pesticides, etc.) were used after the post-World War II agricultural "revolution".

ORGANIC FARMING IN WALLONIA

Evolution of the number of farms and of the agricultural area

The first organic farms appeared in the 1980's (Burny and Gellens, 1988), but this way of production became significant only during the 21st century (figure 1).

Between 2000 and 2005, the number of organic farms in Wallonia reached from 400 to 500 only, but it began to increase more rapidly since 2006. In 2014, the number of organic farms reached 1,287, exceeding for the first time the share of 10% of the total number of farms in Wallonia.

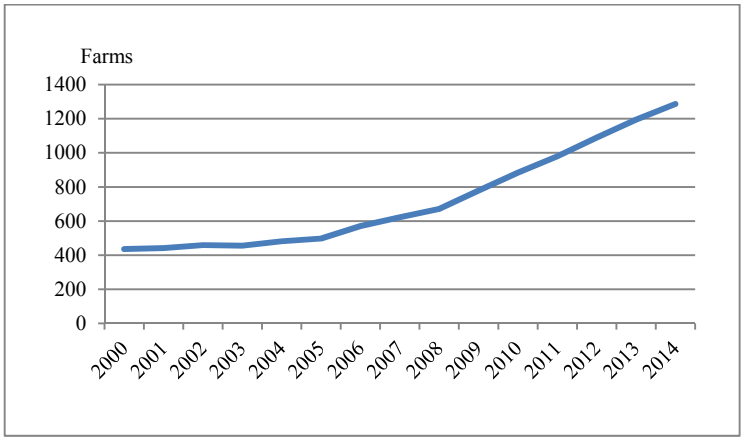

Fig. 1. *Evolution of the number of organic farms in Wallonia from 2000 to 2014 (Source of the basic data: BIOWALLONIE 2015).*

The total area devoted to organic farming followed the same pathway (figure 2).

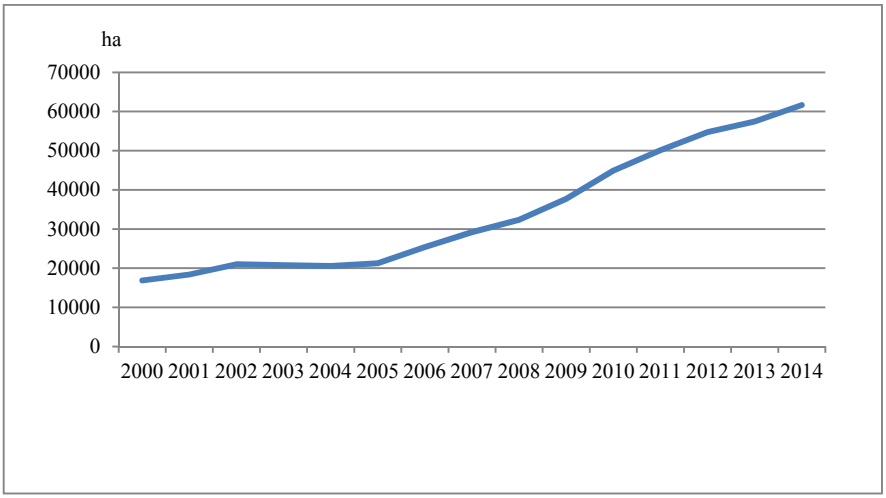

Fig. 2. *Evolution of the organic farming area in Wallonia from 2000 to 2014* (*Source of the basic data: BIOWALLONIE 2015).*

While the total area for organic farming reached around 20,000 ha during the period 2001-2005, it sharply increased later, exceeded 50,000 ha in 2011 and 61,651 ha in 2014, representing the significant share of 8.6% of the total agricultural area. This is not yet the threshold of 20% cited by Dufumier (2012) to be the breakpoint, but an important part of the way has already been done.

The average area of an organic farm reached 39 ha in 2000 and 48 ha in 2014, which is a little bit less than the general mean.

Main organic productions

In 2014, more than 50,000 ha or 83% of the organic farming area were devoted to meadows, while general crops represented 15.4%, vegetables 1.0% and fruits only 0.2%. On the meadows are mainly raised dairy cows (the price of organic milk is much higher than the price of conventional milk, especially after the disappearance of dairy quotas) and the meat races (the Belgian White Blue, Limousine, etc.). The herd reached around 30,000 heads during the period 2003-2006 and then sharply increased, exceeding 70,000 in 2013 and 2014 (figure 3).

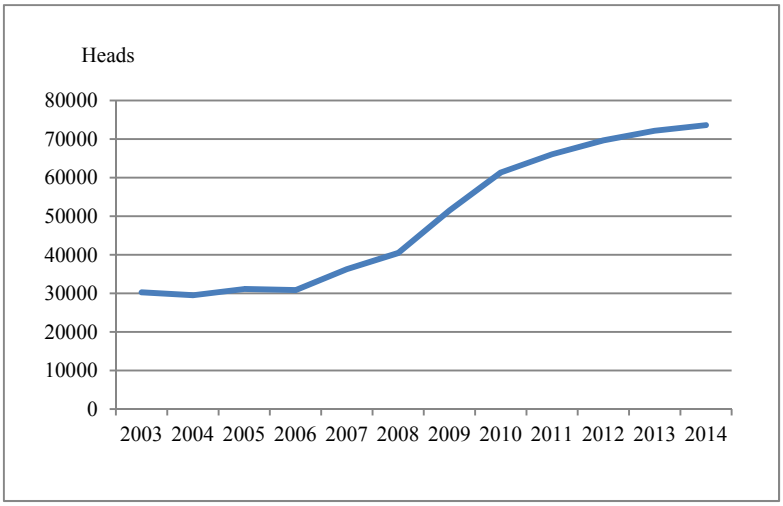

Fig. 3. *Evolution of the number of organic cattle heads in Wallonia from 2003 to 2014 (Source of the basic data: BIOWALLONIE 2015).*

Cereals are more and more important, some large farms being converted to organic farming. This reflects the evolution of the demand.

The production of vegetables is still modest, but continuously increasing since 2011. The local demand is also increasing.

The poultry sector is remarkably dynamic. In 2014, the number of heads reached 1.6 million, more than three times than in 2003. The number of laying hen exceeded 140,000 in 2014, registering a very sharp increase since 2010.

The number of sheep and goats is modest, but also increasing.

The strategic plan for the development of organic farming towards 2020

In 2013, the Walloon Government approved a strategic plan for the development of organic farming towards 2020 (Comase and Di Antonio, 2013).

This plan defined different measures concerning extension services, agricultural research, teaching and promotion and defined the goals towards 2020: 1,750 organic farms and 14% of the regional agricultural area (Burny and Debode, 2013).

Goals are also defined for the processing industry: to reach 500 enterprises (230 in 2011) with a total turnover of 500 million € (109 in 2011), and for consumption: to reach 3% of the food market (1.7% in 2010).

In 2016, organic farming is also proposed to the citizens as one of the measures of the future “Walloon strategy for sustainable development” (Service public de Wallonie, 2016).

Financial support to organic farmers

Organic farmers are not only eligible to all financial supports from the CAP, including the direct payments (and the green payment among them), but they can also get specific financial support from the second pillar of the CAP, devoted to "rural development".

In Wallonia, the financial support for organic farming for the period 2015-2020 is described in table 1.

Table 1. *Financial support (€/ha) for organic farming in Wallonia (2015-2020) Source of the basic data: Service public de Wallonie 2015).*

Crops	**Area of organic farming**		
	0 to 60 ha		Over 60 ha
Meadows and forage crops	200		120
Other annual crops	400		240
	0 to 3 ha	3 to 14 ha	Over 14 ha
Fruit trees, horticulture and seed production	900	750	400

For the conversion from a conventional to organic farm, the support is even higher (table 2).

Table 2. *Financial support (€/ha) in Wallonia for a conventional farm in conversion to organic farming (2015-2020), (Source of the basic data: Service public de Wallonie 2015).*

Crops	**Area of organic farming**		
	0 to 60 ha		Over 60 ha
Meadows and forage crops	350		270
Other annual crops	550		390
	0 to 3 ha	3 to 14 ha	Over 14 ha
Fruit trees, horticulture and seed production	1050	900	550

Organic products consumption

Organic food is now relatively successful among consumers (Petrescu et al., 2014). The market share of organic food products is still modest in Belgium: 2.3% in 2014. However, it is still increasing. Even more remarkably, the total expenses for organic food products still increased by 5% in 2014, while the total expenses for food products declined for the first time since many years.

The largest expenses per capita in 2014 concern dairy products (5.40 €), vegetables (4.74 €) and fruits (3.71 €).

The highest market shares for organic products are observed for meat substitutes (21.0%), eggs (11.0%) and vegetables (5.4%). The market share reaches 3.5% for fruits and 2.1% for dairy products.

88% of Belgian households bought at least once an organic food product in 2014, while 7% bought at least once per week.

THE GREEN PAYMENT

Implementation of the green payment in Wallonia

A new architecture for direct payments to farmers for the period 2015-2020 has been defined in the Regulation (EU) No 1307/2013 of December 17, 2013. This regulation gives a general scheme, but leaves many possibilities of implementation to the Member States (or their regions according to their own organisation), with the exception of the green payment (Hart, 2015). Indeed, it is compulsory that the green payment must represent 30% of the total amount of direct payments to farmers in each Member State/region. Only the way of implementation is left to the choice of the Member State/region: the same amount for each eligible ha or a sum proportional to the basic payment paid for each farmer. The last solution was chosen in Wallonia.

The structure of direct payments in Wallonia for the period 2015-2020 is shown in figure 4.

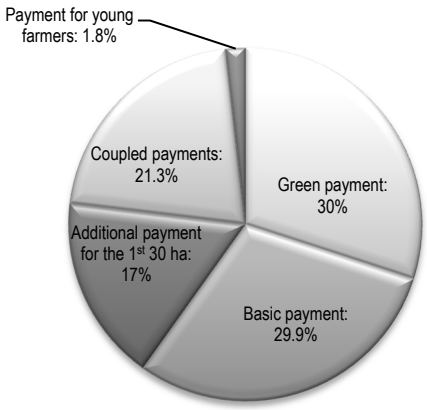

Fig. 4. *Structure of direct payments in Wallonia (2015-2020) (Source: Burny and Terrones Gavira, 2016).*

In order to get the green payment and avoid financial penalties, the farmers must respect three conditions:

- maintenance of permanent pastures;
- crop diversification;
- implementation of ecological focus areas.

Maintenance of permanent pastures

Permanent pastures are supposed to be good for the environment, avoiding erosion, stocking carbon dioxide…

They are defined as grassland since at least five years.

Each Member State/region has to define a "reference ratio" as the area of permanent pastures divided by the total agricultural area at the national/regional, sub-regional or farmer's level, 2015 being the reference year. In the future, the ratio cannot decrease by more than 5%.

The Member State/region must also define the permanent pastures which are considered as environmentally fragile (article 45 of Regulation (EU) No. 1307/2013). In Wallonia, they are situated in the NATURA 2000 zone.

Crop diversification

Crop diversification must be practiced if the farmers manage:

- between 10 and 30 ha of arable land: in such a case, at least two crops are compulsory (the most important does not exceed 75% of the area);
- more than 30 ha of arable land: in such a case, at least three crops are compulsory (no more than 75% of the area for the most important and no more than 95% for the two most important).

Are defined as "crop": land lying fallow, temporary pastures, one gender considered in the botanical classification (Triticum, Hordeum, Beta, etc.) or one species for Brassicaceae, Solanaceae and Cucurbitaceae.

There is no compulsory diversification when:

- the farmer has less than 10 ha of arable land;
- more than 75% of the arable land are devoted to the production of grass (temporary pastures) or fallow and, on the same time, the remaining arable land area does not exceed 30 ha;
- more than 75% of the total agricultural area of the farm are devoted to permanent pastures or the production of grass and, on the same time, the remaining arable land area does not exceed 30 ha.

For the first year of implementation of this measure, 2015, the impact on Walloon farms is shown in table 3.

Table 3. *Number of farms concerned with crop diversification in Wallonia in 2015, (Source: Terrones Gavira et al., 2016)*

	Number of farms	**%**
No obligation	6,323	50
At least two crops	2,040	16
At least three crops	4,221	33
Do not meet the obligations	105	1

Ecological focus areas

When the farmers manage more than 15 ha of arable land, they must devote at least 5% of this land to ecological focus areas (article 46 of Regulation (EU) No. 1307/2013).

The Commission delegated Regulation (EU) No. 639/2014 gives a list of ecological focus areas in which the Member State/region can select which ones are convenient for them. For Wallonia, these areas are presented in table 4.

Some topographic elements need a conversion coefficient to be transformed in an area. Some weighting factors are used because the ecological impact of the different areas is variable.

In 2015, 54% of Walloon farmers were not obliged to implement ecological focus areas (they have less than 15 ha of arable land, are organic farmers).

Among the group of farmers who were obliged to have ecological focus areas, 47% devoted from 5 to 6% of their arable land to these areas, 21% devoted from 6 to 7% and 29% had more than 7% of ecological focus areas. In addition, 2.4% of the farmers did not meet the required 5% and so could get financial penalties.

Nearly 80% of the farmers obliged to have ecological focus areas have only one type of them, and 15% have only two types.

The most important type of area used to fulfil the requirements is by far the "areas with catch crops or green cover", which represents nearly 90% of all the areas to be converted in ecological focus areas (table 5). Far behind are land lying fallow and areas with nitrogen-fixing crops.

Table 4. *Conversion coefficients and weighting factors to transform some areas and landscape features into ecological focus areas (Source: Terrones Gavira et al., 2016)*

Elements	Particularity	Description		Conversion coefficient	Weighting factors	Ecological focus area (m^2)
Surface elements (ha)	Plot	Land lying fallow	Per 1 m^2	n/a	1	1
		Areas with short rotation coppice	Per 1 m^2	n/a	0.3	0.3
		Areas with nitrogen-fixing crops	Per 1 m^2	n/a	0.7	0.7
		Buffer strips	Per 1 m^2	n/a	1.5	1.5
		Strings of eligible hectares along forest edges – without production	Per 1 m^2	n/a	1.5	1.5
	Intercrop plot	Areas with catch crops or green cover	Per 1 m^2	n/a	0.3	0.3

Elements	Particularity	Description		Conversion coefficient	Weighting factors	Ecological focus area (m^2)
	Topographic elements	Ponds	Per 1 m^2	n/a	1.5	1.5
		Group of trees/ Field copses	Per 1 m^2	n/a	1.5	1.5
Linear elements (m)		Field margin	Per 1 m	6	1.5	9
		Ditches	Per 1 m	3	2	6
		Hedges/wooded strips	Per 1 m	5	2	10
Punctual (nb)		Isolated tree	Per tree	20	1.5	30

Table 5. *Area of the different types of ecological focus areas in Wallonia in 2015 (Source: Terrones Gavira et al., 2016)*

	Area (ha)	%
Land lying fallow	983.7	4.1
Areas with short rotation coppice	9.3	0.0
Areas with nitrogen-fixing crops	898.5	3.7
Buffer strips	206.5	0.9
Strings of eligible hectares along forest edges – without production	99.8	0.4
Areas with catch crops or green cover	21,432.8	88.8
Ponds	1.3	0.0
Group of trees/Field copses	111.1	0.5
Field margin	138.3	0.6
Ditches	42.8	0.2
Hedges/wooded strips	200.8	0.8
Isolated tree	1.6	0.0
TOTAL	24,126.6	100.0

CONCLUSIONS

Organic farming in Wallonia is increasingly successful due to the economic, social and environmental problems of the conventional model of agriculture, a strong financial support of the public authorities and a greater awareness of the consumers about health and environmental problems. In such conditions, organic farming is today significant in Walloon agriculture and is a part in the regional strategy for sustainable development. On the other side, the Common Agricultural Policy is going greener and greener, and so-called “ecological focus areas”, directly linked to financial support, also represent significant agricultural areas. Organic farming and ecological focus areas represent in 2015 around 12% of the total agricultural area. This phenomenon clearly proves that the farmers are able to adapt to new situations and to respond to the new wishes of our society, especially when this society defines its vision of the future and offers sufficient financial means to reach its goals. Without any doubt, European agriculture, thanks to the agricultural policy, research, extension gets more and more environment friendly.

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STUDIA UBB AMBIENTUM, LXI, 1-2, 2016, pp. 25-33
(RECOMMENDED CITATION)

STRATEGIC ASSESSMENT OF THE ENVIRONMENTAL IMPACT IN DEVA-HUNEDOARA CONURBATION USING RIAM METHOD – PRELIMINARY RESULTS

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ABSTRACT. Deva-Hunedoara conurbation is a bipolar structure located in central-western Romania composed of 49 settlements. It is located in the center of Hunedoara County at the crossroad of major transport networks. With a remarkable diversity of natural factors and a high share of human and economic activities, the area creates different types of impacts on the environment. The potential impacts derive from the rich industrial activity, day to day human activities, transport, commerce, constructions, etc.

In assessing the environmental impact within the conurbation we used the RIAM method with a modified matrix, suited for our area of study. For each of the 49 settlements we analyzed the environmental impact of 37 components coupled in 4 major categories: physical and geographical components, biological and ecological components, land use and socio-cultural components and economic and operational components.

For the final interpretation and representation of the environmental impact we used the IDWIM - Inverse Distance Weight Interpolation Method to generate maps of impact.

Key words: *conurbation, RIAM, matrix, environmental impact*

INTRODUCTION

Currently the procedure of environmental impact assessment can be performed by more than fifty methods and techniques. These methods and techniques are derived from numerous and varied scientific disciplines dealing in both with human impact on the environmental components and with the socio-economic aspects of management, planning, legislation, etc. Among the most used methods in environmental impact assessment are checklists and matrix methods (Muntean, 2005).The simple checklists are based on a priori judgments issued and achieve a hierarchical list of factors to be taken into account in the assessment. They allow the identification, organization, assessment and character of impacts.

Checklists are important because they allow ordering of ideas, facilitate the collection of data and information and help to better locate the source of impact.

Matrices can be used to identify, systematically study, visualize and evaluate the majority of environmental impacts. A simple matrix is a combination of two checklists; one describes potential impacts on existing activity/project (distributed on columns) and the other includes the environmental and socio-economic factors affected by these impacts (distributed on lines). One of the cheapest, fast and well tested matrices is Leopold's matrix. This matrix creates the connection between environmental factors and human activities and ensures that no type of user impact has been omitted. Assessment of magnitude and importance of impacts involves partially subjective judgments, which diminishes the accuracy of knowing those beneficial and adverse impacts (Leopold et al., 1971).

The best adaptation of Leopold's matrix is RIAM method (Rapid Impact Assessment Matrix) developed by the Pastakia and Jensen. The RIAM method essentially preserves Leopold's matrix structure but offers the possibility of restricting the number of analyzed components. RIAM is a matrix method developed to bring subjective judgements in a transparent way into the EIA process. The method was developed by Cristopher Pastakia (Pastakia and Jensen, 1998) at the end of the 1990s, and since then it has been widely tested in many assessment situations and case studies. RIAM is based on the standard definition of concepts used in the EIA process. With the help of the method different impacts and their significance can be evaluated using commonly defined criteria, each of which has its own ordinal scales. The results of the assessment are placed on a simple matrix, which leaves permanent and reasoned records about the judgments made (Kuitunen et al., 2008). In the original RIAM method five evaluation criteria are used, namely impact importance (A1), magnitude (A2), permanence (B1), reversibility (B2) and cumulativity (B3) (Pastakia, 1998).

METHODOLOGY AND RESEARCH AREA

In the current study we analyzed 37 specific components classified into 4 categories: physical and geographical components (PGC), biological and ecological components (BEC), sociological, cultural and land use components (SCC), economical and operational components (EOC).

In terms of choosing the components analyzed we took in account the area's specificity, thus removing many components which related to very small and specific areas with little relevance. We also eliminated items for which data collection required time/resources that were beyond the current project (sedimentation, compaction, grass, crops, hunting and fishing, animal husbandry, etc.). By eliminating these components we tried to keep the matrix in a simpler format while still analyzing enough information to properly quantify the environmental impact in the studied area (see table 1). On the other hand the rest of the data used in this study is compiled from different bibliographical sources, local and regional authority reports and author's previous studies (undergraduate work, master's thesis, scientific articles developed over the years).

Table 1. *Analyzed categories and components*

Physical and Geographical Components	Biological and Ecological Components	Sociological, Cultural and Land Use Components	Economical and Operational Components
Geological Substrate/ Mineral Resources	Trees	Land Use	Human Health and Safety
Soil	Bushes	Open Spaces and Wilderness	Unemployment Rate
Terrain Morphology	Aquatic Plants	Forests	Tourism
Water Quality	Birds	Pastures	Population Density
Surface Water	Terrestrial Animals and Reptiles	Farmland	Waste Storage
Air Quality	Fish and Crustaceans	Parks and Reservations	Transport Networks
Air Temperature	Ecological Corridors	Rare and Unique Species and Ecosystems	Utility Networks
Floods		Historical and Archaeological Sites / Objectives	Residential Areas
Torrential/Linear Erosion		Landscape Quality	Commercial Areas
Landslides		Green Spaces	Industrial Areas

In order to determine the environmental impact of each component analyzed, the fallowing formulas are used:

(A1) x (A2) = (At) (1);

(B1) + (B2) + (B3) = (Bt) (2);

(At) x (Bt) = (SE) (3); where SE is total evaluation score.

Finally, based on the evaluation scores and notes obtained (factorial and total) impact categories are created.

Graphical representation of impacts (sectorial and general) was done using ArcGIS 10 software, specifically with IDWIM - Inverse Distance Weight Interpolation Method. The method is based on the principle that the magnitude of the impact is directly proportional to the source location of impact. This method literally takes the concept of spatial autocorrelation, based on the presumption that the more a standard point is closer to the place to be determined, the value to be determined will be closer to standard point value (IDW - Spatial Analyst ArcGIS Resource Center).

This method is best suited when we apply it to a dense network of points, as in our case with 49 locations distributed over 420 square km. To further refine the results of this method each point is given a positive value, representing the hierarchical position within the conurbation. The highest value is assigned to the most powerful coordination center. By implementing this extra step the method generates maps that are more detailed and closer to reality. The overlap of different types of impact maps allows quick interpretation and retrieval of information.

Deva - Hunedoara conurbation is a bipolar structure located in central - western Romania. In the county of Hunedoara the conurbation is located at the confluence of Cerna and Mureş rivers (Zotic, 2007), at the contact the four major geographical units: in the north Apuseni Mountains with subdivision Metaliferi Mountains, in the west Poiana Ruscă Mountains, in the south the Haţegului Depression and in the east the Orăştiei hills (Dobrei, 2013).

Deva - Hunedoara conurbation is formed by the union of 49 settlements, 4 towns and 45 villages. From the administrative point of view these 49 settlements are divided into seven administrative units. The spatial and socio-economic evolution of the 49 settlements caused different environmental impacts, depending on the specific evolution and profile of each settlement.

The majority of environmental impacts are generated by industrial and economic activities, the vast majority of impacts being located in the industrial centers of Hunedoara and Călan. With more than 200 years of continued industrial activity and with increasing road and rail transit, the area experiences increasing levels of water, air and soil pollution (see table 2, 3 and 4).

Table 2. *Statistical data of Deva-Hunedoara conurbation*

Administrative Unit	Number of Settlements	Population in 2002	Administrative Surface (sq.km)	General Density (inh./sq.km)
Deva	5	69257	61.85	1119.75
Hunedoara	6	71257	104.05	684.83
Simeria	7	13895	48.59	285.96
Călan	13	13030	93.54	139.22
Băcia	4	1797	29.04	61.88
Peştişu Mic	9	1290	49.95	25.82
Cârjiţi	5	798	45.82	17.41
Conurbation Total	49	171324	432.84	395.81

Table 3. *Hierarchy of settlements in Deva-Hunedoara conurbation (Surd, 2003)*

Rank	Settlement
County Coordination Centers	Deva
Zonal Coordination Centers	Hunedoara
Local Coordination Centers	Simeria, Călan
Large Communal Coordination Centers	Cârjiţi, Peştişu Mic
Small Communal Coordination Centers	Sântuhalm, Bârcea Mică, Mânerău, Săuleşti, Sântandrei, Bârcea Mare, Uroi, Cărpiniş, Batiz, Nădăştia de Jos, Nădăştia de Sus, Sâncrai, Valea Sângeorgiului, Călanu Mic, Strei, Tâmpa, Valea Nandrului
Village Coordination Centers	Archia, Răcăştia, Boş, Hăşdat, Simeria Veche, Streisângeorgiu Strei-Săcel, Ohaba Streiului, Grid, Sântămăria de Piatră, Petreni, Almaşu Sec, Chergeş, Cozia, Popeşti, Almaşu Mic, Josani, Nandru
Isolated Village Coordination Centers	Totia, Groş, Dumbrava, Ciulpăz, Cutin

Table 4. *Classification and description of categories of environmental impact based on assessment scores*

Environmental Score	Impact Categories	Category Description
over +101	+E	Major Positive Changes / Impacts
+76 to +100	+D	Significant Positive Changes / Impacts
+51 to +75	+C	Moderate Positive Changes / Impacts
+26 to +50	+B	Positive Changes / Impacts
+1 to +25	+A	Slightly Positive Changes / Impacts
0	N	Lack Change of the Status Quo / Not Applicable
-1 to –25	-A	Slightly Negative Changes / Impacts
-26 to –50	-B	Negative Changes / Impacts
-51 to –75	-C	Moderate Negative Changes / Impacts
-76 to -100	-D	Significant Negative Changes / Impacts
under -101	-E	Major Negative Changes / Impacts

RESULTS

Score wise general results, after the application of the RIAM method, range from -181, in Călan, to +21, in Batiz. The vast majority of results, 40 out of 49, indicate negative impacts. All of the 9 positive impact results fall in to the category +A (Slightly Positive Changes / Impacts).All of the positive results are located in rural settlements where the past and present lifestyle of inhabitants coupled with the preservation of natural resources, lack of industrial activity and with general low human density generate a well preserved natural environment. As for the other results they are distributed across 4 impact classes: 31 results in Slightly Negative Changes / Impacts category, 6 results in Negative Changes / Impacts category, 1 result in Moderate Negative Changes / Impacts category and 2 results in Major Negative Changes / Impacts category. The majority of the negative results are generated by multiple factors, both internal and external to the analyzed location. Even if the majority of the results are recorded in –A category we cannot ignore the cumulative perspective and must be aware of the potential future growth of impact associated with the predicted socio-economic development of the conurbation.

Referring to the results in Physical and Geographical Components category we can identify 16 locations with a positive impact with scores ranging from +1 to +10 (Josani). In the negative impact category we obtained 33 results with scores ranging from -1 to -65 (Hunedoara). The very low score given to Hunedoara is a consequence of intense air, water and soil pollution of the area. Again we observe a clustering of the moderate negative impacts in the urban centers of Deva, Hunedoara and Călan were the impact of factors such as air quality, water quality and soil is significant. In general, many of the negative impacts from the –A class suggest one of the fallowing two scenarios: proximity to a stronger source of impact (with cumulative and dispersive effect) or a slightly negative impact in one of the analyzed components (air, water, soil, etc.). As for the limited number of positive impacts recorded they are a consequence of a general low human density and distance from major impact sources.

A similar trend is recorded in the Biological and Ecological Components category were 17 results indicated positive impacts from +3 to +43 (Deva), 26 results indicated negative impacts from – 1 to -15 (Călan) while 6 results were 0 (no change). The positive impact reported in Deva is a consequence of the many protected areas that have the role of ecological corridors (Dealul Cetăţii, Dealul Colţ, Pădurea Bejan). The lowest score is recorded in Călan and is a consequence of the low quality, quantity and diversity of biological components. Historic industrial pollution of the area also had an effect on the biological components drastically reducing the number of biological species that thrive in the area. The high number of result ranging from -3 to +3 (26) showcases the remarkable stability and resilience of the analyzed components. Opposite to other classes analyzed these results do not present any particular spatial clustering (figure 1).

In the Sociological, Cultural and Land Use Components category the recorded trend in results is reversed, 37 out of 49 locations have a positive score with the highest being +51 (Deva). Similar results are recorded in Hunedoara (+25) and Simeria (+33). Again, the lowest recorded result is in Călan (-28) and is a combined consequence of imbalanced Land Use, lack of forests, low overall Landscape Quality and lack of Historical and Archaeological Sites / Objectives and lack of Rare and Unique Species and Ecosystems. At the other end of the result scale in Deva the high score reflects the presence of many Unique Species and Ecosystems, Archaeological Sites and also a higher Landscape Quality. All of the +A class (+1 - +25) results (34) are located in rural areas and can be regarded as the result of a balanced land use, preservation of forests and pastures and the presence of vast open spaces.

As expected in the last category, Economical and Operational Components, the vast majority of results are in the negative scale (47 out of 49). This is due to intense urbanization and industrialization of the area which causes intense anthropogenic pressure on the analyzed components. The lowest score is recorded in Călan (-86) while the only two positive results are registered in Cîrjţi and Mânerău (+2). Major deficiencies in Waste Storage, Utility and Transport Networks, high Unemployment Rate, abandoned or poorly structured industrial areas are the cause of the high negative impact scores. Regarding the spatial distribution of these impacts we identified only one major clustering pattern which fallows the major transport corridors and incorporates the 4 urban centers and the villages located in the corridor (results from -16 to -86).

A much clear and suggestive analysis of the distribution of the total impact within the conurbation is shown after applying the IDWM. Thus we observe a clear clustering: significant negative, negative and moderate negative results tend to cluster along the Călan – Hunedoara – Peştişu Mare – Cristur – Deva alignment, slightly negative and slightly positive results on the other hand tend to occupy the western part of the territory on the Zlaşti, Peştişului, Nandrului and Cristurului valleys and in the eastern part on the Săuleşti – Simeria – Băcia – Petreni – Batiz alignment. We also observe several isolated locations with positive results that tend to form a cluster in the southern part of the conurbation: Nădăştia de Jos – Nădăştia de Sus – Strei – Ohaba Streiului – Grid (table 5).

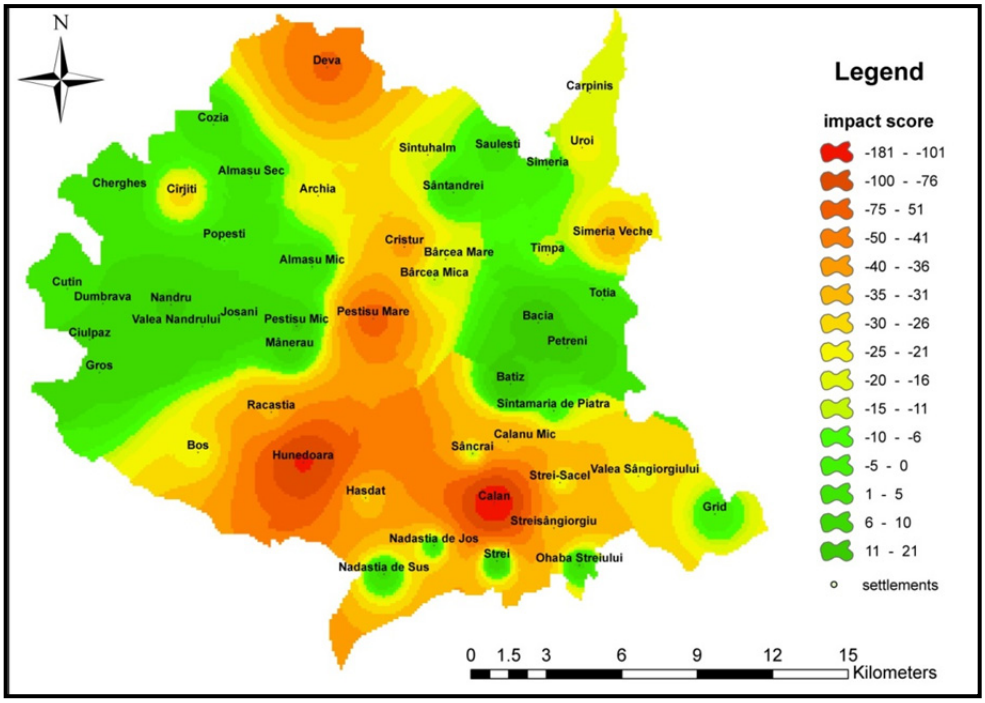

Fig. 1. *Environmental impact in Deva-Hunedoara conurbation – IDWM – preliminary results*

Table 5. *RIAM method - preliminary results*

Name	Physical and Geo-graphical	Biological and Ecological	Sociological, Cultural and Land Use	Economical and Operational	Total Impact Score	Total Impact Class
Deva	-59	+43	+51	-69	-34	-B
Hunedoara	-65	-4	+25	-57	-101	-E
Simeria	-17	+35	+33	-56	-5	-A
Călan	-52	-15	-28	-86	-181	-E
Almaşul Mic	+6	-4	+7	-12	-3	-A
Almaşul Sec	-13	+13	+9	-14	-5	-A
Archia	-9	-6	-3	-3	-21	-A
Băcia	-3	+4	+13	-3	+11	+A
Bârcea Mare	-5	+3	+12	-23	-13	-A
Bârcea Mică	-5	+3	+9	-19	-12	-A
Batiz	+3	+10	+19	-11	+21	+A
Boş	-12	+6	-4	-10	-20	-A
Călanu Mic	-3	-6	-1	-16	-26	-B
Cârjiţi	-3	-9	-6	+2	-16	-A
Cărpiniş	-18	+6	+6	-8	-14	-A
Chergheş	-5	+3	+4	-8	-6	-A

Ciulpăz	-7	-1	+10	-3	-1	-A
Cozia	-7	+3	+12	-12	-4	-A
Cristur	-9	0	-3	-11	-23	-A
Cutin	-10	-1	+10	-10	-11	-A
Dumbrava	-3	-1	+6	-6	-4	-A
Grid	-4	-3	+3	-7	-11	-A
Groş	-1	+3	+3	-6	-1	-A
Hăşdat	-18	+3	-2	-12	-29	-B
Josani	+10	-3	+9	-9	+7	+A
Mânerău	+3	0	-2	+2	+3	+A
Nădăştia de Jos	+9	-5	-4	-6	-6	-A
Nădăştia Sus	+6	-5	+4	-6	-1	-A
Nandru	+6	-2	+14	-10	+12	+A
Ohaba Streiului	+3	-3	+6	-8	-2	-A
Peştişu Mare	-17	0	-11	-31	-59	-C
Peştişu Mic	+9	-3	+9	-9	+6	+A
Petreni	+4	+9	+7	-8	+12	+A
Popeşti	-3	-3	+2	-6	-10	-A
Răcăştia	-16	+3	-9	-17	-39	-B
Sâncrai	-4	-3	+4	-9	-12	-A
Sântămăria de Piatră	-3	-8	+3	-5	-13	-A
Sântandrei	+2	0	+6	-12	-4	-A
Sântuhalm	+3	+3	+7	-26	-13	-A
Săuleşti	+1	+3	+8	-17	-5	-A
Simeria Veche	-13	-6	+6	-26	-39	-B
Strei	+2	-6	+11	-5	+5	+A
Strei-Săcel	-14	-3	+3	-6	-20	-A
Streisângeorgiu	-9	-6	-3	-10	-31	-B
Tâmpa	+3	0	+6	-22	-13	-A
Totia	-9	-8	+6	-3	-14	-A
Uroi	-15	0	+9	-10	-16	-A
Valea Nandrului	+7	-6	+12	-9	+4	+A
Valea Sângeorgiului	-3	-8	+3	-8	-16	-A

CONCLUSIONS

Conducting Environmental Impact Assessment studies with RIAM and IDWM combines flexibility with a powerful spatial interpolation method allowing the development of multiple impact scenarios with limited resources.

The flexibility offered by RIAM in choosing the components that are analyzed allows this method to be successfully applied to multiple areas of study. In our case this method provided satisfactory results combining the author's knowledge of the area with data gathered from local and regional authorities. Displaying the matrix in an electronic form (excel) offers multiple possibilities for extracting and interpolation and alteration of data, in order to create and validate impact scenarios.

The graphic representation done with IDWM further enhances the results obtained with RIAM by adding weight to the impact point. Maps created with this method are suggestive and easily understandable by both professionals and common folk alike.

The limitations of the method are well known and discussed and refer to the subjectivity of the person applying the method. Proposals to counter this fault include mitigation of results and interdisciplinary teams of local experts.

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STUDY ON TYPES OF SOIL DEGRADATION CAUSED BY FOREST EXPLOITATION

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ABSTRACT. Sustainable management and development of forest sector should become an essential element in the strategy of prevention of the degradation of the land of each state. The forests play an important role in debts settlement of water courses, in ensuring the water quality, in maintaining land stability including the erosion control, landslides or avalanches.

Forest exploitation represents a main source on degradation on the soil, having a major impact on the environment. Accelerated erosion caused by forest exploitation and soil degradation has become the main factor which limits the sustainable use of the soil. Through irrational forest exploitation, the nature of damage that occurs is ecological, social and economic. Forests are sours of other goods and services for society, such as processed wood and non-wood products, space of recreation, landscaping etc. The large number of sites affected as a result of the forest exploitation, emphasizes massive environmental risks and their existence without urgent action has a negative impact on human health and the environment.

Key words: *soil degradation, forest exploitation, sustainable environment*

INTRODUCTION

The forests play an important role in water flows adjustment, ensuring water quality and the protection of water sources for local communities without alternative sources of water resources. It is the case of forests situated in protected parameters of groundwater resource or surface water, forests and natural lakes located on the flanks and accumulation (Haynes and Naidu, 1998).

In all the places where the exploitation and the processing of some mineral resources are made, that is in the industry of exploitation and processing of wood, there also occurs some environmental issues which can be seen through: soil degradation, water and air pollution, the negative effect over terrestrial and aquatic ecosystems, over health population, but also socio-economical effects (Moțoc, 1983).

For all human communities or for natural ecosystems from the industry of exploitation and processing of wood, pollution and the risk do not occur with the end of the exploitation and processing of the useful mineral substances, but they continue their activity and the grounds remain at risk and pollution sources (Kinnell and Risse, 1998).

As Dîrja and Pepine (2008) say, inside a forest ecosystem, as a result of the negative action of the physical agents from the environment, but also of the anthropic ones, the initial physical and chemical characteristics of the soil may suffer important changes which have as a result the partial reduction, in some cases even total reduction, of its fertility. These degradation processes are classified by the nature of the factors and by the manner the agents act, as it seems: erosion processes, slips of the land, salinization and swamped processes.

From the study published by FAO in 2013, we can notice that the situation of the grounds which are seriously damaged by the forest exploitation, excessive pasture and the bad administration of the grounds is worrying.

There is estimated that more that 34% from the soil degradation is due to excessive pasture, 29,5% because of forest exploitation and 35% because of the bad administration of the soils.

There is imposed the necessity of a suitable evaluation of the relations between the patterns of spatial landscapes (landscapes and the composition of some necessary elements for landscapes) and the human processes (cutting off the forests, the degradation of the forests, forest exploitation and deforestation) which was emphasized during the last decades, especially concerning the global changes of the environment (Ferrier and Drielsma, 2010; Holmes et al., 2010; Liu and Taylor, 2002).

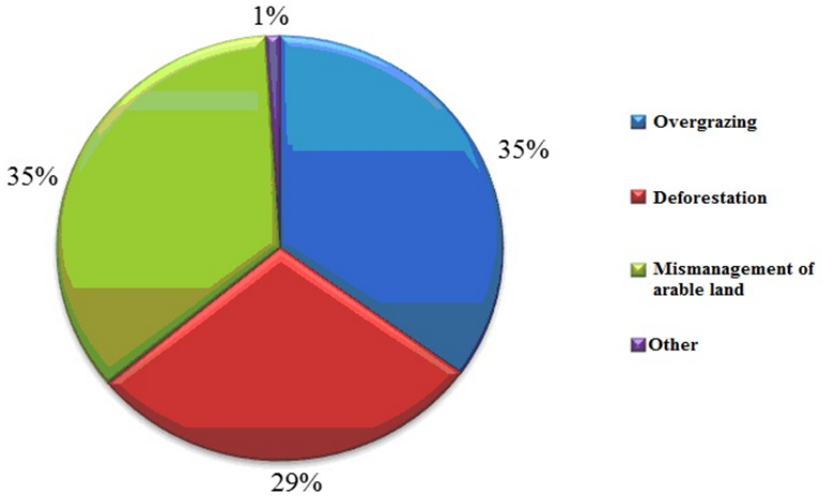

Fig. 1. *The major causes of soil degradation (http://ec.europa.eu/agriculture/envir/report/en/inter_en/report.htm#map3)*

Processes and forms of soil degradation in areas of forest exploitation

The main causes are deforestation, overgrazing, but also because of the inappropriate administration of the soil.

Currently, a very important thing that should be taken into consideration is the fact that if deforestations from the tropical areas still continue (with a broadcasting of carbon estimates to approximately 1.5 Pg/ a year), other positive flows from 1.8 to 2 PG C/ a year will be sequestered in terrestrial ecosystems.

The forms of soil degradation through forest exploitation are large enough and different, but they can be grouped with different criterions taken into consideration. In relation with the human activities, there are two big groups of processes:

- natural degradation processes where man is a conditional factor (pluvial erosion, wind erosion, slipping, swamping),
- anthropic degradation processes where man is accidental factor (compaction, repeated disturbing of grounds and pollution).

Inside of soil degradation process caused by forest exploitation takes place the destruction of soil and deterioration of its characteristics, presented in detail in table 1.

Table 1. *Processes of soil degradation in areas of forest exploitation (Forest magazine, no 2/2010)*

Processes of soil degradation in areas of forest exploitation	**Deterioration of soil characteristics**	*Physical*	➢ Destructuration ➢ Compaction ➢ Crusting; strengthening
		Chemical	➢ Soil acidification, acid drops ➢ Pollution (chemical) with fuel or emissions of machinery
		Biological	➢ Reduce the population of microorganisms ➢ Reducing population macro organisms and mezzo fauna ➢ Pollution pathogens (agents)
		Complex	➢ Excess water, swamped processes, salinization and alkaline of soil ➢ Desertification ➢ The exhaustion of fertility
	Soil destruction	*Dislocation*	➢ Water erosion ➢ Wind erosion ➢ Landslides ➢ Excavation
		Covering	➢ Soil coverage (soil clogging) with infertile sediments ➢ Soil coverage with waste wood
		Loss of land	➢ forest road construction induce land degradation

Cerdà et al. (2010) and García-Orenes et al. (2009, 2012) observed that Mediterranean areas had suffered changes in the land use which caused deforestations, exhaustion of organically material, erosion, soil degradation, salinization and crusting.

Many studies (Haines and Naidu, 1998, Kladivko et al., 2001; Kocyigit and Demirci, 2012) have showed that the administration of lands have a crucial influence upon chemical, physical and biological properties of the soil, mentioning that deforestations are not a reason for the scalping of a forest area with the purpose of obtaining an agricultural area.

Soil erosion is classified according to the climate, torrential degree, the equation of good classification of erosion which takes into account the determination of active, general and specified factors (climate agresivity, topographical factor, vegetation factor and the use of the soil and also the lithological factor) (Morgan and Quinton, 2001).

The factors which have an influence upon soil erosion can be grouped into two big categories: natural factors(climate factors- rains, temperature, winds/ soil factors- length, shape of the slopes, exhibition etc/ lithological factors- the nature of mother rock, the mixture of different rocks/ edaphic factors- texture, structure skelet composition) and anthropical or social-economical factors. Dîrja and Budiu, 2006; Toiy et al., 2002; Gobin et al., 2004; Eckelmann et al., 2006).

Mathematical modelling and determining the degree of soil erosion

Universal equation of soil erosion (Wischmeier and Smith, 1978; Patriche et al., 2006) estimated the amount of eroded soil based on six factors, according to the formula:

$$\mathbf{A=R \cdot K \cdot L \cdot S \cdot C \cdot P}$$

A = average annual soil loss
R = rainfall-runoff erosivity factor
K = soil erodibility factor
LS = slope length and steepness factor
C = cover management factor
P = support practice factor

USLE method tends to give higher results for the erosion in small measured values and low values for soil erosion with higher real values. In this case (Risse et al., 1993) the Initial USLE equation has changed, introducing new evidences for the account of soil erosion, so we have a new method of calculation, RUSLE.

The revised equation of calculation of soil erosion is composed of five factors according to equation.

$$\mathbf{A\ (t/ha/y) = R \cdot K \cdot LS \cdot C \cdot P}$$

Also there were achieved studies for calibrating these coefficients and their adaptation to local and regional environmental conditions for different areas of the world.

In Romania, this process was conducted by Research Institute for Soil (Moţoc et al., 1975), (ICPA, 1986).

The effects of soil degradation caused by forest exploitation

The importance of soil vegetation cover is particularly important to combat the degradation processes. The loss values of soil are decreasing from 28 to 2 t / ha * year, depending on the covered surface with vegetation, 90% of the absorbed water is oozed, representing 20-50 m^3 / ha / day for productive species, hardwood and softwood (Oroian, 2010).

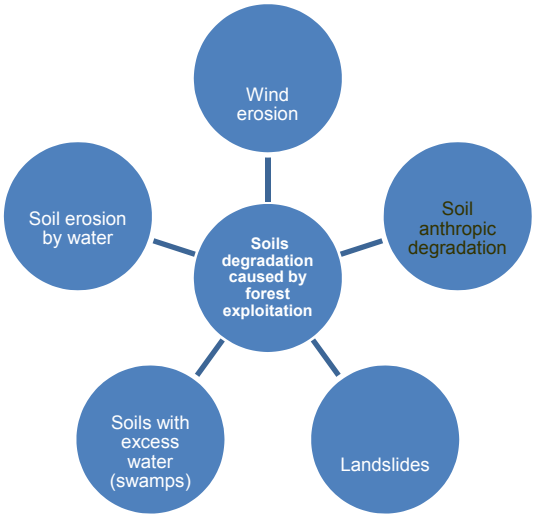

Fig. 2. *The main forms of soil degradation caused by forest exploitation*

Following this classification (Figure 2) we can say that the first four categories are concomitant after forestry in a certain area has been finished and the last and the worst that trains other types of soil degradation is where the soil has suffered major changes due to human action, namely land degraded by human activities.

The areas eroded by water can be: areas with surface erosion, revenant areas (revenant), torrential storehouses (river deposits).

The researches made in U.S.A show that the turbidity of water in the mountains from the west side of Virginia state has risen from 0.025 g / litter in the case of selective cutting to 56 g / litter in the case of the cutting on large surfaces.

The areas eroded by wind can be those areas with wind erosion of surface or wind storehouses, less met in the case of forest exploitation.

By rolling are transported bigger particles and laboratory researches have showed that the majority of soil particles (62-97%) are transported in the air up to 1 m height, by slaps like wind. In this way, the particles of 0.05-0.5 mm are transported. Big particles (0.5-2.0 mm), the heavier ones, are transported by rolling them to the surface of the ground without obstacles (vegetation, strictness's of the ground (Chepil, 1954).

The areas with too much water can be: with permanent access or prolonged and with periodic access, having to mention the fact that these areas can be seen in high places (bogs) but also in low places.

Degraded soil through the humidity excess are characterized by content at the surface but also in their water table which stop the normal functioning of plants and make the soil in an inappropriate condition to be working and cropped. (Kosmenko, 1956)

The excess moisture is more pronounced doubly so as the ratio of precipitation (P) and evapo-exudation (ETP), meaning the index of aridity - P / ETP is bigger than 1 (Dirja and Budiu, 2006) or it is met like notation the rate of soil wetting (Apetroaiei, 1977). High quantities of carbon are found in soils, especially in peat, wetland referred to permafrost compared with the atmosphere, by Davidson et al., 2006.

Displacement field (landslides) can be found in different forms: slippery soils, warehouses collapses, mudflows and rock deposits, deposits of debris (Lee and Lee, 2006).

One cycle of water erosion according to the definition has three phases (Dîrja and Budiu, 2006): detachment (dislocation), transport and deposition. During an extreme event, more than 100 $t \cdot ha^{-1}$ soil can be detached and transported, even if the loss of quantities of 2 to 40 $t \cdot ha^{-1}$ soil, indicates the beginning of erosion (Eckelman et al., 2006).

Fig. 3. *Deforestation causes landslide (http://scienceheathen.com/)*

Despite of technological improvements introduced in the 20th Century, the agricultural fields converted from forest land are the source with the most sediment in direct run-off waters (Cerda et al., 2007b).

According to a report by FAO in 2012 regarding forests and landslides, it was found that: the main cause of landslides in the mountains areas are logging with negative impact on soil and forest tree planting on susceptible down-grades can also reduce the risk of landslide, but it is not enough, because the fast-growing of tree planting and shrubs is more indicated, due to the fact of time of taking effect of retaining soil but also in terms of socio–economical problems.

Anthropic degraded lands are lands uncovered by layer of soil, land disturbed or dirt, artificial embankments, soil compaction, formation of ruts, roads etc.

Studies made by Jandal in 2007, Johnson in 1992 and Post and Kwon in 2003, concluded that the conversion of forest land that have been changed by compaction or production of ruts situations encountered in forestry, supposing that there were implemented ecological reconstruction measures, specifically afforestation, has noted an increase C storage in soil.

Fig. 4 . *Production of ruts (Forest magazine no. 3/2013)*

Soil degradation induces changes in the amount of organic carbon in forest topsoil, the estimated loss are 22% of soil organic carbon over 50 years, establishing through this aspect that arable land is a dynamic ecosystem that changes very quickly (Doetterl et al., 2012).

Based on the results from the current study and considering the fact that:

● According to some studies made by ICAS in 2014, water reservations are constantly supplied through infiltration. It is said that one ha of forest can retain at a soil level, in the first 50 cm, 1 450 m^3 of water (the equivalent of 145 mm of rain).

● Afforestation surfaces have the role of absorbing water (Untaru, 2010).

●The importance of soil vegetation cover is particularly important to combat the degradation processes. The loss values of soil are decreasing from 28 to 2 t / ha * year, depending on the covered surface with vegetation. 90% of the absorbed water is oozed, representing 20-50 m^3 / ha / day for productive species, hardwood and softwood (Coe et al., 2009, 2013; Costa et al., 2003; D'almeida et al., 2007; De Moraes et al., 2006; Lathuillière et al., 2012; Nepstad et al., 1994; Pongratz et al., 2011; Scanlon et al., 2007; Silvério, submitted, Oroian, 2010), therefore necessary to prevent the occurrence forms of degradation and remediation of degraded soils in areas forestry.

●The researches made in S.U.A show that the turbidity of water in the mountains from the west side of Virginia state has risen from 0.025 g / l in the case of selective cutting to 56 g / l in the case of the cutting on large surfaces (Harbek and Reinhart, 1964).

CONCLUSIONS

Analyzing the effects and degradation processes can be said that the impact of forest exploitation on the ground is a complex systemic phenomenon, lengthy, which manifests itself extensively on the landscapes in the area of forest exploitation requiring an extensive research of all the elements which contribute to appearance.

The main processes and forms of soil degradation after forest exploitation sometimes grows observe without being visible just after a few years. Mainly, the causes that favour these processes and the development of soil erosion are related to human activity - abusive exploitation, deforestation, destruction of grass carpet, forming roads, along favours the action of water and wind to destroy and remove large quantities of topsoil.

Knowing the consequences of enlargement for the protection of forest soils erosion processes is very important human activity, in terms of systematization of forest cultures, choosing exploitation area of forest use technological system of forest resources management and sustainable development.

It requires ecological restoration of degraded lands by forest exploitation or affected by various factors natural restrictive (climate, topography, edaphically conditions) or human, due to wasteful use of land or under the influence industry of exploitation and wood processing through processes degradation.

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ASSESSMENT OF THE TRANSFER PHENOMENA FOR HEAVY METALS IN A FRESHWATER ECOSYSTEM: A FIELD STUDY

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ABSTRACT. Increasingly higher concentrations of heavy metals in aquatic environments pose a major risk to living organisms, as a result of their bioaccumulation and toxicity. For the assessment of the bioaccumulation and trophic transfer, samples of water, sediments, aquatic plants (*Ceratophyllum demersum, Potamogeton crispus* and *Spirogyra algae*), molluscs (*Viviparus viviparus*) and fish (*Ameiurus nebulosus* and *Scardinius erythrophthalmus*) have been collected from Plumbuita Lake, located in a highly urbanized area of Bucharest city (Romania). After bringing the samples in solution, the following heavy metals have been determined using a spectrophotometer with atomic absorption - ContrAA 700 (Analytikjena): copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb) and nickel (Ni). The distribution of heavy metals in the aqueous and solid phase for the collected samples has been assessed using their bioaccumulation factors in relation to water and sediments. For the molluscs species, metal determinations have been performed separately both for the soft tissue and for the shells, revealing that the soft tissue is more effective in accumulation of heavy metals compared to the shell.

Key words: *heavy metals, Plumbuita Lake, bioaccumulation*

INTRODUCTION

The development of technology and industry, along with global population growth has led to a critical problem concerning the fate of the environment as a result of new challenges (Adams, 2014; Resetar-Deac and Diacu, 2015). Deterioration of freshwater habitats occurs much faster than of terrestrial and marine habitats, since the density of the human population is much higher in their proximity and the interdependence of organisms and aquatic environment is much closer for aquatic organisms than for terrestrial (Cieszynska et al., 2012).

One of the strongest threats to the biodiversity of aquatic ecosystems is the metal contamination (Kibria et al., 2016). At the aquatic ecosystem metals are differently distributed among the aqueous phase, suspended matter and sediments through various mechanisms (Islam, 2015; Maria et al., 2013; Radu et al., 2015).

As a result of their toxicity, persistence and tendency to bioaccumulate, heavy metals representd a major environmental health problem (Islam et al., 2015; Li et al., 2016; Radu et al., 2016).

Some metals such as chromium, zinc and copper play an essential role in carrying out all the biochemical and energetic changes with a role in the living tissues, while others such as mercury, cadmium and lead are highly toxic even at very low concentrations, causing numerous health problems (Deák et al., 2015; Mohammadizadeh et al., 2016).

Numerous studies have confirmed that the metals accumulate along the aquatic food chain, reason for which consumption of contaminated fish presents a potential risk to human health, as demonstrated by studies regarding metal concentration in their eatable part (muscle) (Benhamed et al., 2016). In order to obtain an integrated image with respect to the bioavailability of metals, an alternative to physico-chemical measurements for the monitoring of environmental compartments (water/sediment) is the quantification of concentrations of metals in the tissue of the aquatic species (De Jonge et al., 2015). Bioaccumulation of metals in fish and shellfish species may have much higher concentrations compared to their environment (El-Moselhy et al., 2014).

Checking and maintaining contaminants to acceptable levels in terms of toxicity is essential to protect public health. The effects of heavy metal pollution on the human body are extremely serious, in the EU legislation quality standards being set for the content of these metals in the flesh of fish: mercury (0.50 mg/kg), cadmium (0.05 mg/Kg) and lead (0.30 mg/kg) (Commission Regulation (EC) 1881, 2006). Municipality of Bucharest (Romania) is crossed by lakes formed along the Colentina River, one of them being the Plumbuita Lake, in the vicinity of which many constructions with inadequate infrastructure were developed, representing a potential risk to water quality.

The present study was conducted to highlight the levels of heavy metals (Pb, Cd, Cr, Cu, Ni) in water, sediments, aquatic plants (*Ceratophyllum demersum, Potamogeton crispus* and *Spirogyra algae*), molluscs (*Viviparus viviparus*) and fish (*Ameiurus nebulosus* and *Scardinius erythrophthalmus*) from Plumbuita Lake.

MATERIALS AND METHODS

Study area

To characterize the process of transferring heavy metal abiotic compartment to biotic compartment, a sampling campaign for collecting water, sediment, aquatic plants and fish samples from the Plumbuita Lake was organized in June 2015. Water and sediment samples were taken from three locations (L1, L2 and L3) shown in figure 1 (Ionescu et al., 2016).

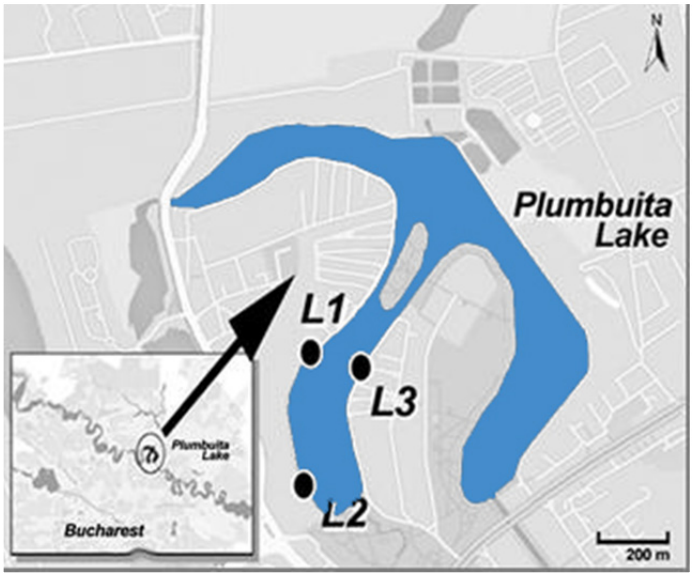


Fig. 1. *Map of study area with sampling locations*

Sampling and Sample treatment

Water samples were collected from about 50 cm below the water surface in polyethylene bottles decontaminated beforehand with nitric acid solution and then rinsed with distilled water (ISO 5667, 2000). To determine the total metal concentration, a volume of 250 mL taken from the test water was acidified to prevent hydrolysis of the metals by adding 0.5 mL of HNO_3 (65%) in it (ISO 8288, 2001).

Sediment samples were collected in polyethylene bottles, washed with detergent and rinsed with distilled water using the core sampler. Approximately 0.5 g of dry sediment sample (fraction <63 μm) was digested with aqua regia (9 mL HCl (37%) and 3 mL HNO_3 (65%)).

Samples of plants (*Ceratophyllum demersum, Potamogeton crispus* and *Spirogyra algae*) were rinsed in double distilled water to remove any traces of powder immediately after being collected, then they were left at room temperature for several days to evaporate the excess of water.

After being collected, the fish samples (*Ameiurus nebulosus* and *Scardinius erythrophthalmus*) and molluscs (*Viviparus viviparus*) were also rinsed in double distilled water to remove impurities, then the fish were dissected carefully removing scales and bones, preserving only the muscle tissue, while for molluscs, the soft tissue was separated from the shells.

Drying of the biota samples to constant weight was carried out by using a laboratory oven set at 80 ^{0}C. After drying, the samples were homogenized by grinding in an agate and kept in sterile vessels in the refrigerator until mineralization.

For digestion, approximately 0.5 g of dry sample were separated, to which 9 mL of 65% nitric acid (Suprapur) was added for the mineralization of samples of aquatic plants and a mixture of 7 mL of 65% nitric acid (Suprapur) and 1 mL of 30% hydrogen peroxide (Suprapur) was added to the samples of fish and molluscs for their mineralization. Microwave digestion system (Ethos 1, Milestone) equipped with a temperature and pressure control was used to digest the samples.

Analysis procedure

After bringing all the samples in solution, for determining the heavy metals (Pb, Cd, Cr, Cu and Ni), a High-Resolution Continuum Source Atomic Absorption Spectrometer - ContrAA 700 was used. All solutions for calibration, samples, and rinsing were prepared using ultrapure water and Suprapur nitric acid (65 %). The stock solutions were prepared using ultrapure water, obtained through a Micropure Ultrapure water system (TKA, Germany).

Bioaccumulation factor (BAF)

The bioaccumulation and trophic transfer assessment was performed by the calculation of the bioaccumulation factor in relation to concentration of water (BAFw) and in relation to the concentration of sediment (BAFs) (Islam et al., 2015; Uysal et al., 2009), as in ecuatin 1.1 and 1.2.

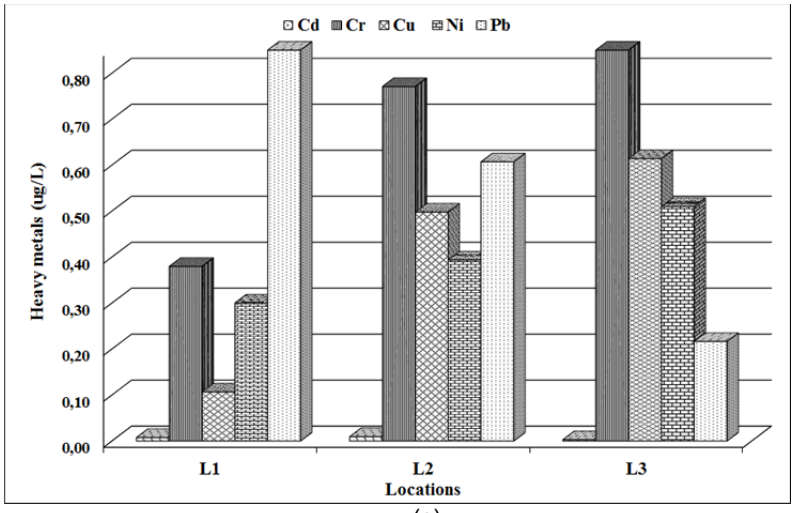
$$BAF_w = \frac{C_{biota\ samples}}{C_w} \tag{1.1}$$

$$BAF_s = \frac{C_{biota\ samples}}{C_s} \tag{1.2}$$

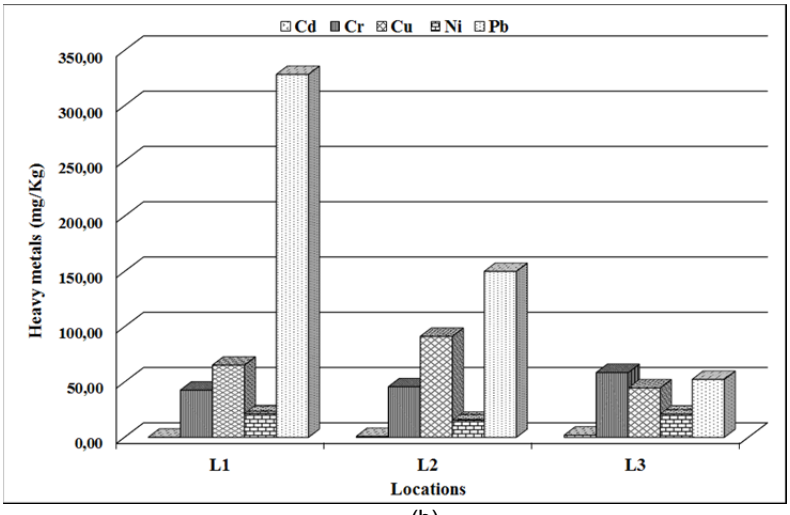
$C_{biota\ samples}$ - the concentration of the heavy metals in biota samples (mg/Kg, dry weight);
C_w - the concentration of the heavy metals in water (mg/L);
C_s - the concentration of the heavy metals in sediment (mg/Kg, dry weight).

RESULTS AND DISCUSSION

Figure 2 presents the variations of metal concentrations in the examined water samples (Fig. 2.a) and in the sediment samples (Fig. 2.b) taken from three selected locations of Plumbuita Lake. After reporting the concentration values determined for heavy metals mentioned in the national legislation (Ministerial Order no. 161, 2006), all recorded values were classified as class I quality for water samples, while sediment samples exceeded the standard of chemical quality for the L2 and L3 sampling locations regarding Cd, for all three sampling locations regarding Cu and for L2 and L3 sampling locations for Pb.



(a)

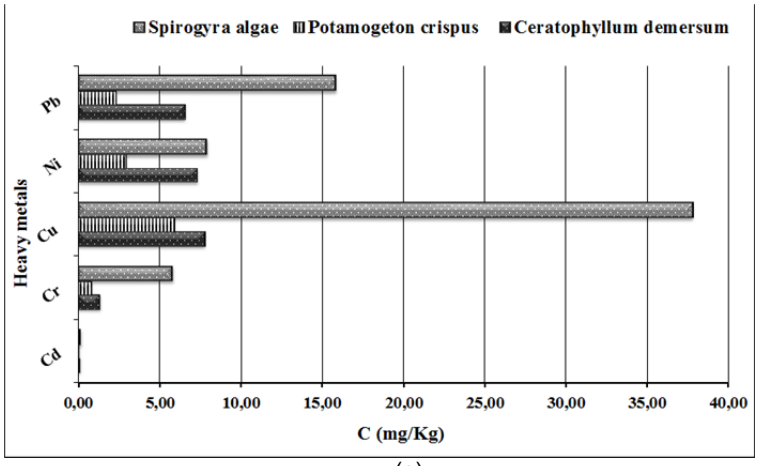


(b)

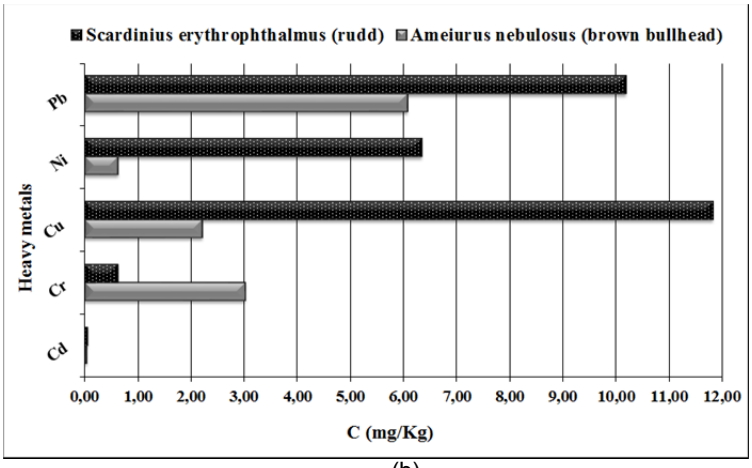
Fig. 2. *Dinamics of heavy metal variation in water (a) and sediment (b) samples*

Figure 3 show the variations in metal concentrations for three species of aquatic plants (Fig. 3.a) and for two fish species (Fig. 3.b) sampled from Plumbuita Lake. Following the graphics, it was found that the samples *Spirogyra algae* (spirogyra) recorded the highest concentrations of metals and in the case of fish species, *Scardinius erythrophthalmus* (rudd) revealed the highest concentrations of Pb, Ni and Cu, while for *Ameiurus nebulosus* (brown bullhead) higher concentrations were recorded for Pb.

Through a comparative analysis of the determined values for heavy metals in fish fillets, with permissible limits laid down in Regulation EC No 1881/2006, it was observed that the values obtained for Cd do not exceed the limit specified by the Directive, while Pb exceeded the limits.



(a)



(b)

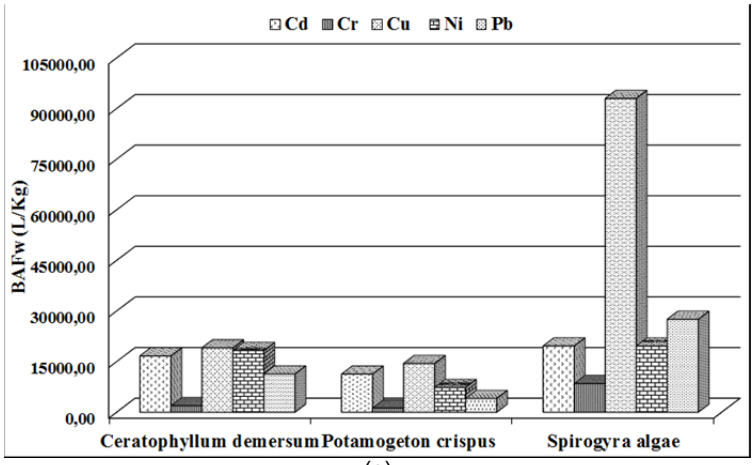
Fig. 3. *Dinamics of heavy metal variation in the three species of aquatic plants (a) and two fish species (b) analized*

Figure 4 shows the variation of bioaccumulation of heavy metals in plants as compared to water (Fig. 4.a) and to sediments (Fig. 4.b).

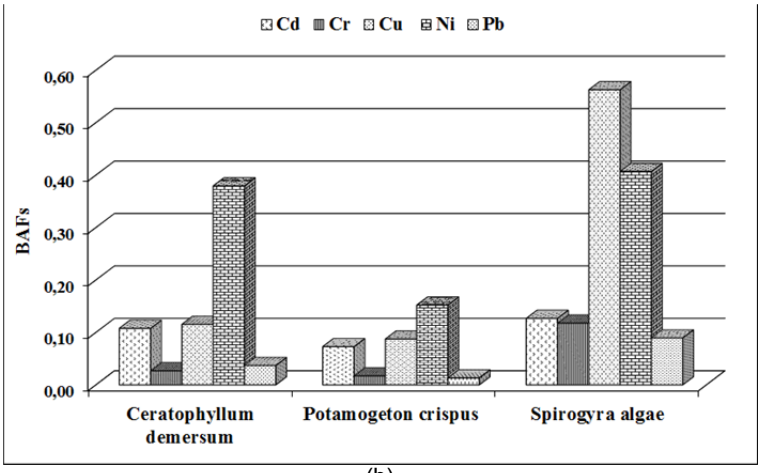
From the comparative analysis of the bioaccumulation factor in relation to water (BCF_w) of the three species of aquatic plants, it was found that the species *Spirogyra algae* presents the highest capacity to accumulate heavy metals in the

following order: Cu > Pb > Cd > Ni > Cr, followed by the species *Ceratophyllum demersum*: Cu > Ni > Cd > Pb > Cr and finally *Potamogeton crispus* presenting the following accumulation order of heavy metals: Cu > Cd > Ni > Pb > Cr.

In a similar way, for the comparison of heavy metal bioaccumulation factor in relation to the sediments (BCF_s), the order of aquatic plants species to accumulate heavy metals resembles the case of BCF_w, but the heavy metals are absorbed in a different manner by the plants. For *Spirogyra algae* the following order was found: Cu > Ni > Cd > Cr > Pb, for *Ceratophyllum demersum*: Ni > Cu > Cd > Pb > Cr and for *Potamogeton crispus* the bioaccumulation trend was the following: Ni > Cu > Cd > Cr > Pb.



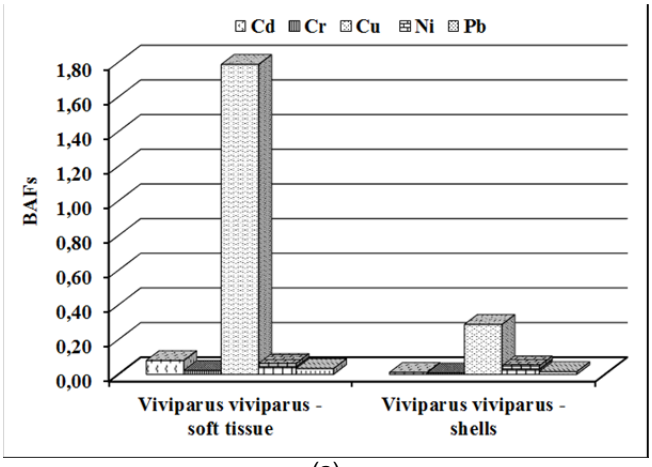
(a)



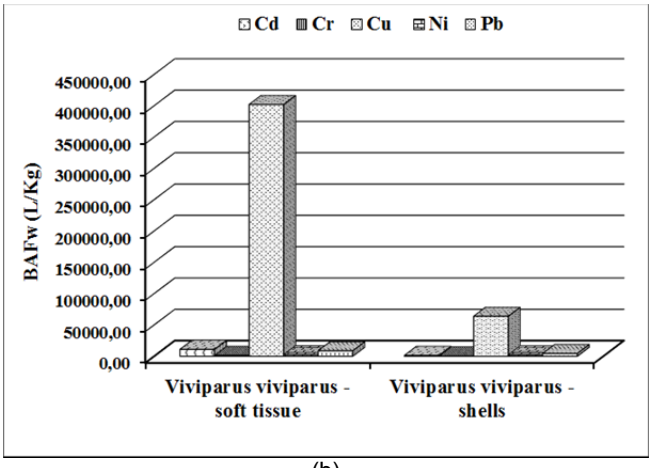
(b)

Fig. 4. *Bioaccumulation factors of heavy metals in plants as compared to water (a) and to sediments (b)*

From the two analysis we concluded that the absorbtion of Cu was higher in the aquatic plants than in the water. In relation to sediments, the aquatic plants have a higher accumulation for Cu and Ni than for the rest of the analyzed heavy metals. Within the analyzed species of molluscs (*Viviparus viviparus*), the recorded values for heavy metals in the soft tissue and shells were higher for both BCF_w and BCF_s in the case of Cu, concluding that this species of molluscs have a tendency to accumulate Cu in the body. Also, after comparing the bioaccumulation factor values it was revealed that soft tissue presents a greater biacumulation rate of the analyzed metals compared to their shell (figure 5).



(a)

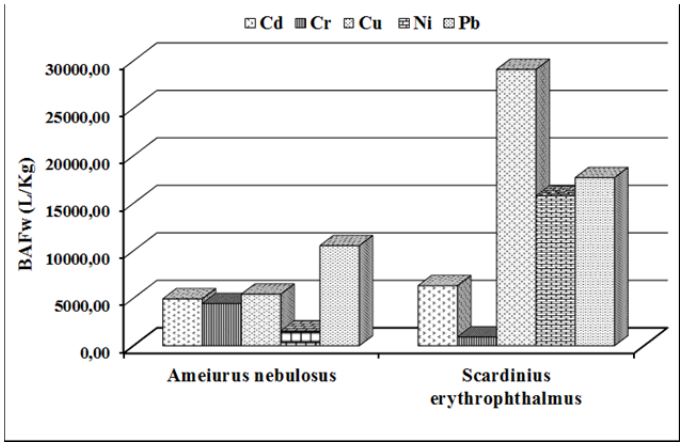


(b)

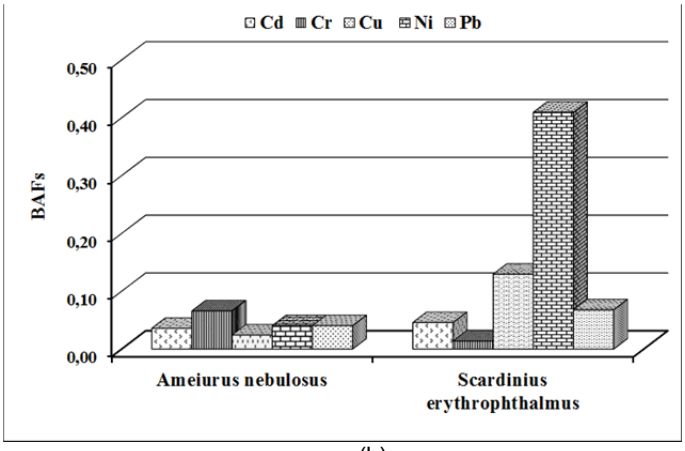
Fig. 5. *Bioaccumulation factors of metals in species Viviparus viviparus for soft tissue and shells as compared to water (a) and to sediments (b)*

Also, for metals analyzed from muscle tissue of both fish species (*Ameiurus nebulosus* and *Scardinius erythrophthalmus*) BCF_w and BCF_s were calculated and the results are shown in figure 6.

By analyzing the graphs obtained for the two fish species (brown bullhead and rudd) it can be concluded that the species of rudd (*Scardinius erythrophthalmus*) has a higher tendency to accumulate Cu and Pb in relation to the concentrations of these metals in water and in comparison to the concentrations of metals in sediments, a higher bioaccumulation rate was found for Ni and Cu. For the species of brown bullhead (*Ameiurus nebulosus*) the values of bioaccumulation factors succeeded in following order: Pb > Cu > Cd > Cr > Ni as compared to the values in the water, as for BCFs the maximum value was recorded for Cr, while the minimum for Cu, and for the metals: Cd, Ni and Pb, roughly equal values were recorded for BCFs.



(a)



(b)

Fig. 6. *Bioaccumulation factors of heavy metals in fish species biota-water (a) and biota-sediments (b)*

CONCLUSIONS

In this paper, concentrations of heavy metals (Pb, Cd, Cu, Ni and Cr) were determined in water, sediments and biota in order to study the phenomenon of transferring them to the freshwater ecosystem.

Metal concentrations determined in water samples taken from the three selected locations on Plumbuita Lake witin the Municipality of Bucharest were low compared to the national legislation (Ministerial Order no. 161, 2006), falling below the first grade of quality, while for sediment samples the recorded values exceeded their chemical quality standards for Cd, Cu and Pb.

For the two species of fish caught in the lake, *Ameiurus nebulosus* (brown bullhead) and *Scardinius erythrophthalmus* (rudd), no exceedances of the limit of 0.05 mg/kg for cadmium required under applicable law (the EC Regulation 1881/2006) were recorded, while the limit of 0.30 mg/kg required for lead was overcome by both analyzed fish species.

From the comparative analysis of the bioaccumulation factor in relation to water (BCF_w) and the bioaccumulation factor in relation to sediments (BCF_s) of the three analyzed species of aquatic plants, it was found that they posess the ability to accumulate metals in the following order: *Spirogyra algae* > *Ceratophyllum demersum* > *Potamogeton crispus*, generally with a higher bioaccumulation affinity for Cu, Cd and Pb from water and Cu and Ni from sediments.

For the analyzed species of molluscs (*Viviparus viviparus)* it was found that the soft tissue presents a higher degree of bioaccumulation of metals compared to the shell.

As a result of the analysis of heavy metals in the muscle tissue of the two species of fish *Ameiurus nebulosus* (brown bullhead) and *Scardinius erythrophthalmus* (rudd) it was found that both species have a higher tendency to bioaccumulate Cu and Ni as compared to other metals.

In conclusion, regardless of the heavy metal analyzed in the plant or animal tissue, when surveyed, BCF values are higher in the water column, indicating that the bioaccumulation of heavy metals (bioconcentration, bioaccumulation) by biota has a higher share on the following trajectory: water - tissue than the corresponding trajectory sediment - tissue.

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(RECOMMENDED CITATION)

SEISMIC RISK ASSESSMENT FOR LARGE ROMANIAN DAMS ON BISTRITA AND SIRET RIVERS AND THEIR TRIBUTARIES

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ABSTRACT. The most important specific requirements towards dams' safety is the seismic risk assessment. This objective will be accomplished by rating the dams into seismic risk classes using the theory of Bureau and Ballentine, 2002, and Bureau (2003), taking into account the maximum expected peak ground motions at dams' site, the structures vulnerability and the downstream risk characteristics. The maximum expected values for ground motions at dams' site have been obtained using probabilistic seismic hazard assessment approaches (PSHA) for dams situated on Bistrita and Siret Rivers and their tributaries. The structural vulnerability was obtained from dams' characteristics (age, high, water volume) and the downstream risk was assessed taking into account human, economical, touristic, historic and cultural heritage from the areas that might be flooded in the case of a dam failure. The results of the work consist of local and regional seismic information, specific characteristics and locations of dams, seismic hazard values and risk classes, for all sites. The studies realized in this paper have as final goal to provide in the near future the local emergency services with warnings of a potential dam failure and ensuing flood as a result of a large earthquake occurrence, allowing further public training for evacuation.

Key words: *earthquake, seismic hazard, risk classes, ground motion, dams*

INTRODUCTION

Not only humans but also dams are getting older. Dams, as all other constructions and infrastructures, are subject of ageing processes. The average age of Romania's 250 large dams tabulated in the Romanian Register of Large Dams (RRMB) from a total of 2617 permanent and temporary dams, is 40 years (http://www.baraje.ro/rrmb/rrmb_idx.htm). In Romania there are 3 dams more than 100 years old. The oldest one (111 years old), Sadu II, Sibiu, was put into operation in 1905, and is a small 18 m high gravity dam. More than 100 dams are in the immediate vicinity of populated areas, like the Morii Dam on Dambovita River in the Western part of Bucharest, the capital of Romania.

On Bistrita and Siret rivers, situated in the North - Eastern part of Romania, Moldavia Region, there are 22 large dams, built after 1960. Izvorul Muntelui dam (Bistrita river, very close to the city of Bicaz) is the largest one, with h=127 m and V lake=1230hm^3.

Although dams are built by following specific design and engineering rules regarding structural strength, serious dam accidents have occurred in the world, and also in Romania, in 1991 on Belci dam (Fig. 1 and 2) situated on Tazlau river that flows into Trotus river a tributary of Siret.

Fig. 1. *Belci dam, on Tazlau river, near Onesti city, Bacau county, Romania (Photo by Constantin Cristache, INCDFP, Romania)*

The story of Belci dam disaster is as follows:

During the night of 28th to 29th of July, 1991, torrential rainfall fell in the Tazlău river basin, with an unusual nature (between 95 l / m² and 150 l / m² in half an hour) that caused a flood wave of almost 7 meters tall near Belci dam, Bacau County (Diacon et al., 1992). Downstream Belci dam's micro-hydropower plant was stopped during that night due to a technical failure. Therefore it was stopped also the power supply for the dam's mechanisms.

Fig. 2. *The left bank of the Belci dam (Photo by Constantin Cristache, INCDFP, Romania)*

The water level in the lake increased very quickly, so that at 2:15 AM the water level reached the crest and started overflow the earth dam. Around 4:50 appeared an increase in the downstream flow at about 1,800 m³/s, which led to the collapse of the dam. At 7:15 the lake was almost empty, and at 7:50 Tazlău river flowed through a fairway formed in the lake's alluvial deposits and passed downstream through a gap formed in the left bank of the earth dam (Figure 4). Maximum flow of the flood on the river Tazlău from 28th to 29th July 1991 was 3,100 cm/s (http://www.hidroconstructia.com/dyn/2pub/proiecte_det.php?id=112&pg=9). That summer morning, Slobozia, the little town downstream from the dam was flooded, 25 people died and 250 homes were destroyed.

These kind of events have occurred all over the globe, despite of the great attention paid to constructions behavior monitoring, due to various causes like acts of terrorism, dam structural problems, different errors during the exploitations or natural disasters such as: huge storms and associated runoff and flood events, slope failures, or earthquakes and landslides. Dams fracturing and collapsing in the last decades have caused thousands of casualties Worldwide, losses of hundreds of billions of dollars and destroying of entire downstream villages. ***The main mission of many international agencies and organizations is "To protect people against loss of life and property from dam failure."***

The present work, financed by UEFISCDI (Romania) PCCA 2013 Program, Project DARING 69/2014, is a step toward downstream safety assurance in the Eastern part of Romania. The paper will deal with probabilistic seismic hazard assessment in dams' sites, structure vulnerability and downstream risk evaluation, having as final goal the seismic risk rating of all 22 studied dams on Bistrita and Siret river and their tributaries.

METHODOLOGY FOR DAMS' RATING INTO SEISMIC RISK CLASSES

The methodology used in this paper offers a way to evaluate the most vulnerable hydro-technical facilities among the multitude of dams existing in a country that could be affected by crustal-depth or intermediate-depth earthquakes. Various risk factors and weighting points can be used to approximately quantify the Total Risk Factor (TRF) of any dam (Bureau and Ballentine, 2002 and Bureau, 2003). The TRF depends on the dam structure characteristics, the downstream risk potential, and the dam vulnerability.

This procedure can be used to quickly asses the potentially most vulnerable facilities in a large dam inventory. The risk classification based on the TRF, provides guidance to dam safety officials to select appropriate evaluation procedure and to assign priorities for seismic safety evaluation of the most critical dams.

The TRF is expressed as:

$$TRF = [(CRF + HRF + ARF) + DHF] \times PDF \quad (1)$$

The dam structure influence is represented by the sum of capacity, height, and age risk factors (CRF + HRF + ARF). **The downstream hazard factor** (DHF) is based on population and property exposed at risk. **The vulnerability rating** is a function of the site-dependent seismic hazard and observed performance of similar dams, as defined by a predicted damage factor (PDF).

Dam structure Influence

There are three factors quantifying the risk of a dam and its reservoir:

1. The capacity risk factor (CRF) and the height risk factor (HRF) – that indicate that high dams or large reservoirs can cause significant flooding and an increased – Table 1.

Table 1. *Definition of capacity and height risk factors (Bureau and Ballentine, 2002)*

Risk factor	Contribution to the total risk			
	Extreme	**High**	**Moderate**	**Reduced**
Capacity (m^3)/**CRF**	>61.673.500/**6**	61.673.500-1.233.470/**4**	1.233.470-123.347/**2**	<123.347/**0**
Height (m)/**HRF**	>24,38/**6**	24,38-12,192/**4**	12,192-6,1/**2**	<6,1/**0**

2. The age rating factor (ARF) expresses that old dams are often more vulnerable than modern dams because of possible deterioration, lack of maintenance, use of obsolete modes of construction (concrete masonry or hydraulic fill), insufficient compaction, reservoir siltation, or insufficient foundation treatment (Bureau and Ballentine, 2002) – Table 2.

Table 2. *Definition of dam age risk factor (Bureau and Ballentine, 2002)*

Dam's age	<1900	1900-1925	1925-1950	1950-1975	1975-2000	>2000
ARF	6	5	4	3	2	1

Downstream Risk

The overall downstream hazard factor (DHF) is defined as:

$$DHF = ERF + DRI \quad (2)$$

The downstream evacuation requirements factor (ERF) depends on the human population exposed at risk. The downstream damage risk index (DRI) is based on the value of private, commercial, industrial, or government property in the potential flood path (Table 3). These factors should preferably be obtained from a combination of detailed dam breach, inundation mapping, and economic studies. The DHF should be updated whenever new information becomes available or when the dam is repaired, modified, or raised.

Table 3. *Definition of downstream risk factor DHF (Bureau and Ballentine, 2002)*

Risk factor	**Contribution toTRF (share)**			
	extreme	**high**	**moderate**	**reduced**
No. of people/ **ERF**	>1000/12	1000-100/8	100-1/4	0/1
DRI	high/12	moderate/8	reduced/4	none/1

Seismic Vulnerability Rating

Dam vulnerability curves developed by Bureau and Ballentine, 2002 from observed seismic performance of dams during earthquakes can be used to compute a predicted damage index (PDI). The PDI depends on the dam type and on the site seismic hazard and tectonic environment (Froehlich, 2008). The expected ground motion at the dam site for the scenario earthquake considered is expressed by the earthquake severity index (ESI), a robust estimate of the severity of shaking for dam evaluation purposes (Bureau, 2003).

The ESI is expressed as:

$$ESI=PGA*(M-4.5)^3 \quad (3)$$

Where: PGA is measured in *g*, M is the Richter or moment magnitude (*Mw,* if available) of the causative event.

The PDI depends on the ESI at each dam site, for each postulated earthquake scenario, and is obtained from graphical relationships shown in Fig. 3.

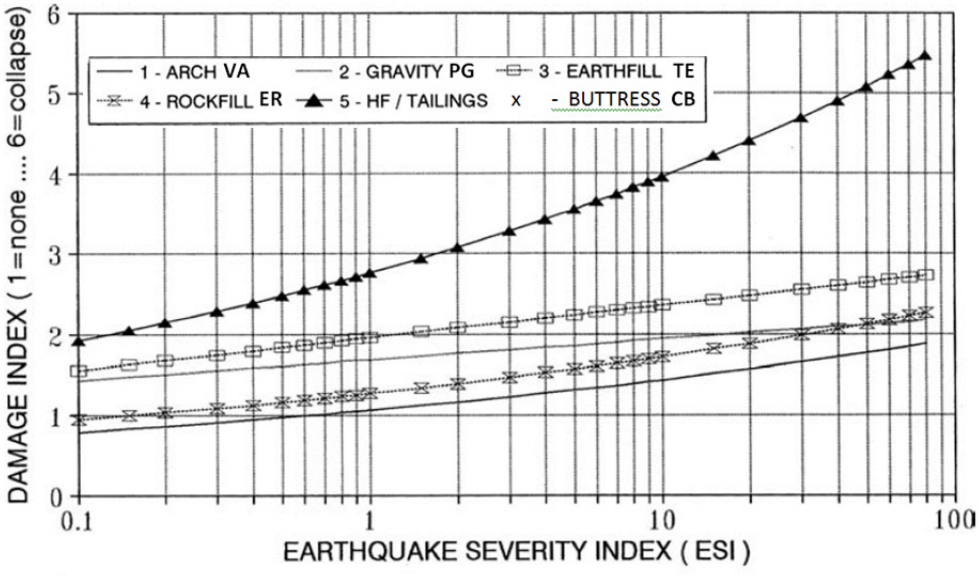

Fig. 3. *Dams' vulnerability curves*

The PDI rates only the relative vulnerability of each dam type, and includes a significant uncertainty, especially when extrapolated to large ESI values, which can be quantified from the standard deviations associated with the mean estimates.

Curve 1 corresponds to the dam's "Arc" type, curve 2 to "gravitational"-weight type, curve 3 to "earth filling" type, curve 4 corresponds to the embankment dams and curve 5 to the so-called hydraulic filled dams (hydraulic fill - HF). It appears that the most vulnerable are those of HF type (hydraulic fill), while "Arc" type dams had the best performance, but conclusions were drawn from a limited number of data. There are no information about buttress dams (CB) and we have used curve 3 for this type of dams.

As is well known, hydraulic fill and tailings dams are clearly the most severely affected, based on historic experience. Arch dams have performed best but the corresponding data are limited. From the graphical obtained PDI, a Predicted Damage Factor (PDF) is assigned to each dam, as defined by the equation (4):

$$PDF=2.5*PDI \tag{4}$$

After obtaining all risk factors (CRF, HRF, ARF, DHF and PDF), The TRF can be computed using Eq. 1. The last step of the assessment is to rank the dams by TRF and assign to each a Risk Class ranging from I (low risk) to IV (extreme risk), as shown in Table 4.

Table 4. *Definition of Dam Risk Classes*

TRF	Dam's risk class
2-25	I (reduced)
25-125	II (moderate)
125-250	III (high)
>250	IV (extreme)

The vulnerability and risk ranking of all Romanian dams (more than 250), was compiled in that way during the fulfilment of several National Projects. In this paper we will present the case of 22 large dams situated on Bistrita and Siret rivers, situated in the North - Eastern part of Romania, Moldavia Region.

RANKING LARGE DAMS ON BISTRITA AND SIRET RIVERS IN SEISMIC RISK CLASSES

The main source of information about studied dams was Romanian Register of Large Dams (RRMB) that contains information in Excell format regarding commissioning year, dimensions, characteristics, etc. for 249 dams in Romania. The information in RRMB were completed with existing information from Ro Water site (http://www.rowater.ro/dasiret/default.aspx). Table 5 and Fig. 4 present the 22 dams on Bistrita and Siret rivers and their tributaries.

Table 5. *Dams characteristics (Dams type is defined in Fig.3)*

Dam No.	Dam	Long	Lat	River	County	Year PIF	Type
1	ANTOHESTI	27.2381	46.5514	Berheci	Bacau	1984	TE
2	BACAU	26.9283	46.5573	Bistrita	Bacau	1966	PG/TE
3	BACAU	26.9235	46.5741	Bistrita	Bacau	1966	PG/TE
4	BELCI	26.7647	46.2882	Tazlau	Bacau	1963	PG/TE
5	BERESTI/ ROGOAZA	27.1860	46.1852	Siret	Bacau	1985	PG/TE
6	CALIMANESTI SIRET	27.2469	45.9486	Siret	Galati	1992	PG/TE
7	COSMESTI POD	27.3046	45.8578	Siret	Galati	2015	PG/TE
8	GALBENI	26.9569	46.4544	Siret	Bacau	1983	PG/TE
9	GARLENI	26.9549	46.6784	Bistrita	Bacau	1965	PG/TE
10	IZVORUL MUNTELUI	26.1030	46.9380	Bistrita	Neamt	1961	PG
11	LILIECI	26.8869	46.6306	Bistrita	Bacau	1965	PG/TE
12	MOVILENI	27.3430	45.7831	Siret	Galati		PG/TE
13	PANGARATI	26.2151	46.9259	Bistrita	Neamt	1965	PG/TE
14	PARAUL PANTEI	25.8224	47.1592	Bistrita	Neamt		PG/TE
15	PERESCHIV (Fichitesti)	27.4820	46.1670	Pereschiv	Bacau	1977	TE
16	PIATRA NEAMT (Batca Doamnei)	26.3431	46.9318	Bistrita	Neamt	1963	PG/TE
17	POIANA UZULUI	26.3923	46.3359	Uz	Bacau	1973	CB
18	RACACIUNI	27.0479	46.3340	Siret	Bacau	1984	PG/TE
19	RACOVA	26.7174	46.6916	Bistrita	Bacau	1965	PG/TE
20	TASCA BICAZ	26.0009	46.8866	Bicaz	Neamt	1980	PG/TE
21	TOPOLICENI	25.9230	47.1122	Bistrita	Neamt		PG/TE
22	VADURI	26.2559	46.9392	Bistrita	Neamt	1965	PG/TE

Risk related to structure

For the 22 dams, besides the exact determination of the geographical coordinates there have been determined also information about construction features required in calculating seismic risk: the year of commissioning (PIF in Table 7), type of dam, dam height (in meters) and volume of the lake in hm^3 (millions of m^3) (Table 7). Using this information, in Table 7 are also presented the risk factors due to age (ARF), height (HRF) and lake capacity (CRF).

The downstream risk (DHF)

The risk factor of the downstream water accumulations, take into account the dams location, the villages located downstream, the distance and the height difference between them, the number of inhabitants which should be evacuated and the existing infrastructure (hydro-energetic plants, roads, highways and gas stations, railroad stations, widely populated and visited tourist attractions).

In order to calculate the downstream risk factor, different scenarios were realized regarding flooding areas downstream from dams. There were identified the nearest studied dams' locations, the number of inhabitants (Table 6) and were obtained information regarding the value of downstream properties. Transposing this information in risk factors was done in Table 7. The information related to downstream towns were taken from city halls internet sites and Wikipedia.

Table 6. *Downstream situation*

Dam No	H1 (m)*	Downstream locality	County	H2 (m) **	H2-H1 (m)	Dist (km)	INFO LOCALITY						
							Popula-tion	N° house holds	N° housing	Principal econ activities	1	2	3
1	210	Antohesti	Bacau	210	0	0	258	150	167	Agriculture and fishing	N	N	N
2	152	Bacau	Bacau	152	0	0	144500	56503	67715	Industry	D	D	D
3	157	Bacau	Bacau	157	0	0	144500	56503	67715	Industry	D	D	D
4	199	Belci, Slobozia	Bacau	192	7	1.6	268	-	-	-	N	N	N
5	102	Costisa	Bacau	100	2	1.7	1336	-	-	-	D	D	N
6	70	Malureni	Galati	150	-80	2.7	199	-	-	-	N	N	N
8	136	Galbeni	Bacau	136	0	0.9	826	-	-	-	D	D	N
9	190	Surina	Bacau	188	2	0.7	227	-	-	-	N	N	N
10	532	Dodeni	Neamt	427	105	1.4	1654	-	-	-	D	D	N
11	172	Lilieci	Bacau	172	0	1.1	2483	-	-	-	D	D	N
12	39	Movileni	Galati	38	1	1.7	3269	1168	941	Agriculture	D	D	N
13	360	Pangarati	Neamt	360	0	0.3	5170	1780	1720	Wood manufacture	D	D	N
14	564	Stejaru	Neamt	562	2	0.1	674	-	-	-	D	D	N
15	91	Plesesti	Bacau	110	19	2.9	103	-	-	-	N	N	N
16	324	Piatra Neamt	Neamt	315	9	0.1	104000	4500	36500	Tourism Industry	D	D	D

17	472	Salatruc	Bacau	414	58	1.2	854	-	-	-	D	D	N
18	123	Rastoaca	Bacau	117	6	0.5	106	-	-	-	N	N	N
19	203	Racova	Bacau	202	1	1.4	3602	1284	1284	Agriculture	D	D	N
20	521	Ticos Floarea	Neamt	516	5	0.7	349	-	-	-	N	N	N
21	523	Poiana Teiului	Neamt	520	3	0.2	4344	1596	1878	Agriculture	D	D	N
22	346	Vadurele	Neamt	345	1	0.1	252	-	-	-	N	N	N

* H1 Altitude Dam (m)/ ** H2 Altitude locality (m) /1. School / 2. Railway Station/ 3. Factory

Table 7. *Dams risk factors*

No.	ID	Dam	H (m)	Vlake (hm^3)	No. Loc av	ARF	HRF	CRF	ERF	DRI	ΣFs +DHF
1	1	ANTOHESTI	7	1	258	2	2	2	8	4	18
2	3	BACAU	18.0	4.0	144500	3	4	4	12	12	35
3	4	BACAU (Serbanesti)	18.0	4.0	144500	3	4	4	12	12	35
4	6	BELCI	16.0	12.5	268	3	4	4	8	4	23
5	7	BERESTI/ROGOAZA	29.0	120.0	1336	2	6	6	12	4	30
6	10	CALIMANESTI SIRET	22.5	44.3	199	2	4	4	8	4	22
7	22	COSMESTI POD	20.0	17.0	162	1	4	4	8	4	21
8	34	GALBENI	24.0	39.6	826	2	4	4	8	4	22
9	35	GARLENI	19.0	5.1	227	3	4	4	8	4	23
10	38	IZVORUL MUNTELUI	127.0	1230.0	1654	3	6	6	12	4	31
11	39	LILIECI	19.0	7.4	2483	3	4	4	12	4	27
12	44	MOVILENI	21.5	63.6	3269	1	4	6	12	4	27
13	46	PANGARATI	28.0	6.0	5170	3	6	4	12	4	29
14	47	PARAUL PANTEI	19.5	1.0	674	2	4	2	8	4	20
15	50	PERESCHIV (Fichitesti)	13.0	16.5	103	3	4	4	4	4	19
16	51	PIATRA NEAMT (Batca Doamnei)	27.0	10.0	104000	3	6	4	12	12	37
17	54	POIANA UZULUI	80.0	88.0	854	3	6	6	8	4	27
18	58	RACACIUNI	29.0	103.7	106	2	6	6	4	4	22
19	59	RACOVA	20.0	8.7	3602	3	4	4	12	4	27
20	71	TASCA BICAZ	19.5	0.3	349	2	4	2	8	4	20
21	72	TOPOLICENI	19.5	0.1	4344	1	4	0	12	4	21
22	75	VADURI	27.0	5.6	252	3	6	4	8	4	25

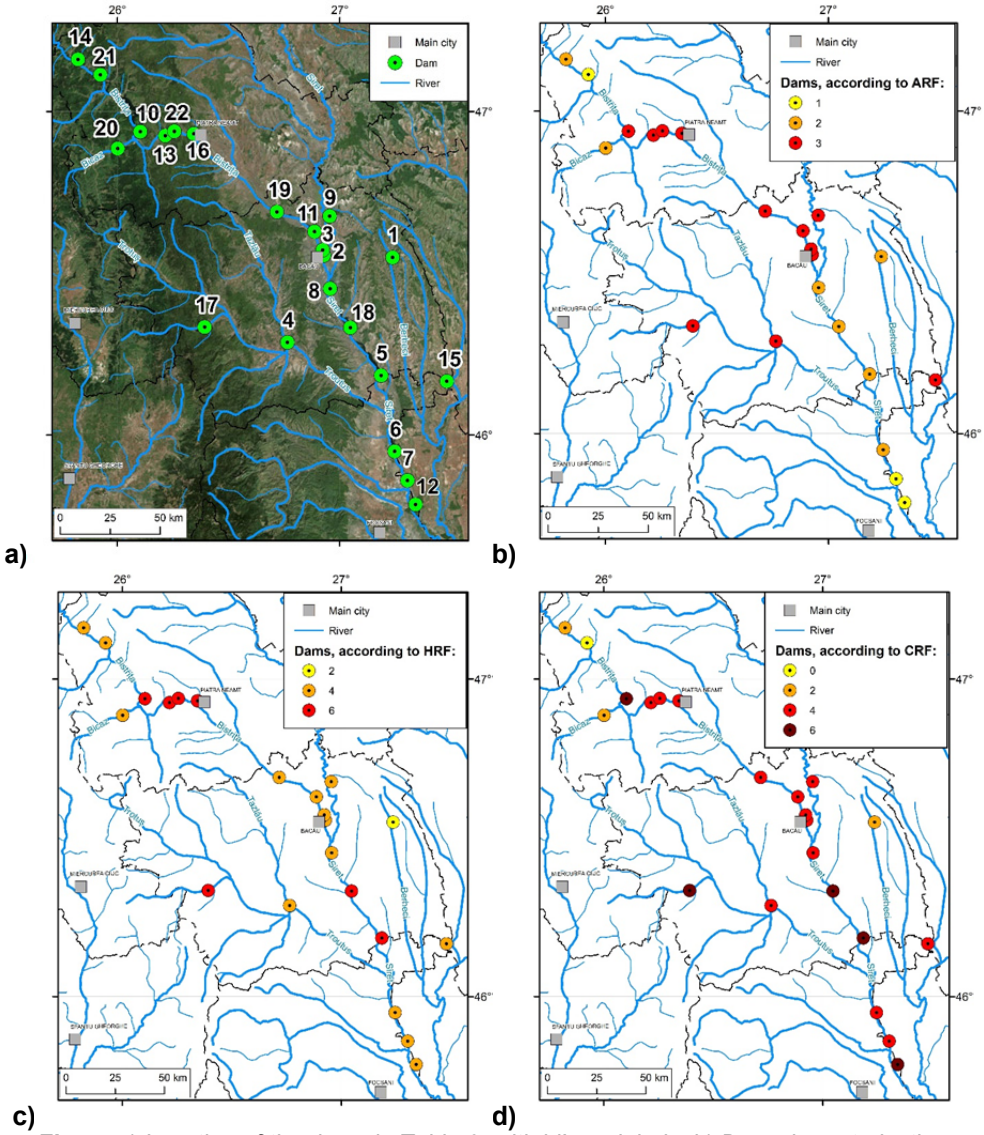

Fig. 4. *a) Location of the dams in Table 6, with id's as labels; b) Dam characterization according to age (ARF), c) height (HRF) and d) accumulation lake capacity (CRF) classes mentioned previously*

Seismic Vulnerability Rating - the predicted damage factor (PDF)

Dam vulnerability curves, curves developed by the Bureau and Ballentine (2002) using dams seismic performance observed during earthquakes can be used to calculate the predicted damage index (PDI). PDI depends on the type of dams,

seismic hazard and tectonic environment. Expected maximum amplitude of soil movement in dam sites is expressed through earthquake severity index (ESI), which gives us a robust estimation of the severity of possible movement in site, in order to evaluate the dam (Bureau, 2003).

Seismic hazard evaluation in dam sites

A key milestone in the development of PSHA was the computer program EQRISK, written by McGuire (1976). A version of machine code EQRISK (McGuire, 1976) improved by Leydeker et al. 2008 was formerly used in practice for probabilistic hazard assessment in Romania (Moldovan et al., 2008 and Moldovan et al., 2012). The code is widely distributed, and today is still the most frequently used hazard software, and has led to PSHA often being referred to as Cornell (Cornell, 1968) - McGuire method.

Figure 5 and Table 8 show the characteristics of all seismic sources used for probabilistic evaluation of hazard (Leydecker et al., 2008 and Moldovan et al., 2016). With the input parameters as defined in Table 8 for the five selected sources which likely affect the chosen area we estimated seismic hazard values for different return periods (Tr = 1, 50, 100, 475 and 1000 years) and also the expected Modified Mercalli Intensity (MMI) values for the same time intervals. The computations were performed in the sites of dams from Table 5. The conversion between ***I*** and ***PGA*** (peak ground acceleration) is given, for Vrancea intermediate earthquakes by Sorensen et al., 2008:

$I = 4.48 \log (PGA) + 6.55$ where PGA is expressed in m / s^2.

Table 8. *The statistical parameters used for probabilistic evaluation of regional and local seismic hazard and dams' sites*

Source	Coordinates		Average depth (km)	M min (Mw)	M max (Mw)	b	min	I max	bi	β i= =bln10	Seismic ctivity rat
VRI	45.65	26.15	130	5.0	7.9	0.85	4.0	10	0.48	1.12183	1.762380
	45.4	26.5									
	45.85	27.05			7.7			10			
	46.05	26.6									
VN	45.44	25.65	30	3.0	5.9	0.95	2.5	7.0	0.6	1.38155	0.514526
	46.22	26.70									
	45.75	27.90			5.5			6.0			
	44.90	27.00									
BD	46.22	26.70	10	2.5	5.5	0.75	2.0	6.5	0.49	1.12826	1.534712
	46.7	26.8									
	46.6	27.8									
	45.79	27.66									
PD	45.23	27.60	10	3.0	5.5	0.81	3.0	6.5	0.53	1.22405	0.360254
	45.75	27.90									
	45.2	29.3									
	44.67	28.74									

For seismic risk studies, the intensity and acceleration values for a recurrence period of 475 years were considered, which corresponds to a exceeding probability of 10% in 50 years or 0.2% in a year. These values are presented in Table 10. In Figure 6 we have represented the maximum possible accelerations (for Tr = 475) in 22 dams' sites in Eastern Romania.

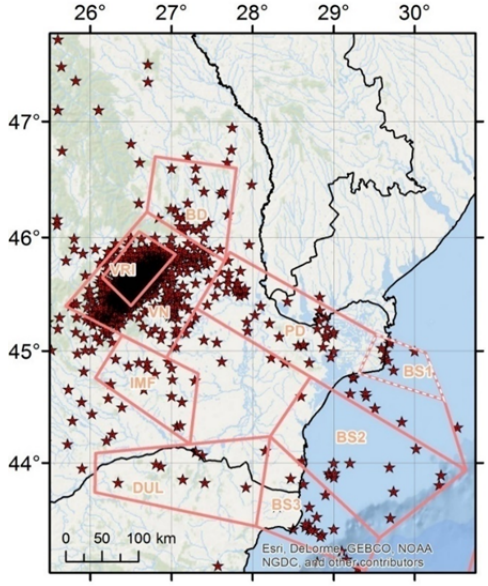

Fig. 5. *Seismic zoning - Seismicity was represented only for earthquakes with Mw> 3.5 (Moldovan et al, 2016)*

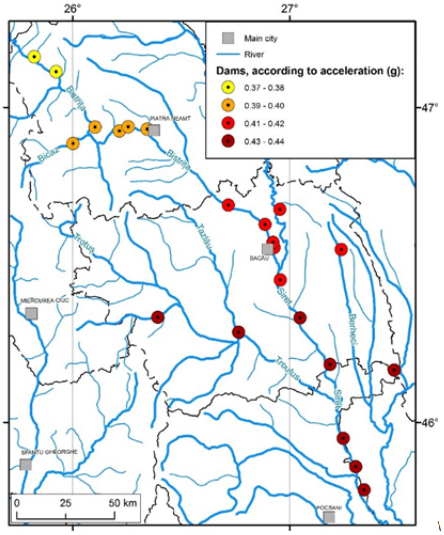

Fig. 6. *Maximum possible accelerations (Tr = 475 years) in sites for 78 dams in Eastern Romania*

To calculate predicted losses PDF factor, we needed information on seismic hazard (the maximum possible acceleration in g units and the maximum earthquake magnitude associated with this acceleration) and the specific vulnerability curves for various types of dams (Figure 5). For the 22 studied dams it was concluded that Vrancea intermediate earthquakes influence the seismic hazard in the most powerful way. This means that Mmax from the equation 3 will be given by Vrancea intermediate earthquakes and will be Mw max = 7.7. ESI index from the same equation (3): ESI = $PGA \times (M_w - 4.5)^3$ is calculated as well in Table 9.

Considering the dam's type, the PDI indices were found from the graphs in Figure 3. All 4 graphics were digitized for quick calculation of the ESI- PDI correspondence. Using PDI values obtained from the graph in Figure 3, we calculated the PDF of every dam using the relation 4. PDI and PDF are both given in Table 9.

Table 9. *Expected maximum acceleration values (in g units) in dams locations, for Tr = 475 years, earthquake magnitude that led to this acceleration and the calculated values of ESI, PDI and PDF*

Dam No	I	a (g)	Mw max	ESI	Dam type	PDI	PDF
1	9.5	0.407	7.7	13.325	TE	2.396	5.990
2	9.5	0.413	7.7	13.532	PG/TE	2.398	5.995
3	9.5	0.411	7.7	13.463	PG/TE	2.397	5.993
4	9.5	0.433	7.7	14.173	PG/TE	2.408	6.020
5	9.5	0.430	7.7	14.100	PG/TE	2.398	5.995
6	9.5	0.439	7.7	14.393	PG/TE	2.413	6.033
7	9.5	0.442	7.7	14.467	PG/TE	2.414	6.035
8	9.5	0.419	7.7	13.742	PG/TE	2.4	6.000
9	9.5	0.402	7.7	13.189	PG/TE	2.394	5.985
10	9.0	0.384	7.7	12.593	PG	1.965	4.913
11	9.5	0.407	7.7	13.325	PG/TE	2.396	5.990
12	9.5	0.442	7.7	14.467	PG/TE	2.414	6.035
13	9.0	0.386	7.7	12.658	PG/TE	2.388	5.970
14	9.0	0.367	7.7	12.023	PG/TE	2.378	5.945
15	9.5	0.422	7.7	13.813	TE	2.408	6.020
16	9.0	0.386	7.7	12.658	PG/TE	2.388	5.970
17	9.5	0.428	7.7	14.028	TE	2.404	6.010
18	9.5	0.426	7.7	13.956	PG/TE	2.408	6.020
19	9.5	0.405	7.7	13.257	PG/TE	2.394	5.985
20	9.0	0.386	7.7	12.658	PG/TE	2.388	5.970
21	9.0	0.371	7.7	12.148	PG/TE	2.382	5.955
22	9.0	0.384	7.7	12.593	PG/TE	2.386	5.965

Dams rating in seismic risk classes

After finding all the risk factors and the PDF value (Tables 6 and 8), we have calculated with Equation 1, the total risk factor, TRF (Table 10). Using risk class definitions in Table 4, we have rated in risk classes the 22 studied dams (Table 10).

Table 10. *Dams rating into risk seismic classes*

Dam No	$\sum F$ + DHF	PDF	TRF	Risk Class	Risk Type
1	18	5.990	107.82	II	Moderate
2	**35**	**5.995**	**209.83**	**III**	**High**
3	**35**	**5.993**	**209.74**	**III**	**High**
4	23	6.020	138.46	III	High
5	30	5.995	179.85	III	High
6	22	6.033	132.72	III	High
7	21	6.035	126.74	III	High
8	22	6.000	132.00	III	High
9	23	5.985	137.66	III	High
10	31	4.913	152.29	III	High
11	27	5.990	161.73	III	High
12	27	6.035	162.95	III	High
13	29	5.970	173.13	III	High
14	20	5.945	118.90	II	Moderate
15	19	6.020	114.38	II	Moderate
16	**37**	**5.970**	**220.89**	**III**	**High**
17	27	6.010	162.27	III	High
18	22	6.020	132.44	III	High
19	27	5.985	161.60	III	High
20	20	5.970	119.40	II	Moderate
21	21	5.955	125.06	III	High
22	25	5.965	149.13	III	High

CONCLUSIONS

From 22 dams studied in this article, only 4 are ranked in the moderate risk class (II). The rest are rated in the high risk class with total risk factor values between 125 and 220. None of the dams from Siret and Bistrita rivers were included in

extreme seismic risk class, which would have been obtained for a TRF= 250. Three dams had however higher TRF values than 200, namely: Bacau (two dams) and Piatra Neamt. Seismic risk calculations were performed for a return period of 475 years, corresponding to a probability of 0.2% a year.

If it will evaluate the risk for Tr = 1,000 years, the 3 aforementioned dams could pass into a higher class of risk. But the legislation does not require return high periods than in nuclear power plants (Tr = 10,000 years), estimates being sufficient for dams for Tr = 475 years.

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CLINOPTILOLITE VS. ACTIVATED CARBON AS A METHOD OF REMOVING HEAVY METALS FROM WATERS

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ABSTRACT. Acid mine drainage (AMD) is considered a major risk for groundwater and soil pollution if discharged in the environment without prior treatment, as it contains important quantities of heavy metals. The paper presents an experiment conducted using the batch technique, for the removal of six metals (Cd, Pb, Cu, Ni, Al, Zn) from AMD at the interaction with two filtering materials [zeolite (Z) and activated carbon (AC)], without chemical treatment. The results showed that the zeolite removed successfully Al and Pb in proportion of 96%, and the AC proved to be very effective in removing five (Al, Cd, Cu, Zn and Pb) out of the six metals studied, in proportion of 97%. Ni is the most difficult metal to be removed regardless the filtering material used. Although, better results are achieved for this metal at the interaction with AC - 20.11%, compared to zeolite - 18.97%. The efficiency of the two materials is given by the interaction time with AMD.

Key words: *zeolite, activated carbon, acid mine drainage, water treatment*

INTRODUCTION

Acid mine drainage or acid rock drainage refers to the outflow of acidic waters from ore or coal deposits, which is formed when materials containing sulphide are exposed to oxygen and water. It is usually characterised by low pH (due to the pyrite dissociation in water), high conductivity and high concentrations of heavy metals (Măicăneanu et al., 2013).

The *zeolites* are microporous crystalline alumina-silicates with a tetrahedral structure, containing Al in the form of $[AlO_4]^{5-}$ and Si in the form of $[SiO_4]^{4-}$, where every metallic atom is surrounded by four oxygen atoms. The pores and the cavities in their structure contain cations, such as sodium, potassium, calcium, magnesium

and water molecules as well (Payra and Dutta, 2003; Shoumkova, 2011). Due to their porous tri-dimensional structure, the zeolites have applications in many areas, among which water decontamination, soil remediation, agriculture, stock raising and health. One of the zeolites properties is their exceptional capacity to exchange ions with the liquid in contact without damaging their own structure (Shoumkova, 2011), therefore contributing to the water decontamination by retaining the heavy metals ions.

Unlike the zeolites which have a crystalline structure, the *activated carbon* is a filtration medium obtained from very different amorphous carbon-based materials (Çeçen and Özgür, 2011) (charcoal, coconut shell, walnut shell, watermelon shell, bamboo, used tires), subjected to pyrolysis (Chang et al., 2003). Its porous structure provides a large adsorption surface, being very efficient in removing both organic and inorganic pollutants.

The purpose of the present paper is a comparison between two methods used in the water decontamination process, the ion exchange and adsorption. In order to make a comparative study of the methods, two different filtering materials (in terms of their way of action) were used: zeolite volcanic tuff and AC. The aim is to show their capacity to reduce heavy metals concentration when used raw, even if the literature shows an improvement in adsorption capacity when chemically treated (Ismael et al., 2012; Chen et al., 2007).

EXPERIMENTAL SECTION

The experiments consisted in acid mine drainage interaction with zeolite ($(Na_{3,.35}K_{1.55}Ca_{0.93}Ba_{0.06}Sr_{0.01})(Al_{6.9}Si_{29.1}O_{72})(H_2O)_4$) and AC, at different time frames and different quantities of the two materials but at the same temperature of the water (25±1^oC).

The AMD sample was collected from Ilba-Handal mine, in Maramureș County. The exchange ions method has been used in the AMD treatment, using volcanic zeolitic tuff, clinoptilolite type, of 1-3 mm granulation, exploited from Racos area, Brasov County, Romania. Granulated AC was used, being provided by Ecopur System SRL Bucharest,

The samples were measured using an inductively coupled plasma mass spectrometer (SCIEX Perkin Elmer Elan DRC II, Toronto, Canada). For calibration, matrix-matched MERCK standard solutions were used for preparation of calibration solution and control points. Samples were analyzed directly and when the concentration was too high, they were properly diluted to fit calibration interval. The DRC was used in rf-only mode. The pH and electric conductivity determination a Seven Multi pH-meter from Mettler Toledo Company was used. A drying oven was used for the drying of zeolite and the activation of activated carbon.

The experiments used dried zeolite and thermally activated AC only (through drying in a drying oven at 105^oC). The two materials were sieved for the removal of the fine particles, on 0.8 mm sieve. The zeolite was repeatedly washed (8-10 times) with distilled water, dried at 105^oC in an oven for 6 hours, and the AC was thermal activated at 105^oC in a drying oven of the AC for 6 hours.

Four sets of experiments using batch technique were performed, for each filtering material at two different quantities. The method consists in static interaction between a solid and a liquid (aqueous) medium, in this case the zeolite/AC and the AMD. The zeolite and AC have been put in contact with AMD in Petri dishes for 1, 6, 24 and 48 hours. The quantities of the two filtration media were 10 g and 30 g and 100 ml for AMD.

The concentration, pH and conductivity of metals in AMD were measured both before and after the contact with zeolite and AC, in order to emphasize the reduction concentration level. The initial characteristics of AMD were: pH - 2.56, electrical conductivity - 3.75 [µS/cm], heavy metals concentrations: Al - 77,500 [µg/L], Cd - 597 [µg/L], Cu - 1000 [µg/L], Ni - 174 [µg/L], Pb - 83.5 [µg/L] and Zn 162,000 [µg/L].

RESULTS AND DISCUSSIONS

The concentration levels of the six subject metals, experimentally obtained before and after the interaction with zeolite and AC are graphically presented in Fig. 1. The graphical representation is made for four interaction time frames, for zeolite 10 g, 30 g and AC 10 g, 30 g.

The concentrations measurements show an efficient action of the AC on every metal studied, starting with the interaction time of 1 hour. The difference between the concentrations measured after 1 hour and after 6 hours is very large. The zeolites action is noticeable only for Pb, where the reduction of this metal concentration is highly reduced compared to the other five metals. It is noted that a three times larger amount of zeolite than AC is needed in order to achieve comparable or better results. For a short timeframe (1 hour), the zeolite action is more efficient than AC.

One can also notice that after the contact with AC, the concentrations fall below the maximum allowed level regulated by the current potability standard (Law 311/2004) for all six metals (Al = 200 µg/L, Cd = 5 µg/L, Cu = 100 µg/L, Ni = 20 µg/L, Pb = 10 µg/L, Zn = 5000 µg/L) at different timeframes. After the contact with zeolite the potability limit is reached for Al, Cu and Pb, after at least 6 hours of interaction between the volcanic tuff and AMD (Fig. 2). Table 1 presents the conditions necessary to achieve the potability limit for Al, Cd, Cu, Ni, Pb and Zn. Although, the AMD treated in these conditions does not become drinking water, as it needs further treatments in order to become drinkable.

The saturation of the filtering material occurs after 24 hours for Ni, Cu and Zn, followed by desorption which occurs after 48 hours. For Al and Pb the saturation occurs after 6 hours and desorption after 24 hours, followed by a new adsorption process after 48 hours. Cd is the only metal among the six metals studied, for which the saturation takes place after 48 hours.

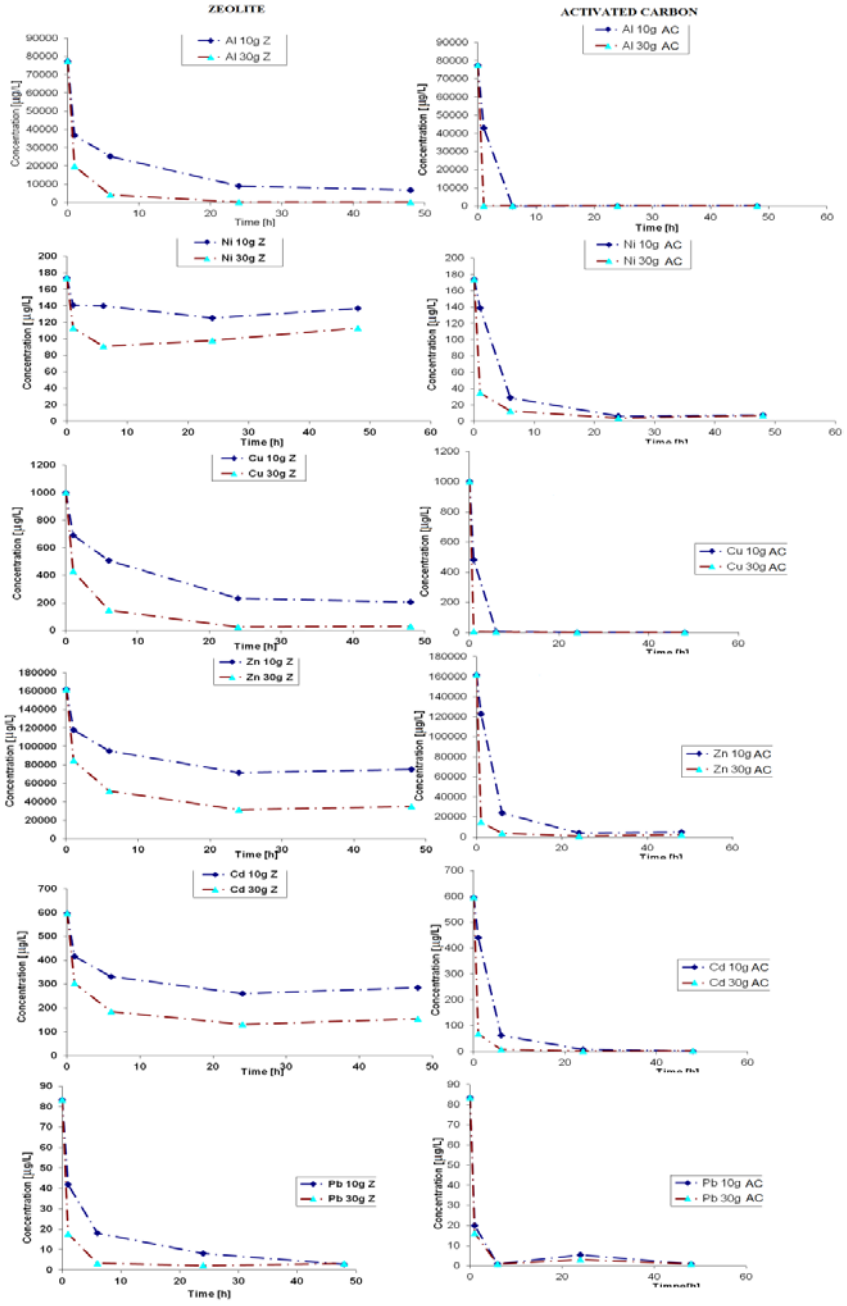

Fig. 1. *Graphical representation of the six metals concentrations levels, experimentally obtained: (a) Al, (b) Cd, (c) Cu, (d) Ni, (e) Pb and (f) Zn*

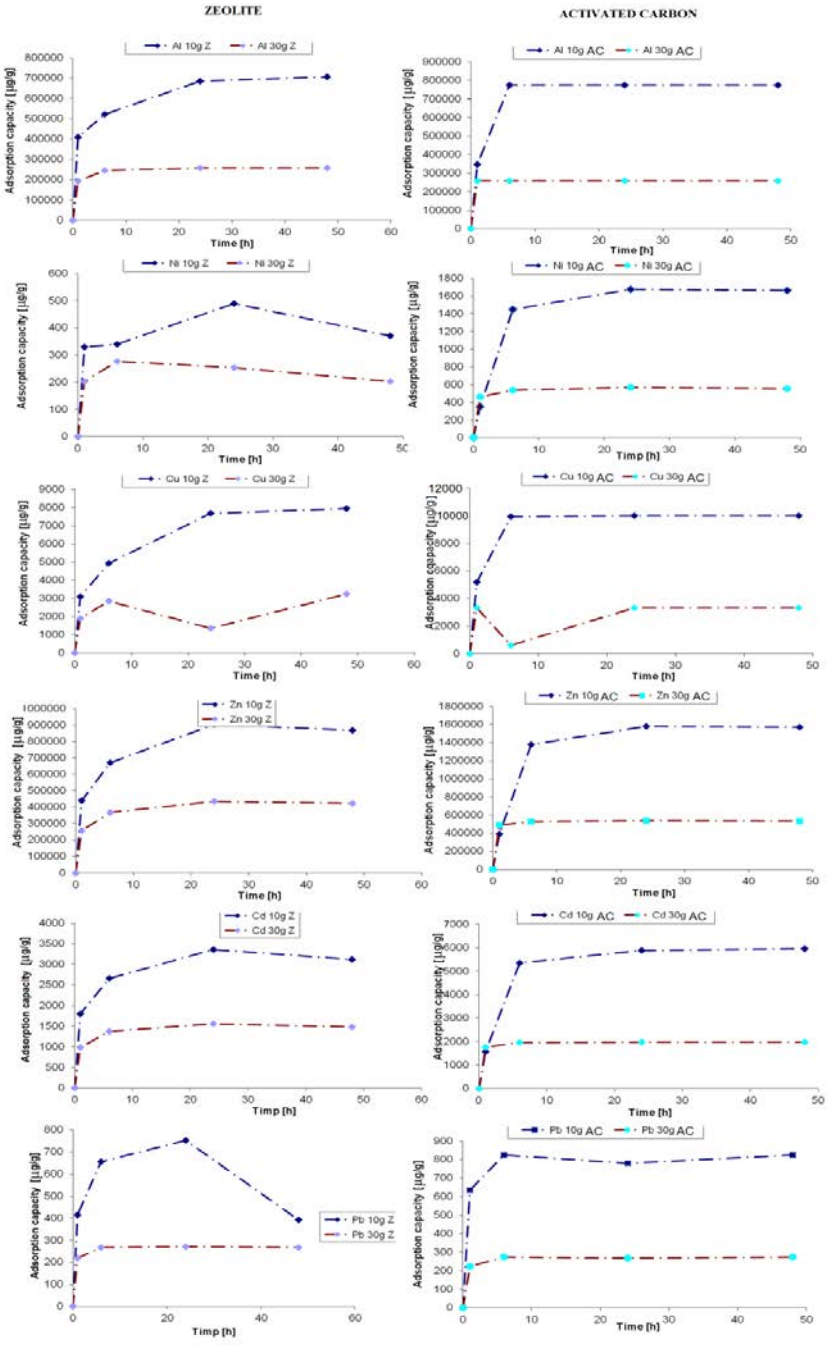

Fig. 2. *Adsorption capacity of zeolite and activated carbon for Al, Ni, Cu, Zn, Cd and Pb*

The interaction with AC (30 g) shows the best results obtained so far for the Ni concentration reduction, by 97.76% (Fig. 5) after 24 hours, this figure falling below the potability limit for Ni (20 µg/L). Although this metal remains the most difficult metal to remove at a short interaction time (1 hour with an efficiency of 79.94%). The maximum reduction of the Al concentration (99.98%) is reached after 24 hours, unlike the AC (10 g) (99.99%), where is reached after 6 hours. AC – 30 g is the best option in metal removal from AMD in this experiment, as all the six metals studied have very good results at a short interaction time (1 hour).

The adsorption capacity of the two materials was calculated with the formula:

$$q = \frac{(C_0 - C_t) \cdot V}{m_{AC}} [\mu g / g] \quad (1)$$

where*: q – adsorption capacity [µg/g]; C_0 –initial concentration of the metals from the acid mine drainage [µg/L]; C_t – metal concentration at a certain time frame retained onto zeolite [µg/L]; V – acid mine drainage volume used in the adsorption experiments; V=100 ml, m_{AC} - zeolite/activated carbon quantity used in the experiment; m_{AC} = 10 and 30 g, respectively.*

Fig. 2 represents the adsorption capacity of the zeolite compared to the one of the activated carbon used for the metals elimination from acid mine drainage.

The results show that the dynamic equilibrium is achieved for 10 g both for zeolite and activated carbon, for all the metals studied. Increasing the mass of adsorbent leads to a decrease in their adsorption capacity. This is probably due to the fact that as the adsorbent mass increases, the total area of interaction in the ion exchange process decreases, due to the particles overlapping and conglomeration (Lo et al., 2012; Huang et al., 2014; Nsami et al., 2013). However, for Ni, Zn and Cd after 1 hour interaction time, the dynamic equilibrium is reached at 30 g, for activated carbon.

From the studies on the adsorption of metals from acid mine drainage onto 10 g and 30 g of zeolite and activated carbon, it can be concluded that the optimum adsorbent mass required is 10 g.

The ***efficiency*** in percentage was calculated using the following equation (2) and is graphically represented in Fig. 3:

$$E = \frac{C_0 - C_t}{C_0} \cdot 100[\%] \quad (2)$$

where: *E is the adsorption process efficiency [%], C_0 – is the initial metal concentration in AMD sample before treatment; [µg/L], C_t – the metal concentration at a certain time t [µg/L].*

When the amount of zeolite is three times higher (30 g), the results are favourable for the Al concentration reduction, with a maximum of 99.78% reached after 48 hours. The lowest efficiency is noticed at Ni with 35.1%, which is almost two

times higher than the one reached for zeolite 10 g. The action of the zeolite for Cu and Pb is notable, with over 95% of concentration reduction. The desorption process can be observed for Cd, Cu, Ni, Pb and Zn, which occurs after 24 hours of interaction between the solid and liquid phase (Fig. 3).

After the interaction with AC (10 g), an important reduction of Al, Cu and Pb concentrations can be observed after 6, 24 and 48 hours, with an efficiency of almost 100% (Fig. 3). The lowest adsorption is for Ni, after 1 hour of interaction, with a concentration reduction of only 20.11 %.

In terms of *pH and electrical conductivity*, there is a growing trend after the contact with both materials (Table 1), with a higher efficiency of activated carbon over zeolite. Following the treatment of AMD with activated carbon, a change in pH is achieved, from acid to neutral (from 2.56 to 7.08 after 24 hours), pH values that correspond to drinking water. Both zeolite and AC influence positively the conductivity value, which increases to about the same level (above 4.20 µS/cm after 48 hours). This phenomenon reflects the increase of the dissolved salts in the water, due to the ion exchange process that takes place in the interaction with zeolite and adsorption-desorption in contact with activated carbon.

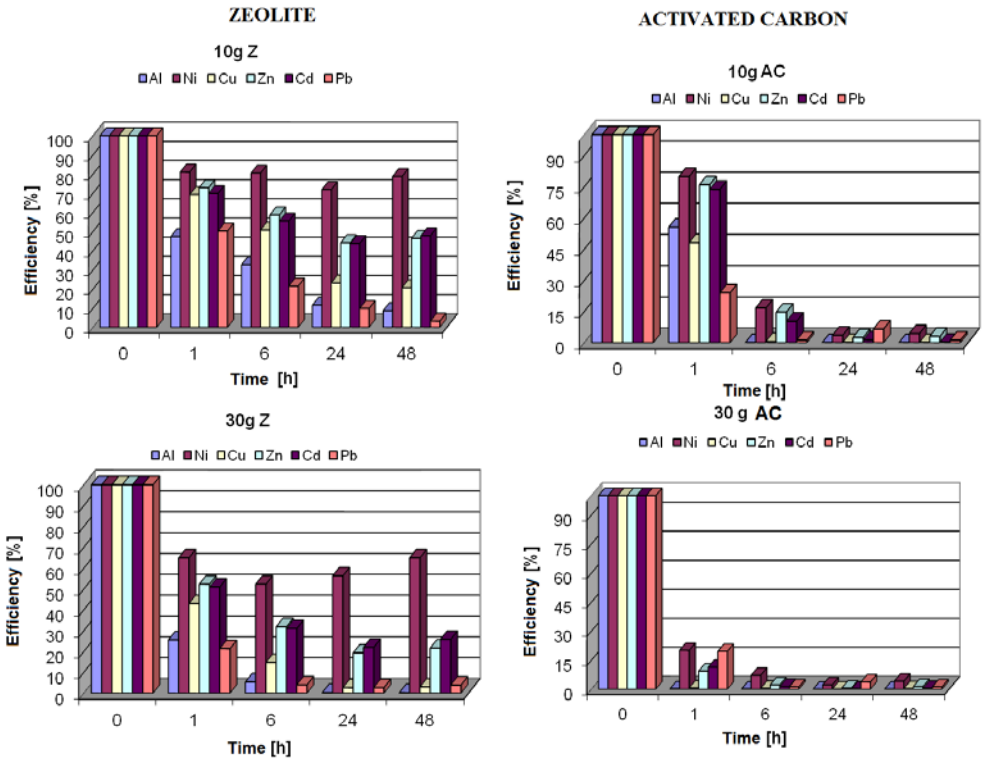

Fig. 3. *The zeolite and activated carbon (10 and 30 g) efficiency in reducing the Al, Ni, Cu, Zn, Cd and Pb ions concentration, after the interaction with acid mine drainage*

The adsorption/desorption equilibrium confers basic data for evaluating the physical and chemical applicability of the adsorption processes on an industrial scale. The equilibrium is often described by an isothermal process where the parameters express the surface properties and the affinity of the adsorbent (Ho et al., 2002). Based on these isotherms, equipment can be designed, estimations of the required adsorbent mass can be carried out or the calculation of the efficiency of pollutant purification degree can be made (Dechow, 1989). For this study, Freundlich and Langmuir isotherms have been calculated.

Linearized form of the Freundlich isotherm can be written as follows (Momčilović et al., 2011):

$$\log q = \frac{1}{n}\log C + \log K \tag{3}$$

where: *q –adsorption capacity [μg/g]; C – pollutant concentration [μg/L]; K şi n – constants that depend on the nature of the substance adsorbed and temperature, respectively Freundlich constants.*

Also, the linearized form of Langmuir isotherm given by the following equation, has been calculated (Momčilović et al., 2011):

$$\frac{1}{q} = \left(\frac{1}{q_m \cdot K}\right) \cdot \frac{1}{C} + \frac{1}{q_m} \tag{4}$$

where: *K - Langmuir equilibrium constant; q_m – adsorption capacity for monolayer formation; q – adsorption capacity [μg/g]; C – pollutant concentration [μg/L].*

Table 1. *Value of pH and electrical conductivity before and after the contact with zeolite and AC*

Material	Contact time [h]	Material mass [g]	Before filtration		After filtration	
			pH	Conductivity [μS/cm]	pH	Conductivity [μS/cm]
Zeolite	1	10	2.56	3.75	2.85	3.72
	6				3.47	3.91
	24				4.19	3.88
	48				4.21	4.21
Activated carbon	1				4.16	3.55
	6				6.81	4.20
	24				7.08	4.28
	48				7.21	4.49

The linearized forms of Freundlich and Langmuir isotherms for the metals adsorption onto zeolite and their linearization coefficients are presented in Fig. 4.

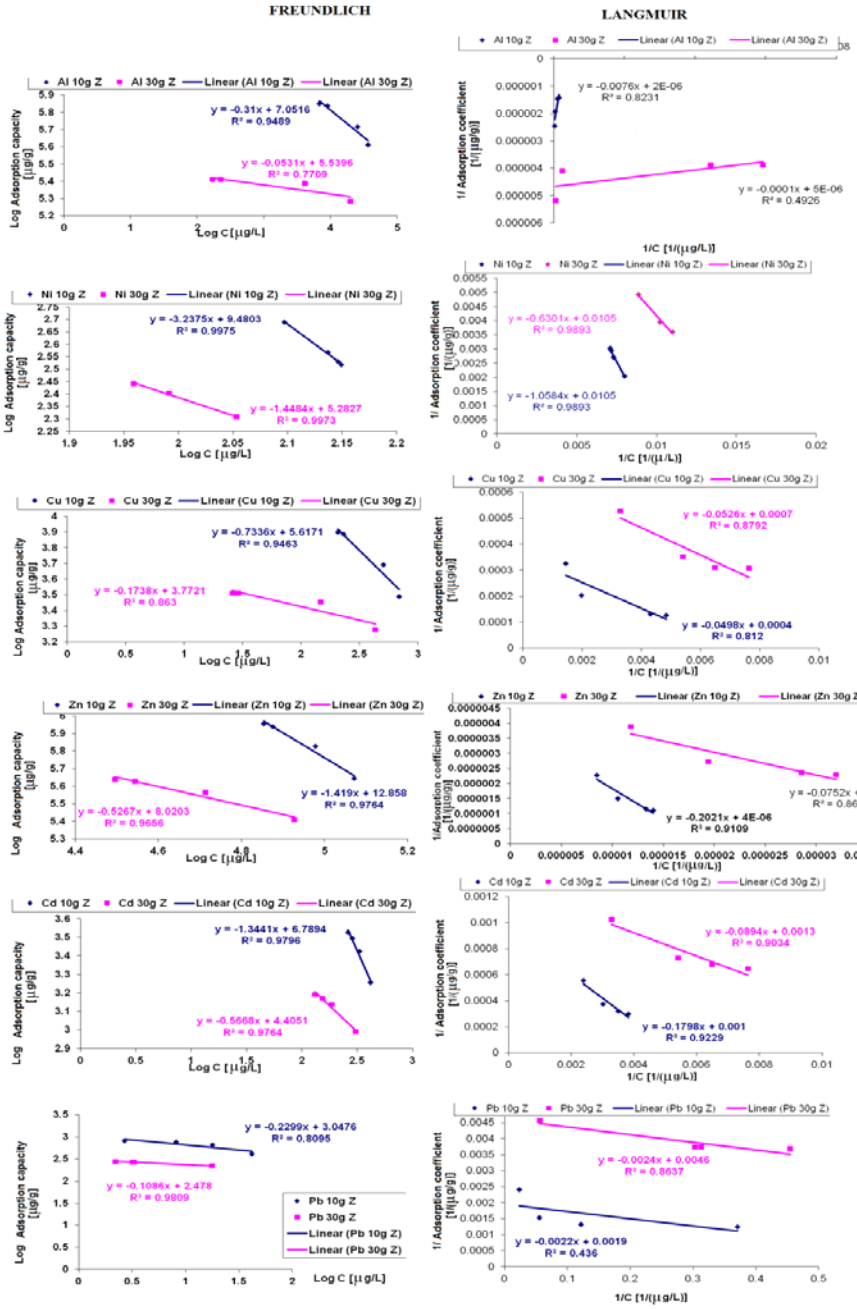

Fig. 4. *Linearized Freundlich and Langmuir isotherms, for the adsorption of Al, Ni, Cu, Zn, Cd and Pb, onto 10 g and 30 g of zeolite*

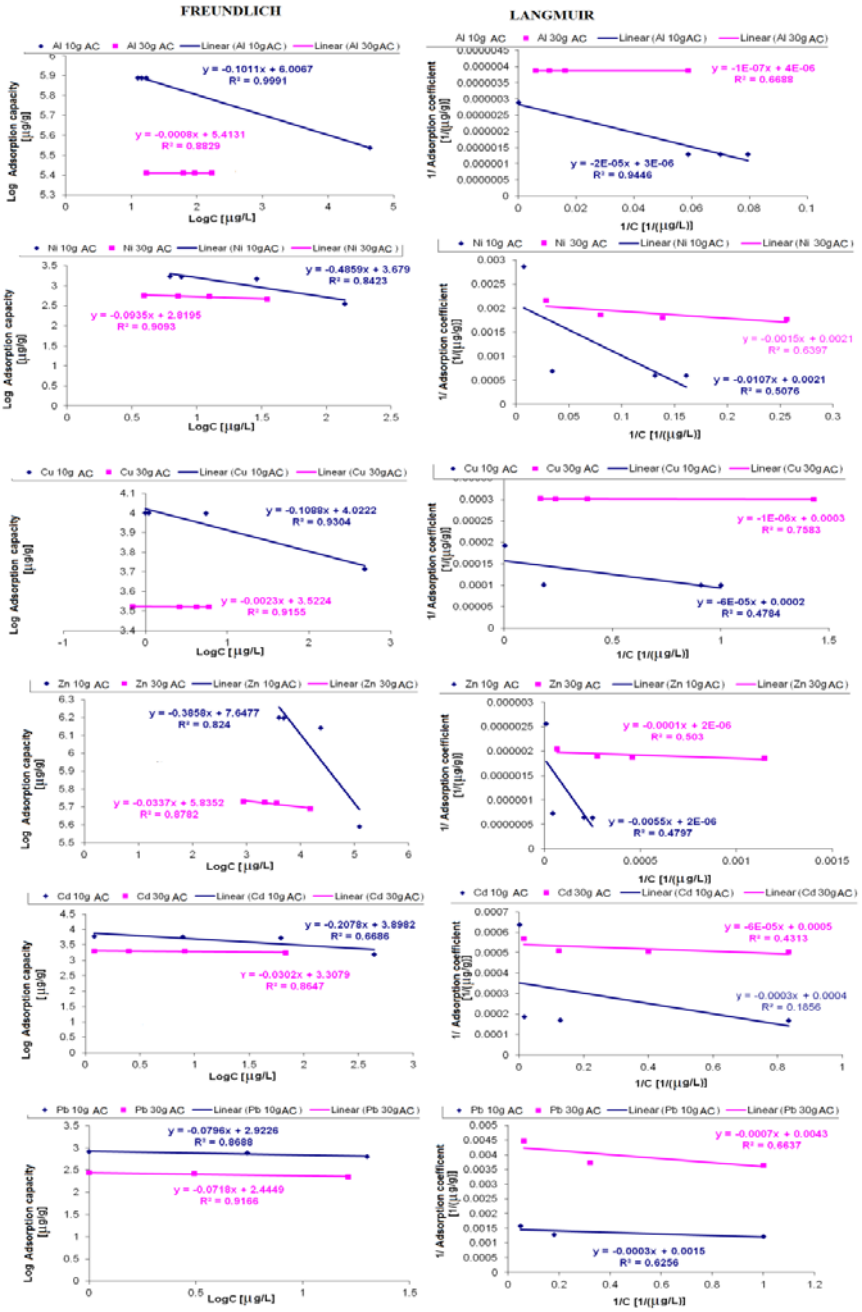

Fig. 5. *Linearized Freundlich and Langmuir isotherms, for the adsorption of Al, Ni, Cu, Zn, Cd and Pb, onto 10 g and 30 g of activated carbon*

Adsorption is considered favourable of $0<R^2<1$, unfavourable if $R^2>1$, linear if $R^2=1$ and irreversible if $R^2<0$ [10]. From the data presented in Figure 4, it can be observed the fact that the mathematical model of the adsorption process for all the studied metals is Freundlich isotherm, where the correlation coefficient R^2 is closer to the value 1. For Ni and Cd, 10 g of zeolite is needed and 30 g in the case of Al, Cu, Zn and Pb.

The linearized forms of Freundlich and Langmuir isotherms are presented in Fig. 5 for the adsorption of Al, Ni, Cu, Zn, Cd and Pb onto 10 g and 30 g respectively of activated carbon.

From Fig. 5, it can be observed that considering the correlation coefficient R^2, the adsorption process derives from Freundlich isotherm using 10 g of zeolite Al and Cu, and 30 g of activated carbon for Ni, Zn, Cd and Pb.

CONCLUSIONS

The data presented in this paper highlight the effectiveness of using dried zeolite and thermally activated AC only, emphasizing their ability to reduce the concentration of some heavy metals in waters, below the maximum level of contaminants accepted for drinking water, as regulated by law.

Increased efficiency of the AC in comparison with zeolite is evident when using the same amount of filtering material. Comparing the results for the Al, Cu and Pb after the contact with the two materials, one can observe that the use of AC involves a much lower interaction time than the use of zeolite, with better results in reducing the metals concentrations in the sample.

When the amount of zeolite increases, the results become comparable to or even better than those obtained after the contact with AC for two of the six metals studied (Ni after 6, 24 and 48 hours, and Pb after 24 hours). For certain metals (Al, Cd and Zn), the zeolite is more effective than AC in a short interaction timeframe (1 hour).

Aluminium as a metal is well removed from the waste waters probably due to the fact that the aluminium atom has the smallest atomic volume among the studied metals. This fact facilitates both ion exchange with the zeolite and adsorption on AC surface.

In the experiments carried out, both on zeolite and AC, the metal most easily to remove is aluminium and the most difficult one to remove is nickel.

Nickel is removed in small amounts from the wastewater due to the fact that the Ni^{2+} ion has the $[Ar]3d^8$ electronic structure, which facilitates the occurrence of the octahedral complexes in the water. The occurrence of these complexes is probably favoured, as compared to the ionic exchange with the zeolite or to the AC surface adsorption.

The use of AC for AMD treatment is more efficient than the zeolite in terms of pH, as it reaches a neutral level which corresponds to drinking water after 24 hours for the samples treated with AC.

The experiments made showed that in the retention process of metals from acid mine drainage onto zeolite and activated carbon, the adsorption capacity decreases with the increase of the adsorbent mass, the dynamic equilibrium being reached at 10 g of both zeolite and activated carbon. The mathematical model for the adsorption process on the two filtration materials is Freundlich isotherm.

As the two filtration materials act in different ways in the process of heavy metals retaining, and the results obtained for the same metal are different, the optimal choice for a water filtering would probably contain both zeolite and AC.

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METHODS OF RECOVERY OF CRT GLASS WASTE FROM WEEE

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ABSTRACT. This paper represents an ample study on hazardous waste came from WEEE, namely CRT glass. The aim of this study was to obtain a composite structural material which would integrate CRT (cone) glass. The hereby study is structured and presented into three main parts: literature data, the experimental part and results interpretation and general conclusions. Chemical analyzes were made with Atomic Absorption Spectrometry method and the lead (Pb) leachability of the new material made was monitored. Also mechanical strength test were made using a Tehnotest device. Mechanical tests were conducted for resistance to compression and flexure of the material. For the new material were obtained good results and it can be viable both from metal leachability and mechanical resistance point of view. The obtained data and results show the possibility to incorporate hazardous waste into new composite materials and represent a foundation for further research and new directions to follow are opened for profound investigation in this area.

Key words: *CRT, WEEE, composite material, lead*

INTRODUCTION

Waste began to be increasingly visible in our lives and we can say that their management is one of the challenges of this century. From the many categories of waste some waste of them impresses with by quantity and others via their environmental damage (Gaidajs et al., 2010, Deepak and Pooja, 2013). We chose to focus on hazardous waste from WEEE, specifically those from CRT (Cathode Ray Tube) glass (obtained from IT equipment and TV) which is a hazardous waste (Mueller et. al., 2012). The danger of this waste comes from the frit that have a high level of lead content and the migration possibility of migration into the soil, sub soil and water can occur, and then through different ways can affect human health and environment (Song et al., 2012).

About WEEE and CRT

Recently, WEEE waste has become increasingly popular and this topic is presented in many contexts (Schumacher et al., 2014). With the understanding of the problems that WEEE uncontrolled landfilling may be caused, the authorities have tightened law in this area. Even that, the problems of WEEE collecting and neutralizing are many and complex (Tung-Chai and Chi-Sun, 2012).

To fully understand the complexity of materials originated from WEEE were presented the major components from WEEE, in Fig. 1.

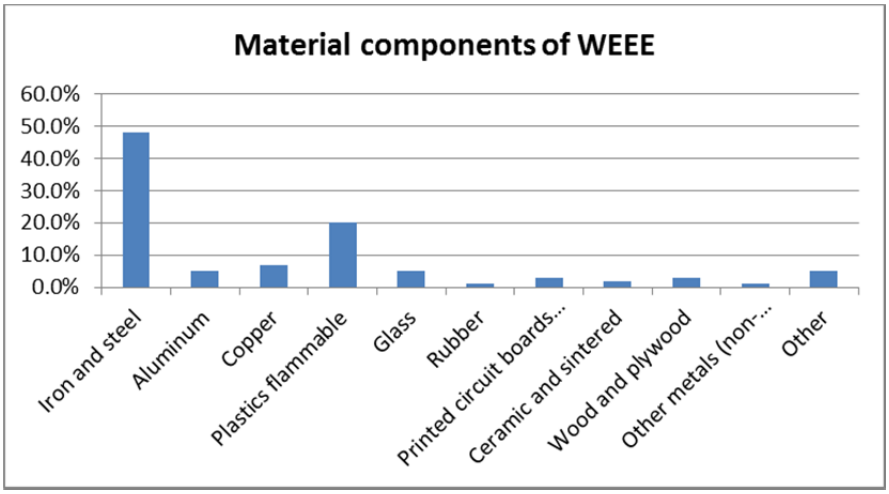

Fig. 1. *Material components of WEEE (Source: Dulamă, 2014)*

From the data presented in Fig. 1, it can be seen the multiplicity and diversity of the materials derived from WEEE. Many of them are recyclable in a high percentage. Some of the materials were found in small quantities but significant from economical point of view (Innocenzi et al, 2013). A good example is the precious metals (gold, silver, platinum, yttrium, etc.). Other materials do not have economic importance but fortunately it hasn't hazardous impact on the environment, it can be directly transferred in landfills.

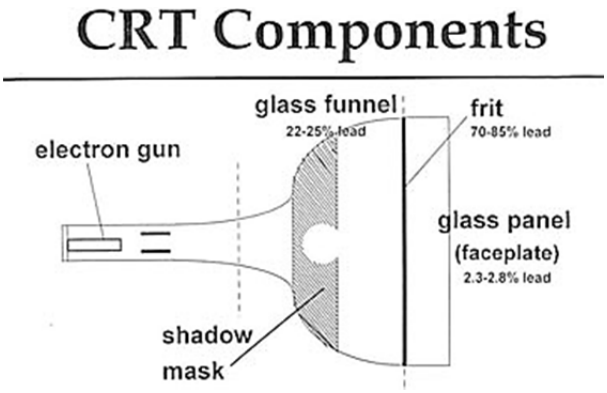

Fig. 2. *CRT Components (Source: Courtesy of Robin Ingenthron, Massachusetts Department of Environmental Protection; http://www.dep.state.fl.us)*

The waste investigated in the present study is a hazardous one which at first glance doesn't have economic attractiveness. In this case were taken two challenges: in terms of scientific research (neutralization and reuse) and economic outlook.

From many available materials, this research was mainly focused on CRT glass derived from TV (Fig.2). It could be distinguished four components of televisions with different percent of lead in CRT glass (Bedekovik, 2015). These components are: front, neck, cone and frit. The lead content in front CRT is between 0-3%, in cone CRT is up to 25%, in neck CRT has a percent about 40%, and in frit CRT the percent is about 70% (Popovici et al., 2013).

EXPERIMENTAL

Several studies demonstrated that CRT glass has been successfully introduced i in several types of composites (Tung-Chai and Chi-Sun, 2014). For this study, was chose the use the cement matrix.

This research had as main objective to obtain a composite material incorporating CRT glass (cone type), which is categorized as hazardous waste. The main objective has other sub-objectives namely: 1) to found if the obtained material correspond to current standards for construction materials and 2) analyze the lead leachability from the CRT incorporated in the material (under the maximum allowed concentration in legislation).

Description of the recipes, tests and analysis

In order to obtain a composite material incorporating the glass cone CRT were made and tested two recipes denoted R1 and R2. According to empirical determinations for both recipes was chose to the further study the recipe R2 which was more suitable for this type of research. Then, from R2 were formed other recipes denoted: R 2.1, R 2.2, R 2.3, R 2.4, R 2.5 and R 2.6. For the composition of these recipes was used: CRT glass cone, cement, zeolite and water. The materials obtained with these recipes have been analyzed in terms of leachability. The main differences between these recipes are given in Table 1.

Table 1. *Granulometry differences between recipes*

Recipe	Diameter glass	Diameter zeolite
R 2.1	Ø 1-3mm	Ø 0-0,6mm
R 2.2	Ø 1-3mm	Ø 0,6-2mm
R 2.3	Ø 7-8mm	Ø 0-0,6mm
R 2.4	Ø 7-8mm	Ø 0,6-2mm
R 2.5	Ø >8mm	Ø 0-0,6mm
R 2.6	Ø >8mm	Ø 0,6-2mm

Recipes for mechanical tests

For mechanical tests had changed the recipes numbering, because the first is represented by classic mortar recipe and had no correspondent in recipes for chemical tests. The first recipe, recipe witness R 3.1 is a classic recipe for mortar. In our study, samples obtained from this recipe will be a good benchmark. This recipe has just three components namely: sand, cement and water. The following recipes have components: sand, cement, glass CRT fine granulometry (1-3 mm) zeolite. The recipe R 3.4 is transposition the recipe R 2.5, that was used for chemical analysis. R 3.2 and R 3.3 are recipes intermediate between recipe for classic mortar and R 3.4. Materials used in preparing these specimens were largely similar to those used to obtain material for chemical analysis.

Chemical analysis

Chemical analyses were divided into three categories. In the first category the material samples were subjected to sonication test. For this test, the material samples were immersed in two types of solution: acidic solution (pH = 3) with ultrapure water and nitric acid (HNO_3) and an alkaline solution (pH = 12) with ultrapure water and sodium hydroxide (NaOH). Then were introduced in an ultrasonic bath for 30 minutes at room temperature. After completing the process, the solution was filtered and then prepared for AAS (Atomic Absorption Spectrometry) analysis.

In the second category the material samples were subjected to undergone maturation. For this test, the material samples were immersed in two types of solution: acidic solution (pH = 3) with ultrapure water and nitric acid (HNO_3) and an alkaline solution (pH = 12) with ultrapure water and sodium hydroxide (NaOH). . The samples stayed in the laboratory for five days without suffering any external intervention. After this period the material samples were removed from the solution and the solution was filtered and prepared for the AAS analysis.

In the third category the material samples were subjected to undergone maturation for five days, but with daily adjustment of pH. As was described in the second category were used the same solutions and the pH was daily adjusted. After this period the material samples were removed from the solution and the solution was filtered and prepared for the AAS analysis.

Mechanical tests

To demonstrate that the composite material belonging to the category of building materials it was necessary to made several mechanical tests. In this respect were made two tests: resistance to flexure and resistance to compression, both with the device Technotest. The flexural load was applied vertically, with an increase of 50 N/s until the material failed. Normally the fracture must be appeared in a period of 30-90 seconds. Attempts were made with standard: SR EN 1015-11:2002 (SR, 2002). The second test is the resistance to compression. Comparison values and methodology for the tests were taken from standard: SR EN 998-1: 2011 plaster mortars (SR, 2011). For the compression test, material was immersed in water for a period of 2, 7 or 28 days.

RESULTS AND CONCLUSIONS

In order to determine the accurately effectiveness of each recipes the data was processed with accuracy for relevant conclusions. First, the behavior of the material in terms of leachability for each method is presented in the Figs. 3, 4 and 5.

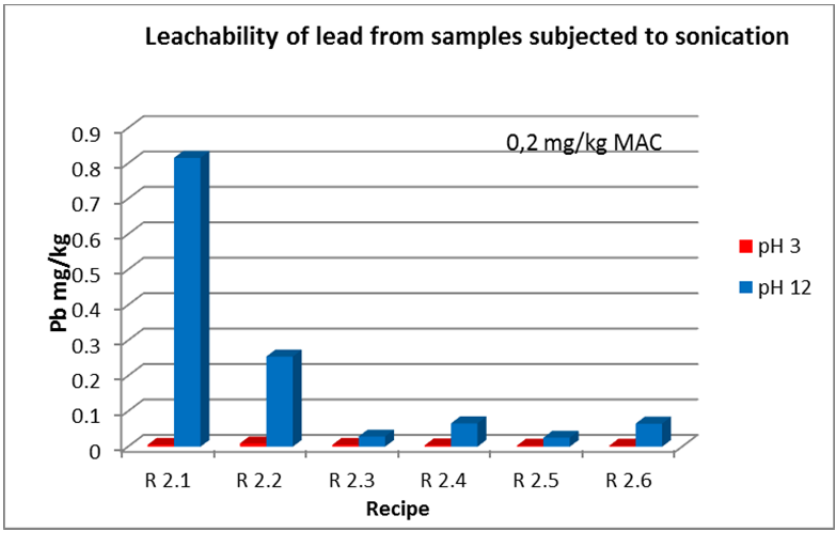

Fig. 3. *Leachability of lead from samples subjected to sonication*

In Fig. 3, it can be observed that the lead leachability passes over the MAC (Maximum Allowed Concentration for inert waste, from waste legislation for the recipes R 2.1 and R 2.2. The MAC was overcome at alkaline pH = 12.

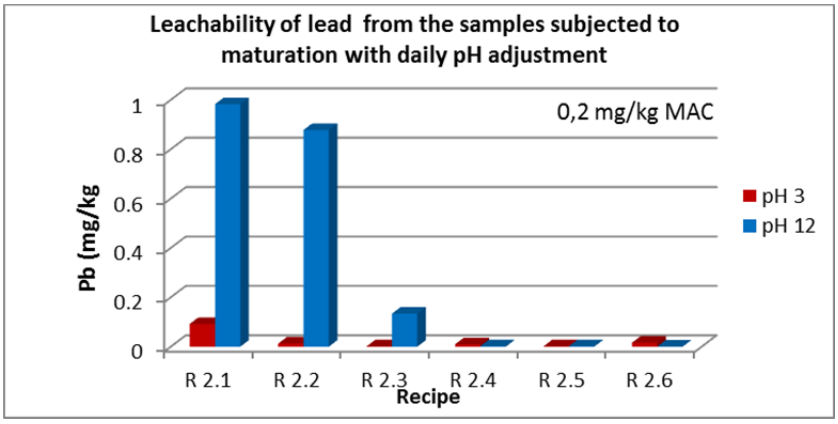

Fig. 4. *Leachability of lead from the samples subjected to maturation with daily pH adjustment*

In fig. 4 is presented the leachability of lead from the samples subjected to maturation with daily pH adjustment. When material was subjected to maturation for 5 days in two types of solution: acidic and basic (daily adjusted to this pH) a leachability over the concentration 0.2 mg / kg was found for the recipes R 2.1 and R 2.2. The other recipes had very small values of the lead concentration, but was established a correlation between pH and leachability.

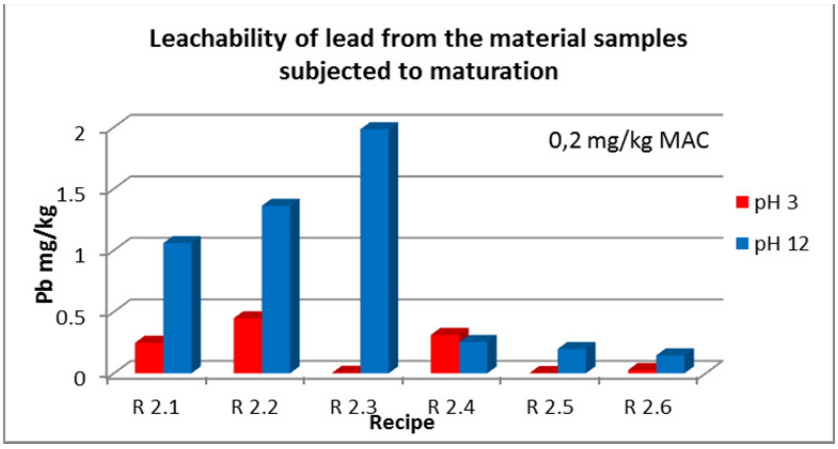

Fig. 5. *Leachability of lead from the material samples subjected to maturation*

The fig 5, presents the leachability of lead from the material samples subjected to maturation for 5 days. Were recorded high levels of lead concentration in leachate, especially for the recipes R 2.1 R 2.2, R 2.3 and R 2.4. Excepting the recipe R 2.3 for the other recipes the MAC was exceeded. The higher lead concentration in leachate was restarted for the material immersed in alkaline solution. Recipes R 2.5 and R 2.6 had a low leachability and don't exceed the MAC of 0.2 mg / kg.

CONCLUSIONS

Conclusions for chemical analysis

From the three methods presented above and applied to the material, it can be observed that created recipes had a low lead leachability from CRT glass. Were used several methods in order to better simulate critical situations which could be subject to material during use. Analyzing the methods was calculated the average leachability for each method depending on the pH and were obtained the following values:

- maturation 0.8338 mg / kg to pH = 12 and 0.1739 mg / kg to pH = 3,
- sonication 0.2095 mg / kg to pH = 12 and 0.0051 mg / kg to pH = 3,
- maturation with adjusting the pH daily 0.3331 mg / kg to pH = 12 and 0.0223 mg / kg to pH = 3.

It can be seen that sonication method has the smallest average leachability which mean that lead migration is very small in solution. Maturation method without adjustment of pH had the highest leachability of lead. It can be attributed to the alkalifying of the solution because of the cement matrix of the material. It is well known that the cement has alkaline pH.

After analyzing the behavior of the five recipes, the conclusions was that the recipe R 2.5 had all the leachability values under MAC (0.2 mg / kg) (Fig 6). This recipe fits perfectly with the aim of the study Almost all lead concentration values of this recipe are below MAC and shows that the material has a high chemical stability.

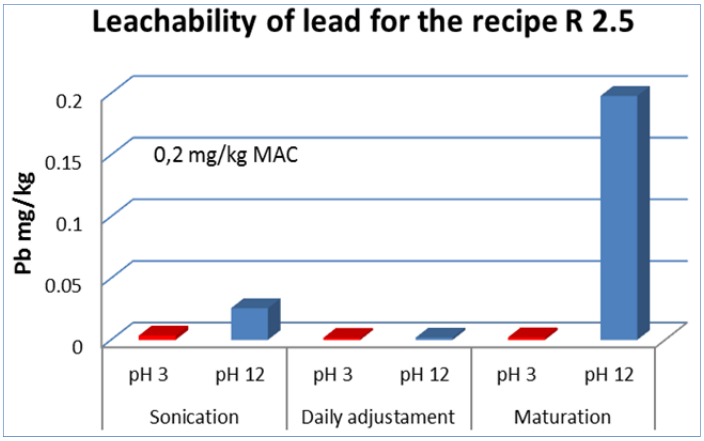

Fig. 6. *Leachability of lead for the recipe R 2.5*

In the Tables 2 and 3 are presented the results for the flexural strength and compressive resistance for the recipe.

Table 2. *Flexural strength test results*

Recipe		Force applied for flexural [N]	Flexural strength N/mm²
R 3.1	A	3320	**7,78**
	B	3980	**9,32**
	C	2410	**5,64**
R 3.2	A	2640	**6,18**
	B	3440	**8,06**
	C	2200	**5,15**
R 3.3	A	2220	**5,20**
	B	2200	**5,15**
	C	2100	**4,92**
R 3.4	A	925	**2,16**
	B	720	**1,68**
	C	1450	**3,39**

From Table 2 it can be observed that the obtained values for flexural resistance are between 1.68 and 9.32 N/mm². The obtained values were compared with mortar standard which provides that the flexural resistance values range between 0.2 and 2 N/mm². Recipe R 3.1 (classic mortar) has obtained the highest flexural strength and the recipe R 3.4 had the worst results in this regard. Regarding the other two recipes (R 3.2 and R 3.3) it can be observed that the general trend for the flexural strength was to decrease with removing sand and adding CRT glass. The proposed new recipes (R 3.4) have passed this test and are viable for use in production.

Table 3. *Compressive resistance test results*

Resis-tance N/mm^2)	**Recipe**											
	R 3.1			**R 3.2**			**R 3.3**			**R 3.4**		
	A 2 days	B 7 days	C 28 days	A 2 days	B 7 days	C 28 days	A 2 days	B 7 days	C 28 days	A 2 days	B 7 days	C 28 days
Rc1	44,2	51,7	44,7	37,7	40,9	47,2	39,9	44,3	44,6	23,3	30,8	43,5
Rc2	50,0	46,4	36,1	38,3	49,2	43,9	40,8	45,2	41,0	23,6	38,3	30,2
Rc average	**47,1**	**49,0**	**40,4**	**38,0**	**45,0**	**45,5**	**40,0**	**44,9**	**42,8**	**23,5**	**34,5**	**36,9**

From Table 3, it can be observed that the obtained values for the recipes were not satisfactory by comparison with mortars standard SR EN 998-1: 2011 (SR, 2011).The recipe R presented better values for compressive resistance. The decrease of the compressive strength can be attributed to the total elimination of sand and using of CRT glass with big size granulometry. Based on the comparison between standard and the obtained results, the materials belong to class IV CS plaster mortars. Again recipe R 3.4 (selected from chemical analysis R 2.5) had good behavior at test.

The objective of this study was reached, namely to obtain a composite building material that incorporate CRT glass (cone). The obtained material meets the standards present in the environmental legislation (namely waste landfilling) and construction legislation (standards).

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WASTE RECOVERY FROM LEATHER

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ABSTRACT. This study aims procurement and testing of ways using leather waste from tanneries, by incorporating them into a composite. This new material was subjected tests to determine leachability total chromium and lead in leather waste. Flow of production was as follows: grinding skin, placing the composite composition of a CRT glass waste to replace natural aggregates, own recipes, samples forming and demoulding. The new composite was then subjected to leachability test for total chromium and lead. The primary objective of this study was to achieve a composite material that can be used as material for the construction, in compliance with current standards of construction and environmental legislation.

The proposed method of waste recovery skin is viable and beneficial to the environment and provides economic benefits by creating jobs.

Key words: *recovery, waste leather, composite material, leachability*.

INTRODUCTION

It can be noted that in the European Union, in 2006 skin processing sector reached about 3700 enterprises. These tanneries are small and medium, developement by families. European tanners are dependent on raw material from outside the European continent. In recent years, this sector is in a downward because Asian and American market experienced a significant development. (Source: www.ec.europa.eu/eurostat).The European Directive 75/442 defines as solid waste: ''any substance or object in the categories from Annex 1, from which the holder discards or intends or is forced to discard''.

Annex 1 clarifies important aspects of which offer the following:

- ✓ it is not mentioned in the specificated notebook;
- ✓ accidentally spilled materials, lost or having undergone other mishap, or any materials equipment;
- ✓ materials that are contaminated or soiled as a result of planned actions;
- ✓ wastes from industrial processes (clay);
- ✓ residues from pollution abatement processes (air filters)

After this pleading about solid waste, can be mentioned unequivocally that the skin is part of this category. This skin-waste results from a technological flow shown in Fig. 1.

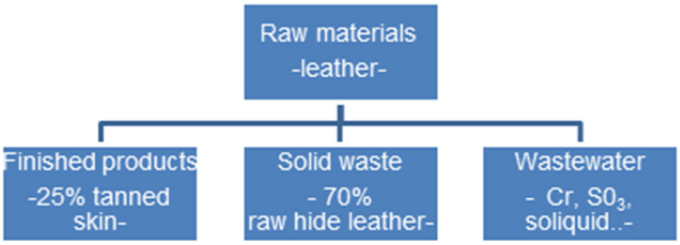

Fig. 1. *Waste from processing of hides and skins tanneries* (Coară et al., 2003).

It can be observed an alarming rate of solid waste higher than 70%. Many institutions of environment focus on water and ground factor. This industry it is important to tanneries because it needs chemical products and in particular because it is needed a large amount of water that is producing huge amounts of industrial waters, which can be categorized as representing ''chemical bombs'' for the environment (Ozgunay et al., 2007).

The needs of population growth have imposed extensive development of the industry through a variety of products through processing and high-tech materials and energy resources. Both directions of development involves an excessive exploitation of natural resources and artificiality material assets compared to the structure of primary resources, constituting essentially an impact aggressive on the balance of the environment, also both in the recovery and conservation of resources and the degree of assimilation / absorption of waste of any kind, whether production waste or consumption waste (Kolomaznik et al., 2008)

In the contemporary society, was imposed a more efficient development of the industry by using production processes in closed system or integrated use of material resources and energetical. This is a result of pressure from some regulation: administrativ, legal, public, circumstantial, local, regional or international, to the environment. The entire industrial process can be thought as a closed cycle, so the manufacturer assumes a total responsibility for the product design as a provider of a temporarily service (Yilmaz et al., 2007)

MATERIALS AND METHODS

New composite material structure

The easiest way that provides clear information is through the flow of implementation process of the composite material shown in Fig. 2.

The first stage of grinding was done with IKA A11 basic tool, located at the Technical University.

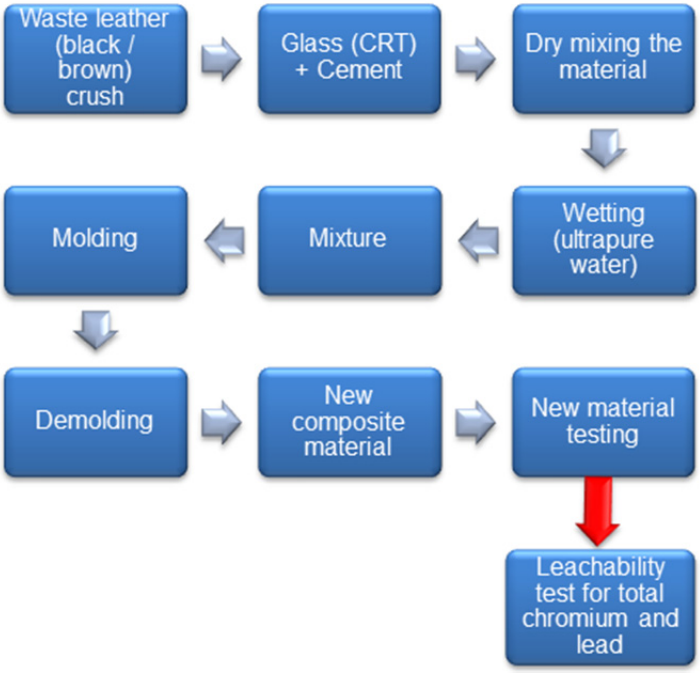

Fig. 2. *Flow stages of achieving and testing of composite material*

Fig. 3. *IKA A11 basic tool*

It has two different procedures for use (source:www.profilab24.com/IKA-A-11-basic-Analytical-mill):

- grinding of hard, breakable or non-elastic materials; the blender is stainless steel and it can be used for a Mohs hardness up to 6.
- cutting soft, fibrous materials; the grinding/cutting is made into a Teflon room, with stainless steel and 80 ml of volume.

The purpose of this paper is to obtain a composite material of solid waste-leather viable for the buildings. Thus, it was thought a recipe for composite material based on article published by Roșu et al. (2015) and Popita et al. (2016), like in Fig. 4.

Composite Material			
Waste leather (black / brown) crush	Glass (CRT) crush	Ultrapure water	White cement CEM_II_A_L_52.2N

Fig. 4. *New composite material recipe*

The homogenized material was poured into formwork 4x4 [cm], left for hardening for 3 days and then was peeled. The new composite material is showing in Fig.5.

Fig. 5. *The new composite with: black leather (left) and brown leather (right)*

Test stages

As evidenced in previous chapters, a major goal is to determine the concentration of total chromium and lead from the new composite material obtained. There were obtained four samples (both from brown and dark leather), and the procedure for both types of leather for testing total chromium and lead is, this stage was done at Faculty of Environmental Sciences and Engineering:

In the first step, the samples were subjected to ultrasound. For this test, there were used four Berzelius beakers and were created four different pH environments:

- in the first Berzelius beaker it was found a pH between 2-3;
- in the second Berzelius beaker it was found a pH between 5-6;

- in the third Berzelius beaker it was found a pH between 9-10;
- in the fourth Berzelius beaker it was found a pH=12.

For the acidic environment it was used a HNO_3 solution, for the basic environment a NaOH solution, for pH between 5-6 it was used demineralized water. In all recipients has been introduced an amount of 20 mL of solution, according to the MO 95/2005. Afterwards, the recipients were introduced, in number of four, for 30 minutes to ultrasound at ambient temperature.

In the second step, after completed the ultrasound procedure, the samples were removed from Berzelius beakers and passed to the filtration step. Then, the samples were adjusted for a pH of 2 with a HNO_3 solution and following after that to be analyzed with an AAS ZEEnit 700 Analytic Jena Spectrometer, flame method, in order to establish the concentration of total chromium and lead.

RESULTS AND DISCUSSIONS

After analyzing with a spectrometer AAS ZEEnit700 Analytic Jena, the concentration of total chromium (without atomic speciation) and lead, the results are in Tabel 1.

Tabel 1. *Total chromium and lead concentrations for different pH*

Composite with leather	pH	Crtotal [mg/kg]	Pb total [mg/kg]	Cr** total [mg/kg]	Pb** total [mg/kg]
Black	2-3	0.59	2.07	0.20	0.20
	5-6	0.28	1.85	0.20	0.20
	9-10	0.28	BDL	0.20	0.20
	12	0.45	0.04	0.20	0.20
Brown	2-3	0.44	BDL	0.20	0.20
	5-6	0.96	4.88	0.20	0.20
	9-10	0.67	7.51	0.20	0.20
	12	2.33	BDL	0.20	0.20

***MO 95/2005- concentration maximum admise (CMA)BDL – below detected limit*

Black leather composite material shows some interesting things. In acidic medium, the concentration of chromium and lead exceeding MAC, this was expected. Between pH 5-6 we have an interesting thing we have a very close CMA total chromium but is well above the total lead CMA. Between pH 9-10 we have a resemblance to pH 5-6 chromium close by CMA total value and total value of lead BDL. At pH 12 total chromium is 0.45 [mg/kg] compared to 0.20 [mg/kg] lead CMA and CMA total value is below (Fig.6.)

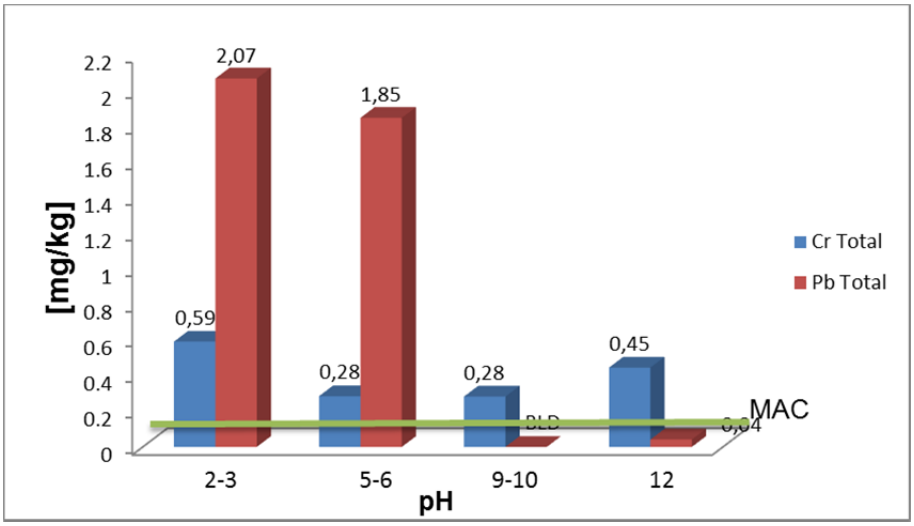

Fig. 6. *Composite with black leather*

Brown leather composite material entails a more rigorous attention. In acid environment, total chromium is 0.44 [mg/kg] double of the CMA and lead is BDL. Between pH 5-6 and 9-10 lead values is more than CMA, 24 and 37 times higher, total chromium is between 0.67-0.96 [mg/kg]. Last pH 12 shows a value of 12 times the total chromium CMA and total lead is BDL (Fig. 7).

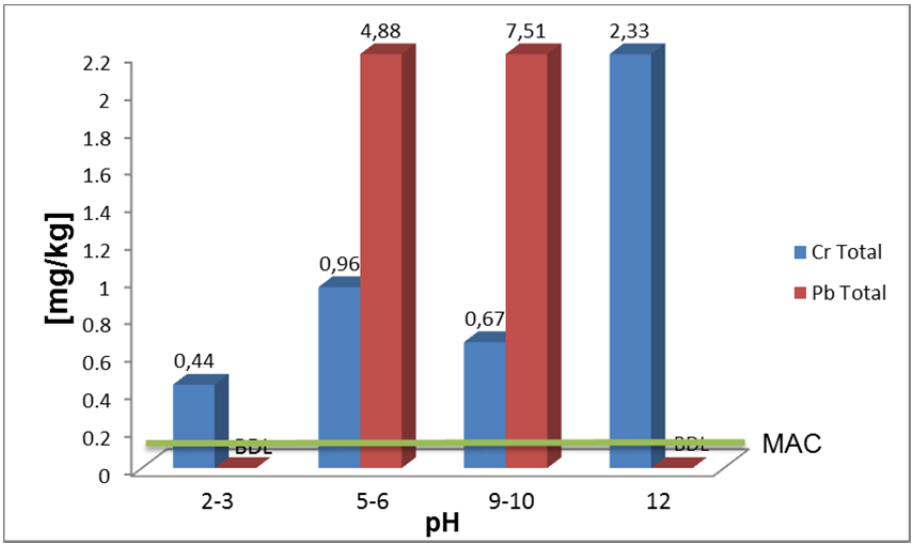

Fig. 7. *Composite with brown leather*

CONCLUSIONS

This study failed to show that leather waste storage is not a solution. This way to encapsulate a composite both leather and glass waste CRT has demonstrated that it can. Future directions should take into account the concentration of heavy metals in composite trying to reduce their percentage, mechanical testing for evidence of mechanical properties of the composite and market introduction of new composite materials in construction.

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PIPELINE MONITORING WITH DRONES

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ABSTRACT. Possible pipeline leakages along routes that are not always manned or populated often cause (if hazardous substances are released) significant environmental damage, with substantial economic impacts for subsequent cleanup and recovery. In the case of releases of flammable substances, there is also the risk of fire and explosion, which can involve people, production facilities, residential or commercial areas, infrastructures and other possible vulnerable targets in the area. Timely identification of possible leaks can make it possible to take immediate action and limit the amounts released, and thus reduce the possible consequences. With the systems routinely used for the detection of any containment leaks from pipelines it can be particularly difficult to detect losses that are below the tolerance limits of the installed measurement systems, but are nonetheless able to cause extensive environmental damage of great economic significance.

These issues give rise to the idea of using the SAPR (Remote Piloting Aircraft System) for monitoring pipelines, both underground and above ground, used for the conveying of liquid hydrocarbon products. The use of spectral analyses, combined with RGB input, allows the detecting of possible irregularities due to leakages occurring along the pipelines. The acquisition of multispectral digital images makes it possible to identify possible pools of petroleum hydrocarbons and, in certain cases, also the possible infiltration into the soil. The acquisition of digital images in the visible spectrum allows the determination, through the comparison of successive scans, of any unexpected changes in the morphology of the soil to be subjected to further investigation.

This article illustrates a technologically-advanced, economical and reliable solution, based on the use of drones, for the detection of smaller-sized leaks due to internal/external causes or to illegal removals by third parties, with limited costs, reduced times and excellent performance, also in comparison to other similar monitoring techniques.

Key words: *Drone, Pipeline, Photogrammetry, Thermometric, Spectrometric*

INTRODUCTION

The problems

Pipeline networks normally have many branches and can be built in sections of varying length, even reaching hundreds (or even thousands) of kilometers. They are built mainly in one of two ways: either above ground or buried underground. At present the extension of pipeline networks is continuously increasing; in the world, according to data provided by the CIA (Central Intelligence Agency) in 2013, it totaled $3 \cdot 10^6$ km worldwide (C.I.A., 2013). As for Italy, in 2013 there were 20,223 km of gas pipelines, 1393 km of pipelines for crude oil and 1574 km of pipelines for refined products.

The safety and the protection of all pipelines is important both for the system in itself and for the people and the surrounding environment, i.e. the targets that can be damaged by possible leaks. In order to ensure safety it is essential to keep the pipeline in excellent condition through regular maintenance, so as to prevent the aging of the components and their wear. Despite continuous and effective maintenance, the possibility of a leak cannot be eliminated, since not all causes of leakage can be detected in advance. Leaks from the pipeline can occur due to various causes, such as earthquakes or slippage of the soil (Gómez and Green, 2015), but also due to accidental hot taps or external actions by third parties.

A wide variety of consequences may occur from a leak, and these depend on various parameters, such as the temperature and pressure of the line, the diameter of the leak hole, the location of the pipe and the type of fluid carried. Large spills of fluid can lead to significant scenarios of fire, explosion and spreading, with consequences for the environment and humans. Small spills, however, may be more insidious, being difficult to detect since they do not involve a disruption of the soil in the case of buried pipelines or the formation of pools of liquid on the surface. The failure to recognize a leak allows the diffusion of the liquid hydrocarbon into the ground all the way to the aquifer, resulting in pollution of the subsoil even at great distances from the leak point. In most cases the current instrumental monitoring technologies do not allow the identification of small leaks (or cracking) without interrupting the pipeline transport.

Current monitoring methods

Widely differing methods are currently used for the monitoring and surveillance of both gas and oil pipelines.

The oldest method still in use is visual inspection carried out by “walkers,” i.e. contract employees with pipeline management companies. Walkers have the job of patrolling predefined areas to detect any leaks, inspecting the wells, although in general they are not able to work on any leaks. The main limitation is that it may be difficult to detect small leaks through visual/olfactory inspections, if the pipe is buried and there is no surfacing. Another limitation of inspections is that they are carried out according to a pre-established pattern based mainly on the statistical analysis of the accessible points that have higher probability of loss; thus there are areas that are never inspected.

The pressure monitoring method is based on the use of a series of pressure taps placed at pre-established distances along the pipeline, in order to monitor the trend of the pressure along the line. Through the interpolation of the point pressure values it is possible to extrapolate a continuous pressure trend with regard to the length of the pipe. If a leak occurs, there will be a deviation from the expected pressure trend. The advantage of pressure monitoring is that it allows one to identify the section where the leak is. The electronic equipment sends signals continuously to the control panel, so the trend of the pipeline parameters can be checked moment by moment. The main limitation is definitely the cost, given the high number of measuring instruments and need for wiring all along the pipeline. An additional limit is that of the presence of leaks that are not detected by the instrumentation; small leaks, i.e. those that have a flow rate less than or equal to 2% of the transported flow, and which can create variations in pressure not detectable by the instruments (P & G Journal, 2014) (Offshore Technology Report, 1996).

Leakage monitoring can also be done using ultrasonic flow detectors. The principle of operation behind these detectors is based on the contribution that a moving fluid makes to a sound wave, ultrasonic in particular, and thus the instruments that make use of this phenomenon are called transit time ultrasonic flow-meters. In this case as well, the limits of such meters are the impossibility of detecting small leaks and the costs connected with the installation of the system.

Pipeline monitoring can be done with the determining of the mass flow at different points along the line and the measuring of the flow rate differentials. To do this, detection systems based on the Coriolis effect are used; the mass flow rate should remain constant all along the line, and thus any variation indicates the presence of a leak. The monitoring of the flow rate based on the Coriolis effect is capable of detecting small leaks not easily detected by the preceding systems, although it still has detection limitations. The costs for a control system distributed into sections on the pipeline and its maintenance are decidedly high.

Another leakage monitoring method involves the use of conducting wires along the pipeline. The principle of operation is based on the fact that a mixture of hydrocarbons is an excellent solvent; if there is a leakage of the hydrocarbon mixture, it acts as a solvent for the cable jacket, usually made from plastic material, causing the conductors inside to short-circuit. Detecting the absence of an electric signal in a given portion of wire, it is possible to locate the leak. The main advantage of monitoring via conducting wires is the ability to detect both leaks and fires. The main limitation consists in the difficulty of detecting small leaks, given that to have total coverage of the pipeline it is necessary to wrap the cables along the entire circumference of the pipe, and this entails a very high cost, in consideration of the great length of the pipes.

The monitoring of pipelines, especially those not buried and of considerable length, can be done by flying over them by helicopter or airplane. The capacity of these aircraft allows the transport of a number of instruments, such as the DIAL (Differential Absorption LiDAR) instrument, which uses the radiation emanated to determine the presence and concentration of gas, or ground-penetrating radar to analyze the structure underlying the surface. The advantage of this method is the

possibility to transport a complex series of heavy control instruments, which may also be combined with each other. The possibility of a high-altitude overflight makes it possible to analyze a larger area, but at the same time, it results in a lower resolution at the ground level that the instrument can provide. This may result in the failure to detect small leaks which an overflight at a lower altitude would instead allow. The main limitations lie in the economic impact of the monitoring: the use of a vehicle of this size would require not only investment capital, but also a significant amount of fuel even for overflying relatively small areas.

Lastly, there are systems that acquire data at greater heights than those of the overflight of a normal plane or helicopter, i.e. satellites. Artificial satellites orbit around the planet outside of the earth's atmosphere, allowing the sending, or rather the communication, of data with the earth's surface. Satellites may be equipped with high resolution cameras in both the visible and infrared spectrums, but above all they can carry hyperspectral or multispectral cameras that make it possible to analyze specific precise spectrum bands. The advantage that this method provides is the possibility of using specific sensors, also of considerable weight, that cover vast areas of analysis. At the same time, however, this is a disadvantage for the resolution at ground level, which does not allow details to be obtained in the images. This practice has a substantial economic impact for the pipeline management company.

Table 1 gives, in a comparative manner, the characteristics of the methods currently applied.

Table 1. *Pipeline monitoring methods*

Monitoring method	**Detection**				
	continuous over time	*of visible leaks*	*of non-visible leaks*	*of small leaks*	*of fires*
Walkers	X	X			X
Pressure monitoring	X	X	X		
Flow monitoring	X	X	X	(X)	
Monitoring with conducting wires	X	X	X		X
Monitoring with planes/helicopters		X	X		X
Monitoring by satellite		X			X

Drone applications

One solution that can provide considerable benefits as regards both feasibility and speed of operations is the use of SAPR (Remote Piloting Aircraft System) in the monitoring of hydrocarbon pipelines. This is possible thanks to the multiplicity of sensors that can be mounted on board the aircraft, which allow the study of a wide band of spectra. The small mass also makes it possible to do lengthy scans, and in complete safety from the perspective of possible impacts or flight accidents.

Pipelines, like any transport line, extend for several kilometers. In some cases the areas they cross are hard to reach because they are located in rural areas or on the edge of wooded areas: this can make inspections, even if only visual, extremely difficult for operators of the pipeline management company. The use of drones makes it possible to overcome this limitation, because the operator controls the flight of the vehicle from his station, positioning it over the area of interest in order to obtain the required data. When monitoring large areas it is usually better to use fixed-wing drones, so as to allow a longer flight time and a greater monitoring efficiency. With simple direct visual inspections, without subsequent processing of the data collected, the camera placed on the drone transmits images directly to a video terminal, where a technician checks the state of the system being analyzed.

For inspections that require more detailed and specific analyses, rotorcraft drones are preferable for their greater capacity for movement in restricted areas.

The leakage of liquids and gases from pipes, which originate small but continuous leaks difficult to detect with the naked eye or by fixed instrumentation, propagates into the environment. When accumulating, these leaks can cause fire or explosion scenarios that are dangerous for operators who are in the area. Executing a flyby, rotorcraft drones equipped with appropriate instruments are able to identify small drops on the surface of the pipe or small clouds of gas, as if the operator were performing an analysis on site using the instrument on the drone, but in conditions of absolute safety. Fixed-wing drones, furthermore, travel at a height that makes it possible to avoid the possible igniting of flammable clouds by the drone itself.

The deliberate actions by third parties mainly concern the theft of the transported product, generally from underground pipelines, where it is easier to hide the illegal branch by means of excavations, later covered, with considerable economic damage to the operators of the pipelines and serious environmental risks caused by probable leaks, given the poor quality of the illegal branches. The photogrammetric technique, which can be done by means of aerial filming or multiple photos from the aircraft, allows the obtaining of an orthophoto, either flat or solid, of the area around the pipeline with a very high ground-level resolution. By comparing the images from inspections carried out at different times, it is possible to spot the differences between the images themselves and identify possible human intervention in the surrounding area of the pipeline. In any case the presence of unauthorized vehicles in the area or unauthorized intervention is possible.

THE PROPOSAL

The high-performance solution, designed for monitoring pipelines leaks, regards the use of SAPR combined with software for the management and reprocessing of the raw data. The possibility of installing a variety of sensor types, both individually and in combination, opens up a vast field among the activities that can be carried out. The technological development makes it possible to combine the traditional overflight for visual inspection with actions aimed at the search for specific irregularities in the analysis area. The action involves two types of machines:

- Fixed-wing SAPR, glider drones that allow surveying of very wide areas, in relation to a higher flying speed and lower battery consumption;
- Rotorcraft SAPR, multi-rotor drones that make it possible to obtain maximum detail for medium/small-sized areas, so as to allow close scans of non-buried pipelines.

These two aircraft can be equipped, either individually or in combination, with two types of sensors:

- RGB camera, i.e. a normal photo/video camera, for obtaining images in the visible spectrum;
- spectral cameras, which allow the analyzing of specific spectra, both visible and infrared.

These may be accompanied by thermo-graphic cameras, which allow the analyzing of the far infrared (IR) spectrum.

The Drone

The aircraft primarily used for these actions is the fixed-wing type, which has the following characteristics:

- Dimensions: wingspan 1300 mm (figure 1);
- Mass: <2 kg, variable from 1200 to 1300 g;
- Payload: >400g;
- Batteries: lithium polymer;
- Endurance: approx. 40 minutes;
- Cruising speed: 21 km/h (6m/s);
- Maximum speed: up to 53.6 km/h (14.9m/s);
- Minimum speed: 6.1 to 6.5 km/h (1.7 to 1.8m/s).

Fig. 1. *The drone considered*

PROPOSED DETECTION TECHNIQUES AND PROCEDURES

Photogrammetry

Photogrammetry is a surveying technique based on the central perspective model, which makes it possible to obtain three-dimensional metric information on the shape and position of the object being analyzed, by means of a system that does not require physical contact with the object. The processing is done through the acquisition of photographic images.

The use of the photogrammetric technique thus allows one to identify irregularities in the morphology of the ground, by analyzing the chromatic variation and the variation of the relief through the use of the technique and the aid of suitable software. The result of the method is a KMZ file (a compressed version of the KML -Keyhole Markup Language - file) or GIS file, designed for managing geospatial data, in order to geographically locate the irregularities identified. This technique is thus applicable to both buried and above-ground pipelines that transport either liquid compounds or gas, in order to identify possible interventions (illegal or not) by third parties.

The sensors, or payload, required are the traditional compact cameras for capturing images and/or videos, or which make it possible to obtain a representation of the visible spectrum. The interaction between the sensor and the lens mounted and the flight altitude are fundamental for the determining of the GSD (Ground Sample Distance), which provides the resolution of the picture relative to the ground, i.e. it indicates how many centimeters at ground level are represented by one pixel. The resolution is expressed in cm/px (www.pix4d.com, 2015).

The cameras must have the least possible mass, so as not to require a large-size drone and to allow long flight duration. In fact, a smaller payload is reflected in a reduction of the power required by the drone rotors, which consequently increases the life of the batteries. The camera size is a crucial aspect for fixed-wing drones, since the camera must be inserted inside the body of the aircraft.

The software used for processing allows one to obtain, as main products, two-dimensional and three-dimensional reconstructions of the earth's surface. These reconstructions are respectively called flat and solid orthophotos. An orthophoto is a photograph that has been georeferenced and corrected from a geometrical perspective, so as to have a uniform scale; the photo can be considered the equivalent of a map and can be used for measurements (Ciaramella, 2008).

The procedure is based on the execution of a series of overflights, with the acquisition of georeferenced images of the area around the pipeline. The comparison between the data obtained in two successive overflights allows the identifying of possible illegal actions.

The algorithm uses as input the software output, i.e. the 3D and 2D representations of the surface, in the form of TIFF files, with an RGB color scale, and LAS files. The processing steps can be grouped as follows.

- Acquisition of the first overflight and georeferencing files, by means of vectors, of the pixels constituting the image.

- Acquisition of the second overflight files and georeferencing, by means of vectors, of the pixels constituting the image.
- Uniforming of the color scheme of the two images, in order to reduce the background noise resulting from the mathematical subtraction of the image levels, and the creating of color maps, according to the color difference.
- Comparison of the elevation with the corresponding latitude and longitude, creating a colored map.
- Combination of the two colored maps.

These steps were tested in a practical test, carried out over the Etruria Volo srl experimentation field. The test involved two overflights:

- the first done before creating variations on the ground;
- the second after having created holes having the dimensions given in table 2.

Table 2. *Hole characteristics*

Type of hole	Length (mm)	Width (mm)	Depth (mm)	Number
Small	200	300	50	2
Medium	400	600	50	4
Large	500	900	50	2
Deep	500	900	500	1

The results obtained are shown in figure 2, taking by the outgoing KML.

Fig. 2. *Showing of variations on the KML file*

It can be seen from the images obtained how the “largest” size excavation (highlighted in white in the image) is easily visible, while the smaller ones are less evident. The size of the area removed, also in the case shown, is less than 0.5 m2, which is not overly large. This implies a quite good potential for the proposed technique.

Spectrometric

The term spectrometry indicates the set of measurement methods and techniques carried out using spectrometers, which are instruments that measure the electromagnetic spectrum as a function of wavelength. Spectrometry, which makes it possible in our specific case to analyze the infrared spectrum, is based on the interaction that every single molecule has with electromagnetic radiation: when radiation strikes a substance or material, part of it can pass through it, another part is absorbed by the substance, and part of it is reflected.

The instruments considered for spectrometric analysis do not emit radiation but receive it, thus they are called passive; they receive the radiation that passes through the test substance in the case of a gas, and the reflected radiation in the case of a liquid/solid.

The sensors used are specific to the activity to be performed. A main macro division of the sensors is carried out depending on the bands and are divided into multispectral and hyper-spectral. A multispectral sensor is an instrument that records the intensity of the energy reflected by objects such as the earth’s surface, at different wavelengths of the electromagnetic radiation between the visible and the infrared. The bands taken into account by the instrument are wide, distant from each other and few in number. Reprocessing the reflectance values measured by the instrument at the precise bands through specific indexes, it is possible to analyze the object or surface from which the radiation comes. A hyper-spectral sensor divides the electromagnetic radiation reflected by the object being analyzed into a series of very narrow bands and in large quantities. The analysis spectrum includes ultraviolet, visible and infrared, depending on the type of semiconductor used in the sensor (Masini, 2013).

The result provided by the instrument is a visual representation of the area surveyed, showing the variation of the intensity of the reflected radiation having a wavelength belonging to that band: a greater intensity will be represented by a lighter pixel. Greater radiation striking the element constituting the sensor corresponds to a strong signal sent from the element, represented by a lighter color. Thus different images are obtained, where each represents the intensity of the specific band. Using algorithms (indexes) it is possible to trace the images to a single map, where a color is associated to specific index values. The use of appropriate indices makes it possible to highlight, or differentiate, characteristics of the areas being analyzed.

The spectrometric method is based on the use of the spectrometric technique, employing both multispectral and hyper-spectral systems for the detection and identification of leaks of hydrocarbons in the liquid or gaseous state. The results of the method depend on the instrument used, which may make a simple video or produce a KMZ or GIS file, so as to manage geospatial data in order to geographically locate the irregularities detected. Therefore this technique is

applicable for buried and above-ground pipelines carrying either liquid or gaseous compounds, in order to identify possible leakages.

The use of such instrumentation, however, allows one to obtain a much smaller quantity of information compared to hyper-spectral instruments.

The usable spectrum is the IR that is reflected by the objects, including at wavelengths close to the visible spectrum, in the NIR - Near Infra Red (800-1700nm) region; in fact liquid hydrocarbons have a specific spectrum in the NIR region, as is pointed out by figure 3, in which the reflectance spectra of two mixtures of hydrocarbons are shown. The vertical line indicates the boundary between the visible spectrum and the infrared spectrum.

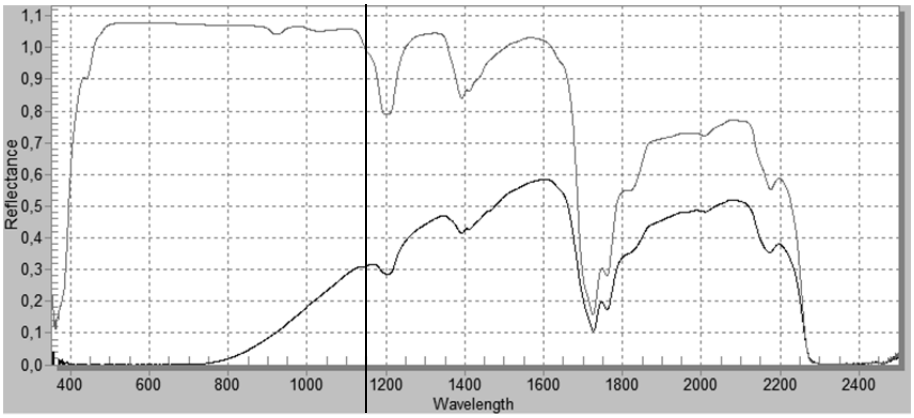

Fig. 3. *Spectrum of two hydrocarbon mixtures (Headwall – www.headwallphotonics.com)*

Figure 4 instead shows the reflectance of the soil, which is dependent on the percentage of moisture it contains.

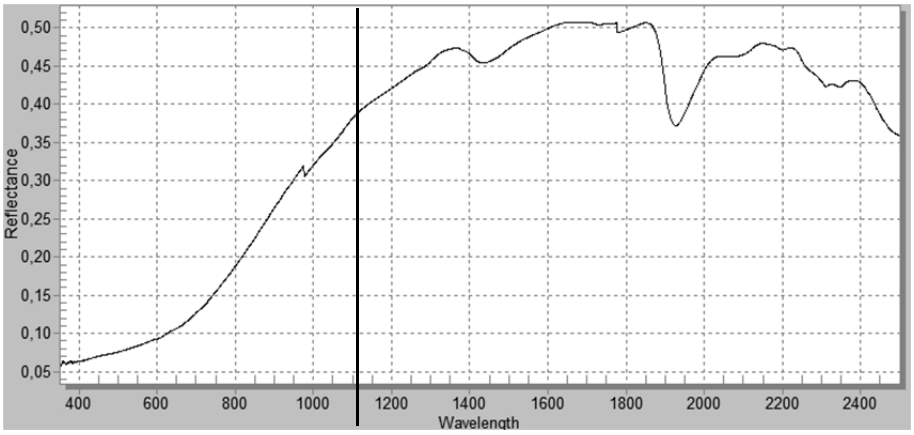

Fig. 4. *Spectrum of the soil (Headwall – www.headwallphotonics.com)*

The comparison between the spectra shows a very different response of the soil with respect to the hydrocarbon mixtures; therefore, using specific indexes it is possible to construct indexed maps for identifying hydrocarbon with respect to the surrounding soil. More specifically, it can be seen that the presence of hydrocarbons has an influence on the NIR band, while the hydrocarbon behavior is similar to that of vegetation, although the response differs in the blue and green bands. These considerations were used to develop an index shown in Equation 1.

$$I_{HC} = \frac{NIR}{G}, \tag{1}$$

where IHC – index; NIR – intensity of the near infrared band; G – intensity of the green band.

According to that described, the sensor considered is a multispectral three-band sensor, with green (G), blue (B) and infrared (NIR).

The procedure conceived is based on the making of periodic overflights along the pipeline, with the acquisition of geo-referenced images of the area adjacent to the pipeline. The immediate analysis of the data obtained allows the detecting of possible leaks.

The algorithm uses the 2D representation of the surface as input in the form of TIFF files. The processing stages can be grouped as follows.

- Division of the data into the three levels of NIR-G-B bands and the creation of the matrix of the index considered.
- Color representation of the matrix developed earlier.
- Graphic representation of the indexed map obtained.

The flow of the operations was subjected to a practical test, carried out at the Etruria Volo experimentation field. The test is based on an overflight, where watertight hydrocarbon containers with the bottom covered with earth had been positioned. Table 3 shows the size of the pools and the hydrocarbon mixtures considered.

Table 3. *Pool characteristics*.

Pool	Mixture	Type	Length (mm)	Width (mm)
Small	Gasoline	Surface film	200	300
	Diesel	Surface film		
Medium	Gasoline	Surface film	400	600
	Diesel	Surface film		
	Gasoline	Soaked soil		
	Diesel	Soaked soil		
Large	Gasoline	Surface film	500	900
	Diesel	Surface film		

The sensor used is a modified camera: in the place of the filter that does not allow infrared to pass a red-block filter was positioned, so as to eliminate the absorption of red.

The results obtained are shown in figure 5.

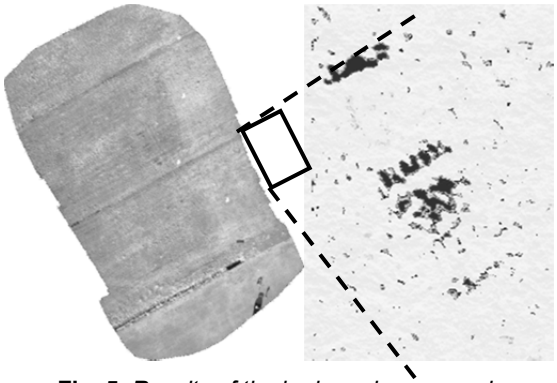

Fig. 5. *Results of the hydrocarbons search*

The images obtained show how the "larger" pools are more easily seen, while the smaller ones are less evident. The extension of the film, in this case as in the previous one, is less than 0.5 m^2, which is still not overly large. This implies a quite good potential for the proposed technique. One disadvantage in the functioning of this technique is the necessary presence of sunlight, as the different radiation reflected from the hydrocarbon film with regard to the surrounding soil is being analyzed. This limit is always found in any instrument that analyzes reflected radiation, such as a classic photo camera.

Thermometric

The use of a thermo-graphic camera, as mentioned previously, makes it possible to analyze the trend of the far IR spectrum (10-12μm) and, therefore, the trend of the surface temperatures of the bodies being examined. It also allows the identification of hydrocarbon gases that interact with the infrared spectrum, which, in this case, are methane, LPG and gasoline vapors. This can be easily understood by analyzing the absorption spectrum of these substances, as shown in figure 6.

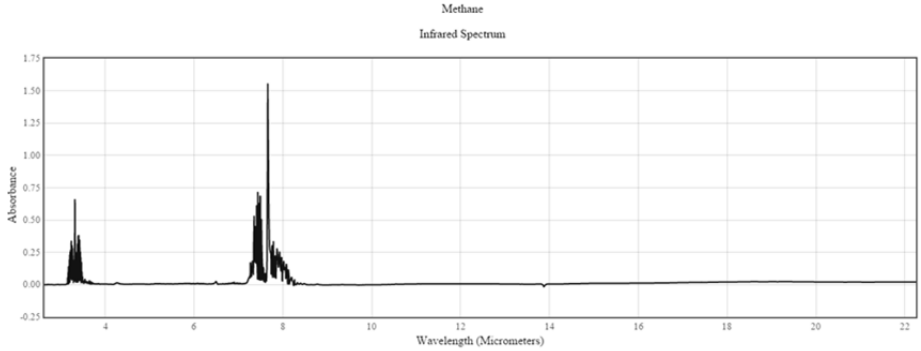

Fig. 6. *Spectrum in the infrared region corresponding to methane (NIRST – www.webbook.nist.gov).*

The highest peak corresponds precisely to the area of interest in the LWIR (Long Wavelengths Infra Red) thermo-graphic cameras, implying a visibility during the use of the camera for the photographing of the area.

CONCLUSIONS

The applications of the proposed SAPR, which can apply the detection techniques selected and described, allow the reliable identification of both large and small leaks of hydrocarbons, both above and below ground, making it possible to act quickly and to limit both the environmental impact of the leak and the economic losses. The drone system allows quick, frequent and complete monitoring, with the acquisition of high resolution data, at very low investment and operating costs.

The initial investment for the purchase of the complete instrumentation is €40,000, and includes the aircraft, sensors, and training necessary for the operators. The investment breakdown is shown in table 4.

Table 4. *Initial investment*

Element	Cost (€)
Drone	12,000
Photo camera	1,500
Thermo-graphic Camera	12,000
Multispectral Camera	5,000
Computer	4,500
Software	3,500
Batteries	500
Operator Training	1,000
Total	40,000

The possibility of having complete autonomy in deciding the analysis frequency and methods, targeted to the specific nature of the work to be monitored, makes it possible to obtain data and information recorded continuously so as to provide a complete and accurate evolutionary view of the phenomena periodically observed.

The strength of this method is that of being able to analyze variations in the morphology of the soil over time, so as to identify illicit actions by third parties.

In this regard, mention should be made of the 2015 CONCAWE - CONservation of Clean Air and Water in Europe report, which provides information on liquid spills and, among these, the frequency of leaks that occur along pipelines over time. The frequency distribution according to the type of cause is shown in the histogram in figure 7; the histogram shows the distribution of average frequencies over five-year periods from 1971 to 2013 (CONCAWE, 2015).

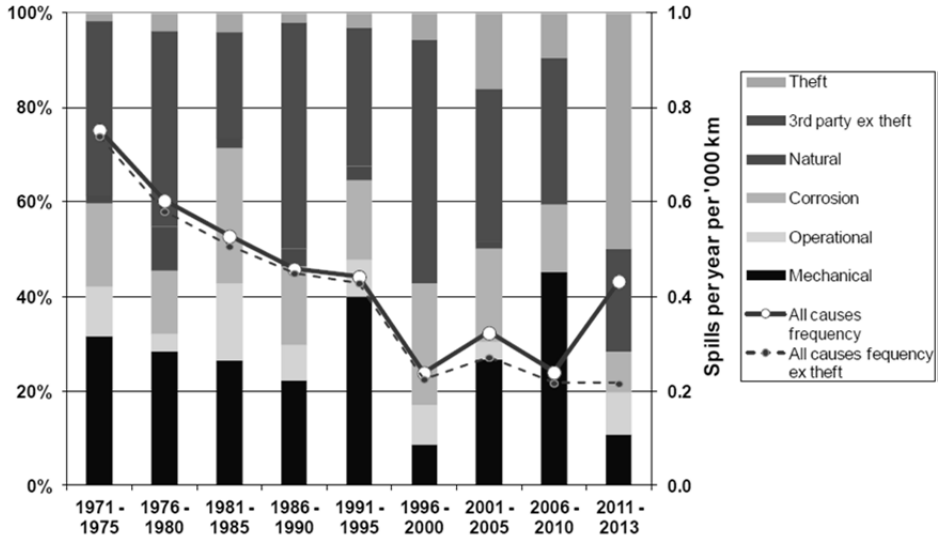

Fig. 7. *Histogram of the distribution of average frequencies according to cause (CONCAWE, 2015*)

The figure shows how activities by third parties is the dominant cause over time. In particular, illegal removals over time have acquired increasingly greater weight. In confirmation of the above, in 2013 the value of thefts came to 50% of the annual leakage rate. The possibility of taking prompt action against this illicit activity therefore appears to be a considerable advantage for the manager of the pipeline.

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GEOMORPHOLOGICAL CONSTRAINTS IN THE URBAN DEVELOPMENT OF THE GRUIA DISTRICT IN CLUJ-NAPOCA

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ABSTRACT. The development and the territorial evolution of the residential complexes specific to urban areas are restricted by the landscape in the territories split by valley corridors. This also applies to the town of Cluj-Napoca, which has experienced during recent years an unprecedented urban increase. This paper deals with the suitability of the ground for new buildings in Gruia district (Cetătuia Hill), located in the central part of the town. As opposed to peripheral districts where the extension of built areas can be made at the expense of the unincorporated areas, in the central parts this is only possible by using the limited surfaces within the built-up areas. Very often, these areas are restrictive with regard to the construction of new buildings. The existing buildings have been initially logged by using GIS techniques. Subsequently, based on the characteristics of natural and anthropic factors, a map indicating the probability of landslides was drafted. Such a map provides valuable information on the plots of land that could sustain new constructions, as well as with regard to the costs of such constructions. All this information should be taken into consideration in the future, since it represents the basis for current and future urban planning decisions.

Key words: *landslides, constructions, probability, urban planning*

INTRODUCTION

The town of Cluj-Napoca is situated in the western part of the Transylvanian Basin, at its boundaries with the Apuseni Mountains or - to be more precise - in the corridor of the rivers Somesul Mic and Nadăs. Due to the fact that these pieces of land are specific for valley corridors, the broadening of residential areas is dependent on the features of the landscape and the dynamics of the associated geomorphological processes.

Knowing the territory of Cluj-Napoca with regards to its geomorphology has a considerable importance because it provides the chance to outline the extension possibilities of the urban area based on the characteristics of a natural component - which is the landscape. At the same time, the occurrence of geomorphological processes and phenomena which lead to the emergence of new landscapes is associated with hazardous geomorphological phenomena that cause constraints for the development of the urban area.

The landscape is an essential component of the environment and, at the same time, the foundation for the rest of the natural components and anthropic activities. It is the reason why possessing knowledge on the landscape constitutes an important prerequisite for drawing up planning programs, urban development, or environment protection programs.

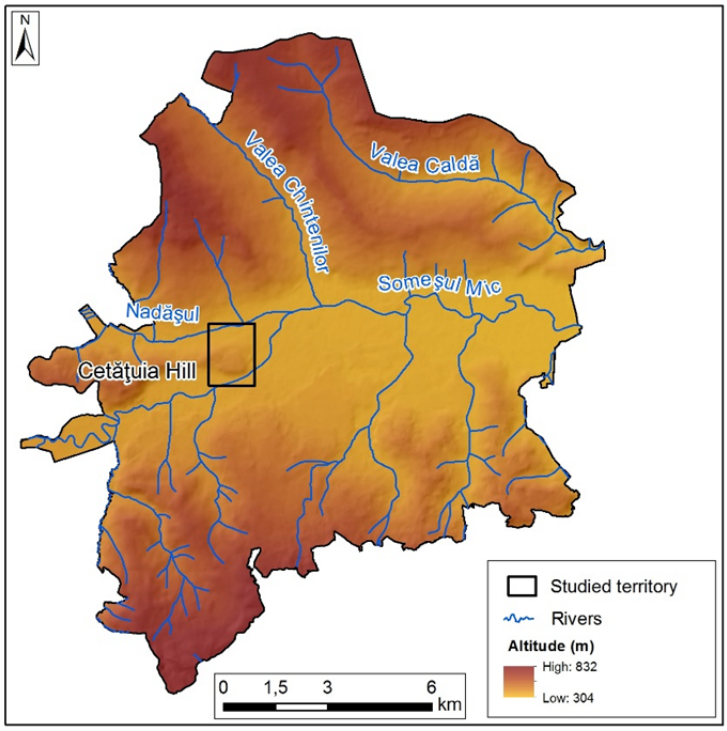

Fig. 1. *The position of the examined territory*

From all the residential areas in Cluj-Napoca, the present work focuses on the Gruia district situated in the central part of the town, which overlaps Cetătuia hill. On this area, the anthropic pressure is increasing, due to the fact that new buildings are being built. The problem is not so much the lack of plots of lands, as their inconvenient features for new constructions.

MATERIALS AND METHODS

In addition to field observations, GIS methods have been used in order to obtain objective results. Initially this consisted in the conversion of information from raster format (from geologic, topographic, cadastral maps etc.) into vector format, so that it could be subsequently used for calculations using the specific functions of the GIS software (ArcMAap10.2.2). For this purpose, the following functions have been used: editor, statistics, extract and export map.

After creating the data base, in order to obtain the map indicating the probability of landslides, the methodology described in the GT-O19-98 (Technical guide for developing landslide risk maps) was applied. It should be added that the data processing has also been carried out using the specific functions of GIS software.

The assessment of the probability of landslides occurring in the central part of Cluj-Napoca (Cetătuia hill) has therefore been conducted based on a methodology that allows the overlapping of several thematic layers. In this case, these are the lithology, the landscape altimetry (the level curves), the landscape parameters (the slant, the fragmentation depths, fragmentation density), the waters, the current geomorphological processes, the use of the lands etc.

After creating the data base, the values from each layer have been assessed according to the existing methodology regulations and to the specific features of the examined territory in order to obtain indicators regarding the vulnerability to geomorphological processes based on which, in the end are established the probability classes for landslides (Bălteanu et al., 2010; Dhakal et al., 2000). The above mentioned calculation is possible due to the fact that the data has a raster format, the operations taking place at pixel level with a size of 5x5m, allowing thus a real and isolated dimensioning of the concerning phenomena.

The centralisation of the values obtained on a single map enables a general assessment of the morpho-dynamic potential, the stability of the areas with regard to the natural balance, or of the risk degree brought on by economic activities (building of roads, residential units, etc.)

In order to draft the map predicting the probability of landslides occurring, the formula given by the GT-O19-98 norm was applied.

$$K_m = \frac{K_a \cdot K_b}{6}\left(K_c + K_d + K_e + K_f + K_g + K_h\right)$$

K_a = lithology factor;
K_b = geomorphological factor;
K_c = structural factor;
K_d = hydrological and climatic factor;
K_e = hydrogeological factor;
K_f = seismic factor;
K_g = forestry factor;
K_h = anthropogenic factor.

The values for the eight factors have been determined as follows: the lithology factor was determined based on geological maps and field investigations; geomorphology factor is based on a high resolution DEM (Digital Elevation Model) from which slope and landform depth maps were obtained; geological structure was extracted from geological maps along with the hydrogeology factor; climatic and hydrological data is obtained from the meteorological station near the study area (included as a constant); seismicity was introduced as a constant value (considering the limited spatial extension of our study area there are no differenced regarding this factor), as specified in the GT-O19-98 Guide; land use and anthropogenic factors were obtained by field investigations and measurement but also using ortophoto data (Sarkar and Kanungo, 2004). In the end of the processing phase all data was converted to raster (5 m spatial resolution) thus resulting 8 raster files. All raster data was reclassified and final scores were assigned according with the 6 classes required by GT-O19-98.

In the final stage all data was included in the formula by using Raster Calculator in ESRI ArcGIS 10.2.2 and the landslide probability map was obtained.

RESULTS AND DISCUSSIONS

After processing the existing data, several graphic materials and statistics ensued. From all the data, the ones referring to geology, landscape, the probability of landslides occurrence, the number and the surface of the properties belonging to each probability class will be presented

The geology

The examined area overlaps a sophisticated geological sub-layer (Fig. 2) with deposits of various ages, from Rupelian to Holocene.

The oldest deposits belong to the Oligocene (Rupelian Age) and these are the Moigrad Formations (consisting of red bed clays with lavender, brown or tile-coloured shades with sand lentils, sandstones or micro-conglomerates), the Dâncu Formations (grey marl clay deposits) and the Gruia Formation (sandstones and sands) (Mészáros and Clichici, 1998; Hosu, 1999; Cristea et al., 2002; Chira and Popa, 2004).

More recent deposits belong to the Pleistocene and Holocene and consist of sands and gravel.

The relief

As one can notice in Fig. 2, the Gruia neighbourhood overlaps with the Hill Cetătuia. The latter is an interfluvial crest between the rivers Somesul Mic and Nadăs (Morariu and Mac, 1967; Pop, 2007). The heights vary from 328 m in the Somesul Mic flood plain to 416 m on the plateau on the upper side. Although the altitude values are not high, with differences of only 88 m, due to the fact that they differ rapidly on distances with low values (120 m at the upper side of the Hill Cetătuia down to the banks of Somesul Mic), the slope exceeds on wide areas 20^{o} (Fig. 4).

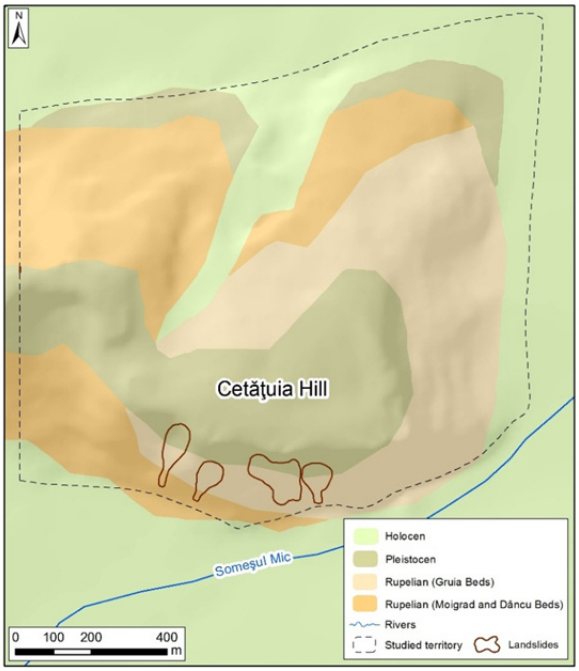

Fig. 2. *Geological map*

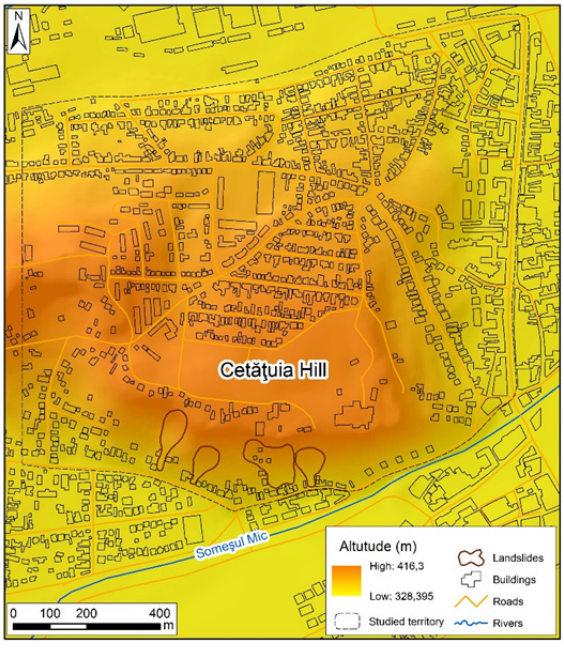

Fig. 3. *Digital elevation model of the terrain*

Put together, geological and landscape-related conditions have been able to favour the emergence of geomorphological processes (GT 019-98, 1998), such as landslides, as it can be noticed (Fig. 2, Fig. 3, Fig. 4), there are four landslides (2.84 ha). They are located on clay deposits belonging to the Moigrad, Dâncu and Gruia Formations.

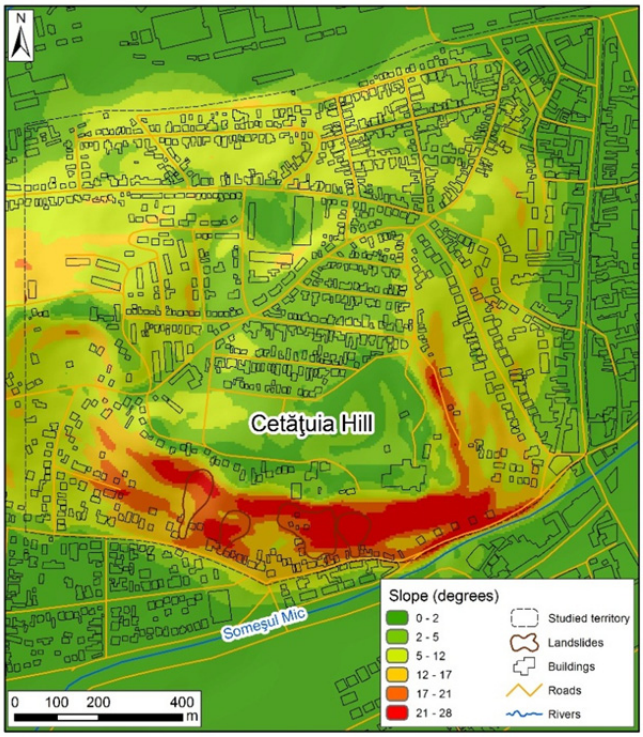

Fig. 4. *Slopes map*

Probability of landslides

From the six probability classes on landslides occurrence established according to Gt-019-98 (virtually nil, low, average, average-high, high, and very high), in the present case five of them can be encountered: low (0-0.1), average (0.1-0.3), average-high (0.3-0.5), high (0.5-0.8), very high (0.8-1).

With regards to the spatial distribution, the following situation can be noticed (Fig. 5, Table 1):

- the low probability class stretches over limited areas, being present in the flood plain of Somesul Mic and Nadăs and in patches on the interfluvial plateau of the Cetătuia hill;

- the average probability class can be noticed on the northern and eastern slopes of the Cetătuia hill;

- the average-high, high, and very high probability classes are only present on the southern slope of Cetătuia hill.

As it can be noticed from the probability map on landslide occurrence, the result of the model is quite balanced: for the flood plain areas the occurrence probability is low (still the values are higher than 0), whereas for the slopes the probability may even reach 0.84 (a very high value) for the surfaces affected by active landslides. It must also be pointed out that, considering that landslides already took place, these have also been included in the drafted model as part of the geomorphological factor.

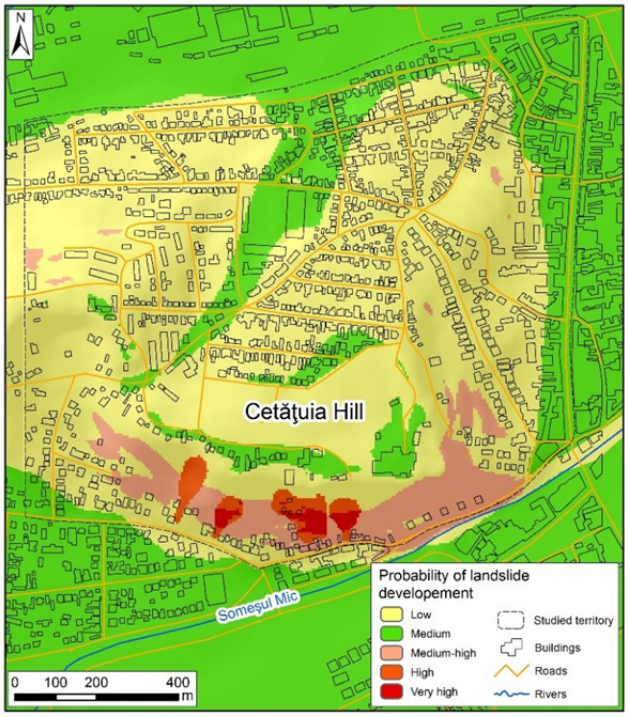

Fig. 5. *The probability map of landslides occurrence*

Table 1. *The correlation between the probability classes and the number of constructions*

Probability class	Surface class probability (ha)	Number of buildings	Surface buildings* (ha)	Surface buildings * (m^2)
Low	33.11	218	9.48	94,800
Medium	104.50	720	19.37	193,700
Medium -high	10.61	39	0.84	8,400
High	1.91	3	0.09	900
Very high	0.87	3	0.02	200
Total	151	983	29.8	298,000

* footprint data (some buildings have several stories)

Surface area of the properties for each probability class

As it can be noticed from table 1, the situation is currently normal in this regard. That means that most of the buildings are located on areas with low (218), medium (720), and medium-high (39) probability classes, whereas for the high (3) and very high (3) probability classes, the number of buildings is very low.

Considering that new spaces for the building of new constructions are needed, the anthropic pressure will increase on lands with high and very high probability classes. This means, that new constructions will be raised on pieces of lands which are ever more prone to landslides. In addition to this, the costs for the new buildings will be higher, considering the necessary additional works needed for their consolidation

Moreover, given that four landslides already took place, measures for their countervailing and for the prevention of new ones are necessary since the land is vulnerable to landslides. Among the works that could counter the occurrence of landslides we suggest the following: works to shape and level the land, support works for unstable areas (retaining walls), afforestation. Prevention works that could be carried out are: works to prevent water access, works to diminish the influence of underground waters, planting of shrubs, drainage works.

CONCLUSIONS

In the Gruia district, the expansion of built areas will take place in the future especially on lands with a medium-high, high, and very high occurrence probability class. Although areas from the classes with low and medium vulnerability are still available, these cannot be used to this purpose due to their special destination (the area around the Parasutistilor Tower, sports grounds, and graveyards). The consequence of the increase of anthropic pressure on fields prone to landslides will reflect in the cost of construction works and in that of the works needed for the maintenance of the constructions.

The building of new constructions requires the expansion of the current road network, which is 17.25 km long in the examined perimeter. These roads also fall within the same probability classes of landslide occurrence (Fig. 5).

The classification of the areas according to the vulnerability to landslides benefits both the territorial planning and development measures, and avoidance to errect buildings in unstable areas. The knowledge of the vulnerability to landslides is useful in order to make a distinction concerning the taxes owed to the local administration, but also for the assessment of their value by insurers. This will force any developer to strictly comply with the local urban plans.

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DYNAMIC ASSESSMENT METHODS IN A CHANGING WORLD

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ABSTRACT. For the field of environmental pollution as for the sustainability field there is a need to have direct access not only to specific methodologies by a systematic approach, but also to assessment methods. In the mentioned fields the difficulty is represented by the fact that sometimes it is difficult to establish limit values. Regarding sustainable development there is often the situation of not having limit values, in contradiction to the environmental pollution field, where emission or immision limit values have already been established for most of the pollutants. Establishing development limit values is pretty difficult in all sustainability fields, i.e. economic, environmental and social fields. In the environmental field in most of the cases there are limit values, but in the other two relevant sustainability fields, economic and social field, establishing limit values is not at all easy. This means that nowadays it is pretty difficult to precociously assess if a certain development will assure the sustainability of the considered region. In the last time several discussions have taken place on scientific level regarding the necessity to develop so-called "dynamic assessment methods", in order to make evaluation in those fields where limit values for a certain development cannot be defined or do not exist, as for instance in medical or social fields. The idea behind dynamic assessment methods is actually that different parameter gradients are compared, and not the parameter values themselves. Results will be debated and conclusions concerning the presented methodology will be drawn.

Key words: *environmental pollution, dynamic assessment, limit values*

INTRODUCTION

Presently several global problems are facing the humanity, as stated in Figure 1, which can be grouped in three categories: growth of world population, growth of energy and natural resources consumption and environmental pollution (Jischa, 2005). Beside these so-called "old" global problems, other issues have arisen in the last years and they can be called "new" global problems. For instance issues related to the use of ICTs and the new information society can be mentioned in this category (Tulbure, 2003).

The world began to realize starting with the ‘70 years, in the time of huge technological development, also the dangers and undesired effects of human activities, especially industrial ones. At latest after the Conference for Environment in Stockholm in 1972 and the first report to the Club of Rome „The Limits to Growth“ in 1972 “ (Meadows et al. 1972), it was understood that besides wanted and positive effects of technological progress, also undesired and negative effects can appear. After this time the environmental awareness in the Western world began changing. It was clear that the arisen regional and global environmental problems are very serious and need to be solved.

Worldwide began discussions on political, scientific and social levels in order to find solutions for the problems shown above, which could be applicable with respect to regional differences to the developed as well as to the developing countries. The Brundtland Report of the World Council on Environment and Development represented a result of these worldwide political discussions. The concept of *sustainable development* was defined in the Brundtland Report 1987 and accepted as a possible solution for the global complex ecological, economical, and social problems, as shown in Figure 1:

"Sustainable development means the ability of humanity to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." (Hauff, 1987).

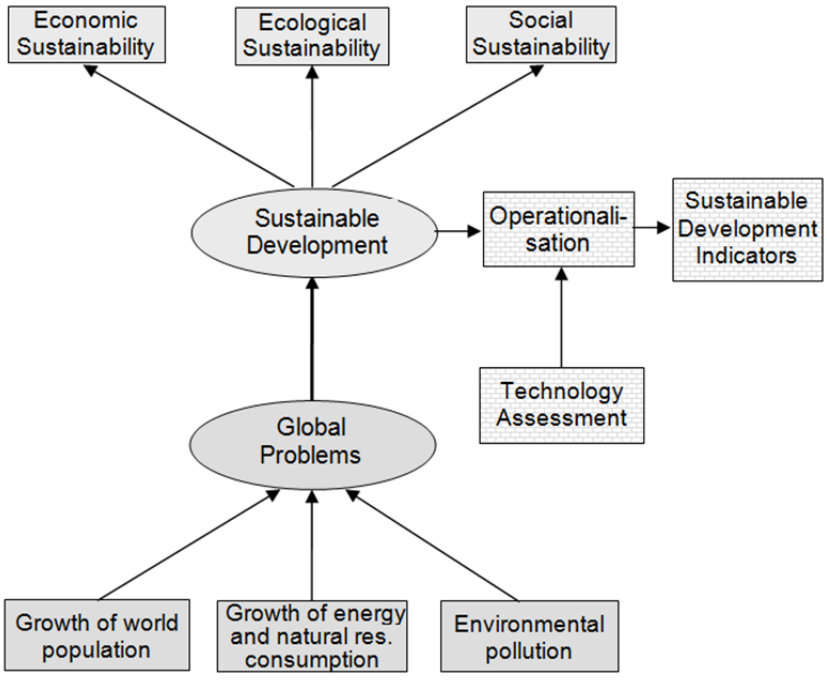

Fig. 1. *Global problems and the concept of sustainable development*

The concept of sustainable development together with its applying forms and understanding patterns was very large discussed on the *United Nations Conference on Environment and Development* in Rio de Janeiro 1992 as well as approached in the closing document *„Agenda 21“*(Engelhardt and Weinzierl, 1993).

Specific sustainable development applying forms and possibilities not only on a global level, but on a regional and local level have been emphasised 2002 during the Johannesburg Conference, called as *Earth Summit*, also known as ”*Rio+10”* - *Conference* (Tulbure, 2013), as well as 2012 during the *"Rio+20"* - *Conference on Sustainable Development*.

Many actions after this time did emphasize that the evolution of technical, social and ecological systems has to be analyzed in synergetic relation (Tulbure, 2003). The general Brundtland definition was worldwide accepted, but alone it does not deliver a concept, that can be applied to the real concrete situations (Lengsfeld et al., 2003).

Sustainable development has become a widely used term today. However, looking in the literature dealing with this topic, the impression arises that there are as many definitions of sustainable development as there are users of the term. In order to make this concept more understandable, rules, strategies and principles of sustainable development have been defined (Tulbure, 1997). The general Brundtland definition has been worldwide accepted, but together with the rules, strategies and principles, it does not deliver a concrete methodology, how to apply it to real concrete situations, especially on local level or even production process levels (Ludwig, 1995).

MATERIAL AND METHOD

The concrete application of the concept of sustainable development for different cases on regional or local level, actually its operationalization, means the transformation or translation of its goals into political measures and controlling instruments, in the form of Sustainable Development Indicators, SDI, as presented in Figure 1. A general methodology in order to concretely apply the concept of sustainable development on regional or local level can be materialized in the following steps (Tulbure, 2013; Jischa 2005):

- defining the sustainability problem;
- establishing the space and time scales;
- systemic approach of the region by modelling the interactions;
- establishing concrete aims for the studied case;
- developing concepts and measures by establishing priorities;
- developing evaluation and controlling instruments, Sustainable Development Indicators;
- verifying the possible results, which could be obtained after introducing the proposed measures, comparing different scenarios;
- applying into the practice the developed concept.

From this methodology follows that for an individual problem-case concrete sustainability aims are generally established, the operationalization being only

possible, when from these aims concrete concepts and measures to achieve them are developed. Sustainability is to be newly defined for each different case. The space and time scales are to be established for each case.

There are several levels to apply the concept of sustainable development. On a global level this means to define general sustainability goals for the whole world, what happened more or less with the Rio - Conferences. On a national level this means to define goals paying attention to the specific conditions of the certain country, these goals and specific measures to achieve them being stated in the National Sustainable Development Strategy of the certain country. On regional or local level concrete measures are stated in the Local Agendas 21 for the respective city.

But what about applying sustainable development on the level of companies, of industrial processes or of products? In this field the operationalization of sustainable development means using new patterns in the form of instruments or tools delivered by the pretty new discipline called Technology Assessment, TA, which did appear at first in the USA (Tulbure, 2013, Jischa, 2005).

Part of what engineers do is to evaluate developments in technology (Jischa, 2005). Their evaluation has up to now almost without exception been focused on technical aspects, like functionality and safety, and on economic aspects following legal and financial boundary conditions. With respect to sustainability more criteria have to be considered like: environmental quality, social and human values, quality of life (Jischa, 2005). This kind of evaluation needs interdisciplinary approaches (Tulbure, 2003). In order to support the activities of engineers when evaluating technologies, Technology Assessment (TA) is delivering specific methods, which should be used, because these are combining different aspects from different fields (VDI-Richtlinie, 2000).

As defined in the German Guideline 3780 (VDI-Richtlinie, 2000), Technology Assessment means the methodical, systematic, organized process of:

- analyzing a technology and its developmental possibilities;
- assessing the direct and indirect technical, economic, health, ecological, human, social and other impacts of this technology and possible alternatives;
- judging these impacts according to defined goals and values, or also demanding further desirable developments;
- deriving possibilities for action and design from this and elaborating these, so that well-founded decisions are possible and can be made and implemented by suitable institutions if need be.

Although in the last 20 years a lot of progress in the field of Technology Assessment has been registered, especially due to several studies which have been carried out in USA, Japan, Germany and other European countries, there is still need in developing integrative methods for Technology Assessment in order to concretely apply the concept of sustainable development (Ludwig, 1995).

There are two strategic possibilities for operationalization of sustainable development (Tulbure, 2003):

- establishing goals on global level, the measures to achieve these goals being prepared on global and national level and applied on regional level;

• establishing goals on regional level, the measures being prepared and applied on regional level; the effects of these measures being evaluated on national and global level too.

As an application example of the first strategy studies in form of scenarios could be mentioned, for instance with the goal of finding future sustainable energy supply systems with minimal effects on the environment. Such a project has been realized at the IIASA (International Institute for Applied Systems Analysis) in Laxenburg/Vienna „Globale Energieperspektiven bis 2050 und darüber hinaus“ (Global Energetic Perspectives till 2050 and more). The IKARUS project (Instruments for Reducing Emissions of Gases relevant to Climate Change) developed by several institutes in Germany represents another example. All these studies base on mathematical models to describe industrial and economic processes; with the help of a database, which describes economic, social and political frame, simulations have been realized and different development scenarios are gained. The goal is to find the right ways for the proposed aims and to help with concrete measures the decision making process (Jischa, 2005).

Many actions in form of Local Agendas 21 do emphasize the second strategy regarding the operationalization of sustainable development. Such Local Agendas 21 have started to be established especially in certain regions or cities in Western-European countries after the Rio-Conference in 1992 and currently are developed in almost all European cities. On this point national scenario studies could also be mentioned, which try to find sustainable ways for the future national development in a global context, for instance the action plan „Sustainable Netherlands“ by Friends of Earth Netherlands in 1992 or the study „Zukunftsfähiges Deutschland“ (Sustainable Germany) initiated from Bund (Friends of Earth - Association for Environment and Nature Protection) and Misereor and led by the Wuppertal Institute for Climate, Environment and Energy (Jischa, 2005).

When going through the given methodology for operationalizing sustainable development one can recognize that many steps can also be identified in the phases distinguished in the definition of Technology Assessment, TA (Tulbure, 2013). Very often a concrete sustainability problem especially related to a technological issue is to be solved by carrying out a TA-study.

On the global level the operationalization means to define general goals for the whole world, things which happened more or less with the Rio-Conferences and the well-known Kyoto-Protocol. On national level the operationalization means to define goals paying attention to the specific conditions of the certain country. On regional or local level concrete measures represent the content of the Local Agendas 21. The field of applying sustainable development on the level of companies, of industrial processes or of products is still in the very beginning in our country and should be done by using analytical instruments of TA (Tulbure, 2003). How do new technologies integrate into environment and society? These questions are in the present conditions of the Eastern European countries from dominant importance, in the process of modernization of old technologies and implementation of new technologies. From this reason TA should play a central role in the future in the next technological, economic, environmental and social development of these countries (Jischa, 2005).

Methodical Problems

Methodical problems appear especially because of the complexity of the analysed processes or do to the complexity of the analysed entities, during sustainability modelling and evaluation. In the process of concretely describing and analysing, as well as evaluating sustainability forms and patterns on regional or local level, difficulties appear do to the missing possibility for a formalistic description of the influencing factors or of the interdependences among them. Shortly said methodical difficulties do result when approaching new sustainability forms and patterns of the human society because there are questions about:

- Handling complexity and uncertainties
- Integrating quantitative and qualitative aspects
- Designing new indicators

New Approaches

With the goal of operationalising sustainability in the last time on different levels did start discussions concerning the existing possibilities to develop new procedures for carrying out a sustainability assessment. In this context first of all the question ”What does it mean enough for the society and for the human being?” has to be newly answered. As it is to be observed this question is a highly aggregated one, including a lot of aspects from social field, as well as from technical, economic and environmental field.

For operationalising sustainability it is necessary to consider different inter-disciplinary aspects in the form of new approaches for succeeding to carry out a Sustainability Assessment, but without having limit values. With this goal it is actually useful to apply so-called *Dynamic Assessment Methods* (Tulbure, 2015).

Currently there is no general agreement regarding an evaluation method, which could be used in order to carry out assessments, in the situations when no limit values can be established, as for instance very often in the environmental, ecological or social field. In this regard, assessing sustainability is a pretty difficult issue, because it is not possible to use precise sustainability evaluation criteria, as regarding sustainable development there are no „reference or limit values“, especially in the social field (Jischa, 2005). This means that in the field of sustainability it is not possible to establish “sustainability reference numbers”, which could be interpreted as reference values and used in order to make comparisons (Jischa, 2005).

In the field of sustainability only changes and developments can be compared, interpreted and evaluated. The question that arises in this regard is connected to the existing possibilities to make comparisons among different developing paths as well as to the existing possibilities to evaluate if a certain developing path is in accordance to sustainable development.

So, if there is no possibility to define some kind of ”reference values” for sustainable development, it follows that only development tendencies can be evaluated. In this regard, scientists from the Finland Futures Research Centre (FFRC) did develop so-called ”*dynamic evaluation methods*” (RANDEurope, 2004). For applying such evaluation methods, some ”postulates” have to be defined and used, in order to compare development tendencies.

Dynamic Assessment Methods for Sustainability Assessment

In the field of Sustainable Development all three fields of Sustainable Development has to be taken into account, as presented in Figure 1. In the following a situation is presented, in which 3 issues are taken into consideration and accordingly evaluated.

For instance, it can be stated that sustainability cannot be achieved without:

Postulate P1: A decrease of Environmental Pollution (EP): **D(EP) < 0**

Postulate P2: A decrease of or at least keeping constant the Energy Consumption (EC): **D(EC) ≤ 0**

Postulate P3: An increase of the Life Quality (LQ): **D(LQ) > 0**

where: D(.) - gradient: $D(X) = (X - X_o)$

X - value of the certain variable in a certain year of the analysis

X_o - value of the certain variable in the starting year of the analysis

Dynamic Assessment Methods applied for the Energy Consumption

Regarding Sustainability Assessment by considering technical aspects, Postulate P2 is becoming relevant, this means that the energy consumption should be taken into account. In this regard in Figure 2 are presented values for the gradients of the energy consumption per capita, ΔE, for different countries.

Considering Postulate P2, three different situations can occur, as follows:

a. if the gradient of the energy consumption is negative, this means $\Delta E < 0$, the development of the considered country is respecting the Sustainable Development;
b. if the gradient of the energy consumption is positive, this means $\Delta E > 0$, the development of the considered country is not respecting the Sustainable Development;
c. if the gradient of the energy consumption is zero, this means $\Delta E = 0$, the development of the considered country is still respecting the Sustainable Development, because at least the energy consumption did not increase in the considered time period.

In order to be relevant such an interpretation have to consider the energy resources, which have been used.

- If fossil fuels have been used as primordial energy resources, then an increase of the energy consumption, $\Delta E > 0$ will have as a result an increase of the environmental pollution and a reduction of available energetic resources, this means that the development of the considered country is not in the direction of Sustainability.
- If renewable energy resources have been used as primordial energy resources, then an increase of the energy consumption, $\Delta E > 0$ will not necessarily have as a result a reduction of available energetic resources and an increase of the environmental pollution, this means that the development of the considered country could be in the direction of Sustainability.
- If the energy consumption will remain constantly from one time period to another, $\Delta E = 0$, this would not necessarily mean respecting the direction of Sustainability, if the percentage of fossil fuels used have not decreased.

RESULTS AND INTERPRETATION

As it can be observed from Figure 2, there are three different cases, as follows:

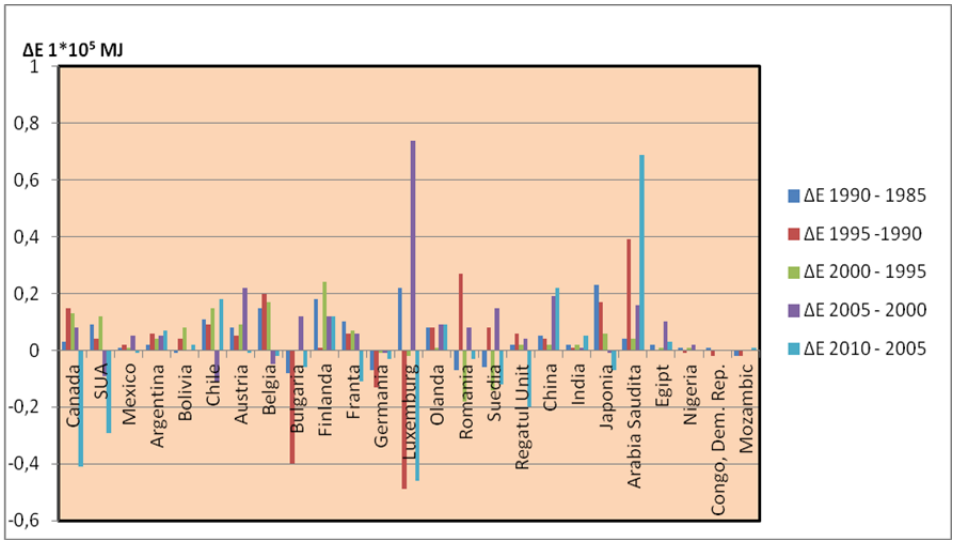

Fig. 2. *Gradients of the energy consumption per capita for different countries*

1. The gradient of the energy consumption is negative, this means: $\Delta E < 0$ – one can recognize the situation a) presented before, what means that the development of the considered country is in the direction of Sustainable Development;

   For instance:
   - for the time period 1985 – 1990: Bulgaria, Germany, Romania et al.;
   - for the time period 1990 - 1995: Bulgaria, Germany et al.;
   - for the time period 1995 - 2000: Germany, Sweden et al.;
   - for the time period 2000 - 2005: Belgium, Chile, Japan, USA et al.;
   - for the time period 2005 - 2010: Canada, Japan, United Kingdom et al..

2. The gradient of the energy consumption is positive, this means: $\Delta E > 0$ – one can recognize the situation b) presented before, what means that the development of the considered country is not respecting the Sustainable Development;

   For instance:
   - for the time period 1985 – 1990: Canada, Finland, India, China et al.;
   - for the time period 1990 - 1995: USA, France, Saudi Arabia et al.;

- for the time period 1995 - 2000: Mexico, Austria, Saudi Arabia et al.;
- for the time period 2000 - 2005: Argentina, Canada, China, India et al.;
- for the time period 2005 - 2010: China, Egypt, Saudi Arabia, Nigeria et al.

3. The gradient of the energy consumption is zero, this means $\Delta E = 0$ - – one can recognize the situation c) presented before, what means that the development of the considered is still respecting the Sustainable Development, because at least the energy consumption did not increase in the considered time period.

CONCLUSIONS

Regarding assessment methods the difficulty is represented by the fact that sometimes it is very difficult to establish limit values, in order to make comparisons, as in several sustainability fields, like in the economic or social field. This means that nowadays it is pretty difficult to precociously assess if a certain development will assure the sustainability of the considered region. In order to overcome this difficulty so-called “dynamic assessment methods” have been developed. Such a Dynamic Assessment Method has been applied regarding the Energy Consumption for several countries, where limit values are indeed very difficult to be established. In the context of this dynamic assessment method different parameter gradients have been compared, and not the parameter values themselves. The gradients of the energy consumption for different countries have been compared and interpreted, as well as conclusions regarding the development trend of the observed countries, if in the direction of Sustainability or not, have been drawn.

From this presentation it clearly follows that there is a need to define new patterns for achieving the sustainability of our society and with this goal, new thinking ways and new visions are needed. One pattern could be represented by the vision of getting a decrease in the energy consumption, as long as most of the energy resources are not renewable ones. Future research work should be carried out in order to clarify the quantification possibilities of EP, EC and LQ on a regional level and to define other postulates as well in order to develop a general Dynamic Assessment Method for Sustainability Assessment.

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