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AMBIENTUM

1/2018

STUDIA
UNIVERSITATIS BABEŞ-BOLYAI
AMBIENTUM

1 / 2018

January – June

ISSUE DOI:10.24193/subbambientum.2018.1

STUDIA
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AMBIENTUM

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Cover 1: *Taxodium distichium* with *Tillandsia usneoides* (moss).
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http://www.studia.ubbcluj.ro

YEAR Volume 63 (LXIII) 2018
MONTH JUNE
ISSUE 1

S T U D I A

UNIVERSITATIS BABEŞ-BOLYAI

AMBIENTUM

1

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(RECOMMENDED CITATION)
DOI:10.24193/subbambientum.2018.1.01

STUDY ON PEDOLOGICAL SOIL PROPERTIES IN THE "HANEȘ" MINE AREA FOR ITS REMEDIATION

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ABSTRACT. Pollution has become an issue of current concern for all humanity, because of the negative impact on the environment and human health. One of the most affected by environmental factors due to human activities is the soil, which is a sponge for contaminants. Soil contamination with heavy metals presents a major concern both global and national levels, in order to control resulted pollutants from industrial activities and finding different methods of eco-friendly and effective remedy. In the present paper is presented the Haneș mine area, the soil from here being very acid due to mining activities performed in the past

Key words: *environment, pedological parameters, mining activities, soil pollution, "Haneș" mine*

INTRODUCTION

Due to development of urbanization and industrialization, soils have become increasingly pollute, which threaten ecosystems, surface waters and ground waters, food safety and human health (Băbuț et al., 2012; Li et al., 2009; Oh et al., 2014). The soil serve as one of the most important sink for trace metal contaminants in the terrestrial ecosystem, seen as indicators that reflect the quality of the environment (Vereștiuc et al., 2016; Yeung et al., 2003). Soil contamination represents a worldwide concern due to the serious risks for human health and ecosystem quality (Gagiu et al., 2017; Sur et al., 2016; Norra and Stuben, 2003; Braz et al., 2013).

Soil pollution by mining we could say that is the worst form of soil pollution. Firstly, the fertile soil layer is lost and then it cannot be used in agriculture (Keri et al., 2010). Haneş mine is located in Almaşu Mare area, from Alba county. It was opened in 1930 and was closed in 2003. Next to the Haneș mine, at a distance of about 150 m is Haneș dump of steril which is located on the left bank of the Ardeu brook and has a length of about 100 m, width 50 m, height of 25-30 m. It is inactive, disobedient process of conservation and reforestation is not covered by soil. In rainy days in its center forms a small puddle (Hulpoi, 2008; Stancu, 2013).

The informations about the pedological properties of soils is needed for evaluating soils in terms of their quality (Mbagwu et al., 1998).

Therefore, the purpose of this paper is to analyze pedological parameters of the "Haneș" mine area for to choose than the most appropriate method of soil remediation.

MATERIALS AND METHODS

From „Haneş" mine area were taken for analysis six samples. Three samples were taken from the Haneş dump, at a distance of about 150 m from mine and of three different depths, such as: 0-10 cm, 10-30 cm and 30-100 cm. The other three samples were taken from a distance of about 100 m from the Haneş mine (between the dump and mine), the same depth.

Sample analysis was performed in the analysis laboratory of soil quality and abatement processes in the Technical University from Cluj Napoca.

Soil sampling for pedological analysis is present in figure 1.

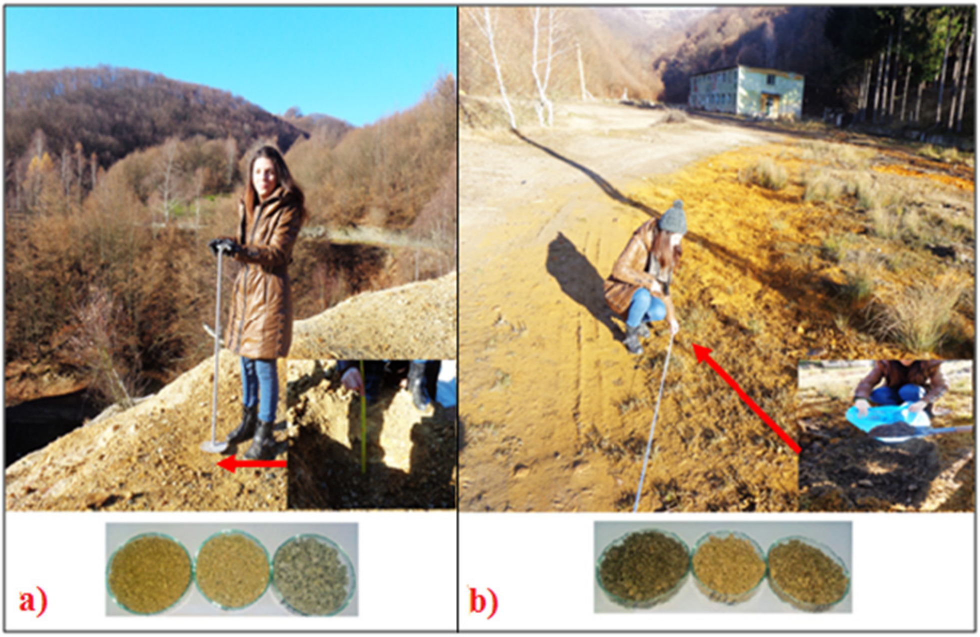

Fig. 1. *The sampling points image: a) soil samples taken from the dump, situated at 150 m distance of the “Haneș” mine; b) soil samples taken from 100 m distance of the Haneș mine.*

Soil samples were brought to the laboratory the next day, where they were analyzed.

The texture of the soil samples and the sterile material was determined using the RETSCH (EP 0642844) AS 200 sifting device. This device operates on an electromagnetic propulsion system and has the role of separating the granulometric fractions by sifting with different dimensional sites: 4 mm, 2 mm, 1 mm, 500 µm 250 µm and <250 µm. Practically, 500 g of soil/sterile material from each sample was then passed through the device for 10 minutes and then the remaining amounts in each sieve were measured.

The pH *was determined by* WTW 2FD47F Multi 3430 Multiparameter Meter *(figure 2).*

Fig. 2. *The Determination of pH in laboratory*

The humidity content of soil samples was determined by gravimetric method. Practically, in each sample was weighed with analytical balance about 100 g of soil was placed in trays (Peri dish). Then they were placed in an oven at 105 °C until they reached constant weight.

The soil structure was determined with Seker method, which consists of dissolution (dispersion) in water the soil aggregates and assessment results after a dash helpful (Micle and Sur, 2012).

RESULTS AND DISCUSSION

The pH values obtained from analysis are present in figure 3.

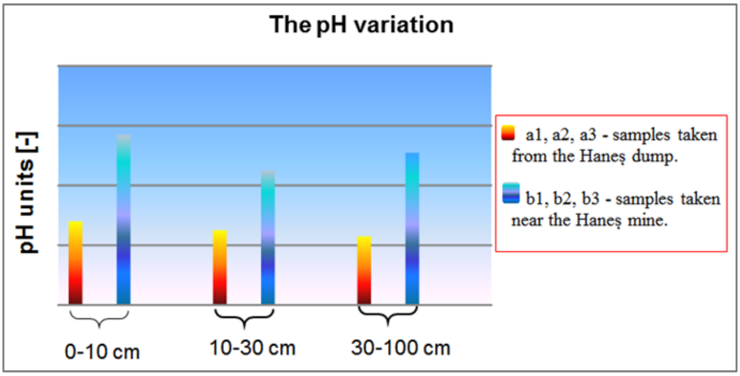

Fig. 3. *The pH values obtained from analysis of soil samples taken.*

pH values obtained indicate that the pH of the dump material and soil which is near the Haneş mine is acid to very acid.

pH of the dump material is in the range 2.3 - 2.8 pH units and in the range of 4.5 - 5.7 is the soil samples taken near the mine.

The results obtained at the determination of soil humidity content from soil samples and waste material from the sampling points 1 and 2 (near the „Haneş" mine and the Haneş sterile dump) are presented in figure 4.

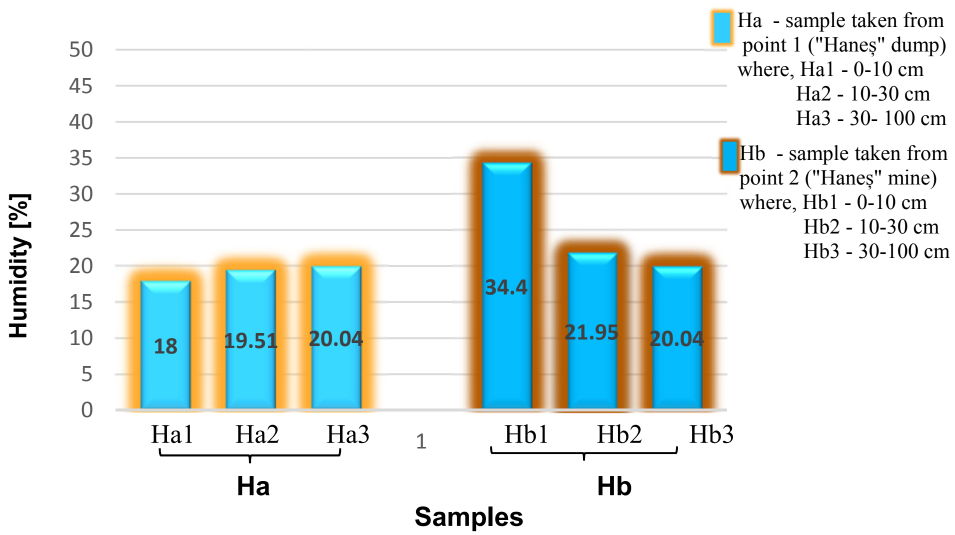

Fig. 4. *The moisture content in point 1 and 2*

The results at the determination of soil humidity content showed that the moisture content of the sterile material taken from point 1 increases with the depth, since on a depth of 0-10 cm the humidity indicated a 18% value, on a depth of 10-30 cm 19.51%, and on a depth of 30-100 cm this indicated a value of 20.04%.

For samples taken from point 2, soil moisture decreases with depth. This indicates a value of 34.4% on the first sampling layer (0-10 cm), 21.95 on the second sampling layer (10-30 cm), and on the third sampling layer (30-100 cm) soil moisture indicated 20.04%.

After performing analysis regarding soil structure, the sterile materie taken from Haneş dump is very poorly structurally. Whereas aggregates are opened almost entirely in small parts (figure 5a).

Regarding of the soil samples taken from 100 m of the mine Haneș (between the sterile dump and mine) this is poorly structured because most of the aggregate are opened in small parts and fewer in large parties (figure 5b).

Therefore soil and sterile material samples analyzed is poorly or very poorly structured, because most aggregates are opened in small parts and less large or only small parts.

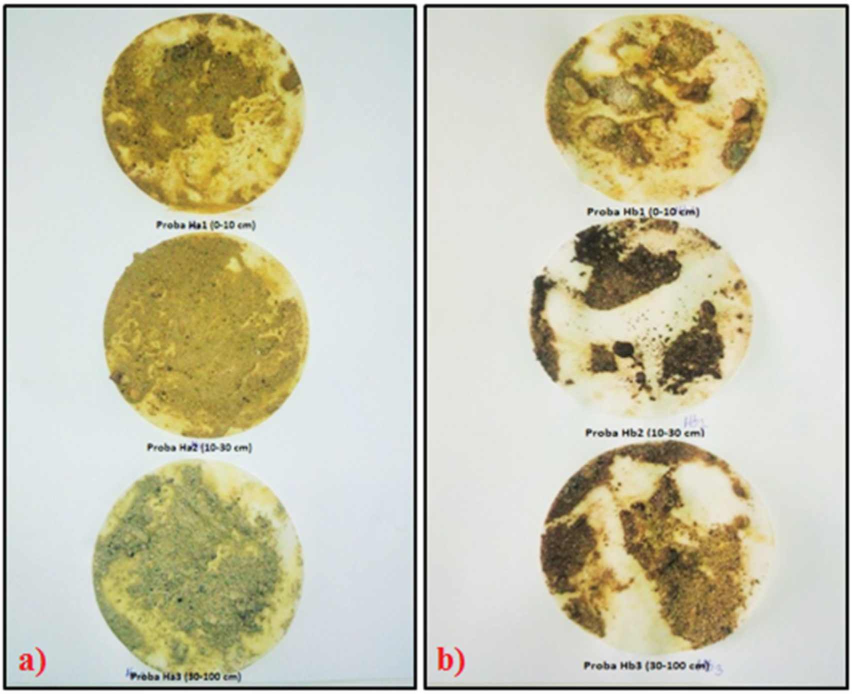

Fig. 5. *The soil structure of samples analyzed on the three sampling depths a) the soil structure of the samples taken from the dump, situated at 150 m distance of the mine "Haneș"; b) the soil structure of the samples taken from 100 m distance of the mine "Haneș".*

Granulometric fractions (%) were calculated using the following calculation relationships (Micle and Sur, 2012):

$$\text{Coarse sand} \ (> 0.2 \text{ mm}) = (100 \times a) / m \ [\%] \quad (1)$$

$$\text{Fine sand} \ (0.2\text{-}0.02 \text{ mm}) = (100 \times e) / m \ [\%] \quad (2)$$

where:

m - the quantity of dry soil;
a - the amount of coarse sand; [G]
e - the amount of fine sand;
100 - percentage reporting factor.

The following granulometric distribution curves (figures 6 and 7) characteristic of each point were obtained following the analysis of the determination of the soil texture and sterile material from the samples taken sampling.

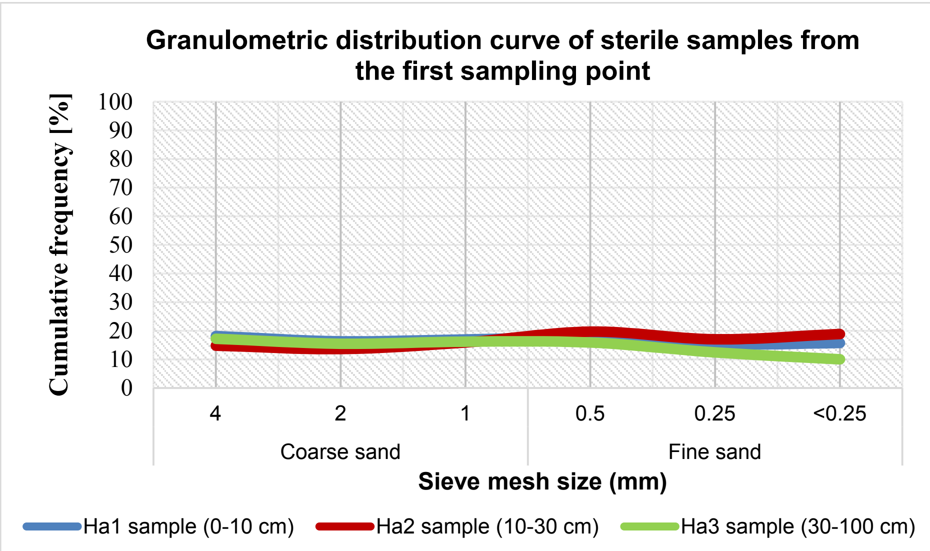

Fig. 6. *The granulometric distribution curve characteristic of the first sampling point*

The results obtained by analyzing the texture of the sterile material in the samples taken showed it to be a clayey sandy texture consisting of a good water retention capacity.

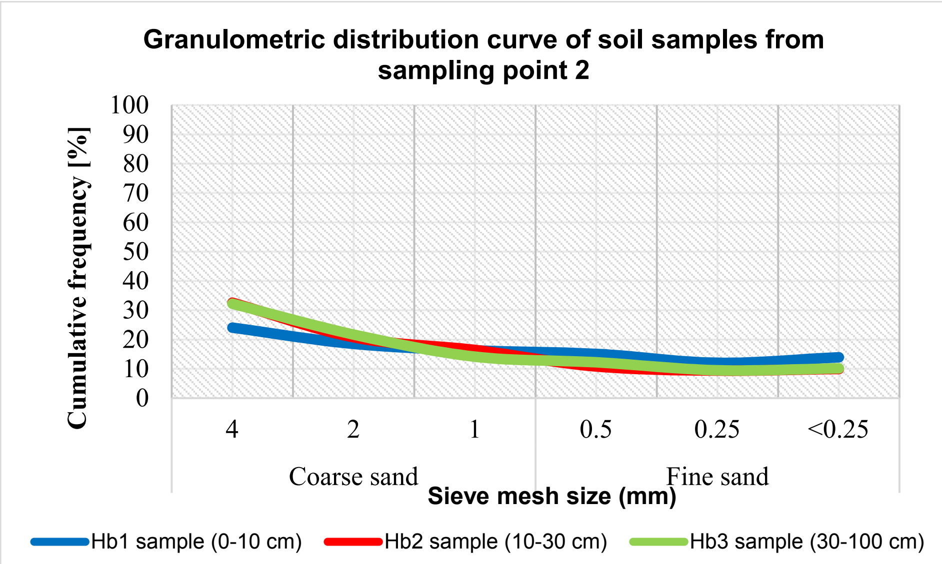

Fig. 7. *The granulometric distribution curve characteristic of the first 2 sampling*

The results obtained in the soil texture analysis from the samples taken showed that the soil has a coarse sandy texture reflecting poor water retention and low fertility.

CONCLUSIONS

The general conclusion that emerges from the study performed on the soil of the Haneș area is that the soil is very acid and is necessary to determine the heavy metals concentrations for to establish the degree of pollution and adopt the most appropriate method of soil remediation.

Ecological restoration of polluted perimeter can be achieved only through complex interventions which can contribute to improving factors of environment: soil and water.

For to accomplish these measures is necessary to conduct complex of studies whose purpose is finding efficient and economic solutions to stabilize ecological reconstruction of dumps, building a treatment plant for mine water and streams.

Acknowledgements

This work was supported by a grant of the Romanian National Authority for Scientific Research, CNCS – UEFISCDI, project number: PN-II-PT-PCCA-2013-4-1717 and with the support of the Technical University of Cluj-Napoca through the research Contract no. 1990/12.07.2017, Internal Competition CICDI-2017 (Project BIOSOLIX).

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STUDIA UBB AMBIENTUM, LXIII, 1, 2018, pp. 15-31
(RECOMMENDED CITATION)
DOI:10.24193/subbambientum.2018.1.02

NEW APPROACHES REGARDING REMEDIATION TECHNIQUES OF HEAVY METAL CONTAMINATED SOILS FROM MINING AREAS

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ABSTRACT. Currently, heavy metal contamination of the soil and water near mining areas is a critical environmental problem that concerned all humanity due to its impact on ecological environment and human health. In order to remediate the heavy metal contaminated soils from mining areas, some technologies, generally based on physical, chemical, thermal and biological approaches, have long been in use to clean-up heavy metal contaminated soils to an acceptable and safe level. However, effectiveness of these methods depends a lot of soil type and characteristics, level of pollution and mixed contaminants present in soil. Moreover, some conventional technologies pose a secondary risk on environment. Thus, efficient eco-friendly techniques, based on natural materials or natural constituents of the soil needs development and research. This paper will provide an overview of the recent exploration and research, attempts of the remediation effectiveness assessment and developments regarding decontamination technologies applicable for the removal of heavy metals from soils near mining areas, being focused on new approaches regarding remediation methods. Moreover, limitations, financial aspects and future remediation research needs are also summary discussed.

Key words: *soil, heavy metals, soil remediation methods, mining areas, remediation effectiveness.*

INTRODUCTION

Nowadays, heavy metal contamination of the soils near mining areas is a widespread environmental problem in both developing and developed countries. Heavy metals such as cadmium, copper, zinc, lead, mercury, arsenic, contained in the residues from mining and metallurgical operations are often dispersed by wind and/or water after their disposal (Navarro et al., 2008).

Unlike organic contaminants, heavy metals are somewhat unique by the fact that they are highly resistant to either biologically or chemically induced degradation. Therefore, total heavy metal contents of soil persist for a long time after being introduced into the soil causing severe environmental problems, making the land resource unavailable and causing risk on human health since soil is the main resource to grow a part of human food (Khalid et al., 2017). Thus, remediation of soil contaminated by heavy metals is necessary in order to reduce the associated risks, make the land resource available for agricultural production, enhance food security, and scale down land tenure problems (Wuana and Okieimen, 2011).

Many technologies are available nowadays to remediate heavy metal contaminated soil near mining areas. Among these, immobilization, soil washing, and phytoremediation are frequently listed among the best available technologies for cleaning up heavy metal contaminated soils and have been mostly demonstrated in developed countries (Wuana and Okieimen, 2011).

Inspite all of these, these technologies have limitations considering efficiency, cost involved and secondary impact on the environment and/or human health due to the release of additional contaminants to the environment.

Considering all these there is a need to develop efficient technologies based on using natural low-cost materials that didn’t pose secondary risk to the environment and/or human health.

Thus, this paper brief describes the long-term used technologies to remove heavy metals from contaminated soil near mining areas with their limitations and the recent research and exploration performed in order to develop new methods to remediate highly heavy metals polluted soils, as the ones from mining areas.

Overview on soil contamination with heavy metals

In mining areas, one of the source that lead to soil pollution is represented by the runoff formed (figure 1) when rainwater reach sulfide-bearing minerals contained by mining deposits which is highly acidic, contain a high level of dissolved metals, sulphate and iron (Varvara et al., 2013).

When runoff reaches the soil, some heavy metals are dissolved and enter into solution, while others remain adsorbed and/or precipitated and move with the soil particles causing an increase in pollution that pose a significant risk to the environment and human health (Navarro et al., 2008).

Fig. 1. *The runoff formed when rainwater reach sulfide-bearing minerals from sterile dump located on Larga de Sus mining perimeter (Zlatna, Romania)*

Heavy metals are listed as priority pollutants by the United States Environmental Protection Agency (UEPA). For the level of toxicity, lead, mercury, arsenic and cadmium are ranked first, second, third, and sixth, respectively, in the list of US Agency for Toxic Substances and Disease Registry (ATSDR) (Singh and Prasad, 2015). Among these, heavy metals are reported to cause several disorders in humans including cardiovascular diseases, cancer, cognitive impairment, chronic anaemia, and damage of kidneys, nervous system, brain, skin, and bones (Khalid et al., 2017).

Numerous studies have reported important quantities, which exceed the permissible limits, of heavy metals in soil in several regions around the world.

In Europe, the polluted agricultural lands likely encompass several million hectares (Lestan et al., 2008).High contamination of soil was found by Navarro et al. (2008) in soil near *Cabezo Rajao* abandoned mine (Spain): 231 mg/kg Pb, 0.80 mg/kg Cd, 335 mg/kg Zn, 24 mg/kg Cu, 16 mg/kg As, 1.1 mg/kg Fe and 669 mg/kg Mn. Extremely high metal and metalloid content was also found in Greece near a mining and metallurgy complex (*Lavrion Technology and Cultural Park*): 64195 mg/kg Pb, 7540 mg/kg As, 4100 mg/kg Cu, 55900 mg/kg Zn and 6500 mg/kg Mn (Moutsatsou et al., 2006).

The situation is the same in the USA (United States of America), around 600,000 ha area has been contaminated with heavy metals (Khalid et al., 2017). Heavy metals are prevalent at almost all sites targeted by major remediation programs. For instance, metals are present in 77% of the Superfund sites (National Priorities List), in 72% of the Department of Defense (DOD) sites and in 55% of the Department of Energy (DOE) sites. The USEPA estimates that over 50 million cubic meters of soil at current NPL sites are contaminated with metals (Dermont et al., 2008).

In China the situation is even worse; the degraded land associated with mining activities reached about 3.2 Mha by the end of 2004, and the figure is increasing at an alarming rate of 46,700 ha per year. The proportion of soils that exceeds environmental standard reaches 16.1% (Lestan et al., 2008).

Due to pollution from mining at country level (Romania) there are 24.432 ha, of which 23.640 ha are excessively affected (Băbuț et al., 2011).

Moreover, all these mining sites over the world aren't polluted only with heavy metals, organic pollutants being present in this soil as well. Every site has unique features considering soil properties and it is not possible to transfer a remediation technology from one site to the other (Jőger et al., 2013).

Considering all these, it is imperative to deploy innovative and site-specific remediationtechnologies which could feasibly and efficiently remediate highly heavy metal contaminated soils.

AVAILABLE REMEDIATION TECHNOLOGIES OF HEAVY METAL CONTAMINATED SOILS FROM MINING AREAS

During the last two decades many remediation technologies has been investigated, developed and have long been in use in order to reduce the total and/or bioavailable fractions of heavy metals in soils near mining areas. The approaches include isolation, immobilization, toxicity reduction, physical separation, and extraction. These conventional technologies, presented in table 1, used to treat heavy metal contaminated soils are based on physical, chemical, and biological processes (Sluser et al., 2011).

Technologies based on *isolation* were generally designed to prevent the movement of heavy metals by restricting them within a specified area when other remediation methods are not economically or physically feasible (Zhu et al., 2012). An isolation and containment system can work adequately, is not expensive (50-150$/ton) but there is no guarantee as to the destruction of the encapsulated contaminant (Khan et al., 2004).

Table 1. *Technologies for remediation of heavy metal-contaminated soils (Wuana and Okieimen, 2011).*

Category	Remediation technologies
Isolation	(i) Capping (ii) subsurface barriers
Immobilization	(i) Solidification/stabilization (ii) vitrification (iii) chemical treatment.
Toxicity and/or mobility reduction	(i) Chemical treatment (ii) permeable treatment walls (iii) biological treatment bioaccumulation, phytoremediation (phytoextraction, phytostabilization, and rhizofiltration), bioleaching, biochemical processes.
Physical Separation	
Extraction	(i) Soil washing, pyrometallurgical extraction, in situ soil flushing, and electrokinetic treatment.

Immobilization refers to decrease in metal mobility, bioavailability and bio accessibility of heavy metals in soil by adding immobilizing agents to the contaminated soils (Khalid et al., 2017). Among amendments used to immobilize heavy metals are reported cement, clay, zeolites, phosphates, minerals, microbes and organic amendments (Sun et al., 2016). Other studies have reported the potential of low-cost industrial residues such as red mud, bark saw dust, chitosan from crab meat canning industry, rice hulls, leaves in immobilization of heavy metals in contaminated soils (Wuana and Okieimen, 2011). The reported cost is 110$/ton.

Biological treatments are most viable option to rectify the natural condition of the soil and are based on using microorganisms, tolerant and accumulating plants to remove, decrease toxicity and/or mobility of heavy metals from soils (Guemiza et al., 2017; Khalid et al., 2017).Cost involved is between 50$ and 90$/m^3. Bioleaching and phytoremediation are the most used biological techniques.

Bioleaching, or bacterial leaching, consists in the extraction by solubilization of the metallic elements from contaminated soil using bacteria. This method does not destroy (eliminate) the pollutants, but it favors their segregation from the contaminated environment, the microorganisms having the property to oxidize the metals, transforming them into a more soluble form. Sur et al. (2016) investigated during 16 weeks the extraction of heavy metals (Cu, Zn, Cd and Pb) from polluted soils near Baia Mare area by in situ bioleaching and aerated bioleaching, using *Thiobacillus ferrooxidans* type of microorganisms in 9K medium. Results (figure 2) indicated that the extraction efficiency of metals is much higher if aeration is introduced in the process (Cu: 17 - 27%; Zn: 14 -27%; Cd: 8 - 14%. Pb: 7 - 13%).

However, this techniques requires long periods to efficiently remove the contaminants from soils and it is only efficient for surface contamination and for the most mobile metals present into the soil. These metals present on the surface of the soil can also be extracted by electro kinetic processes which consist on the application of low intensity electric current between a cathode and an anode inserted into the contaminated soil, making the ions and the small charged particles to be transported to the anode or to the cathode according to their charges (Guemiza et al., 2017). Cost involved: 50-225 $/ton.

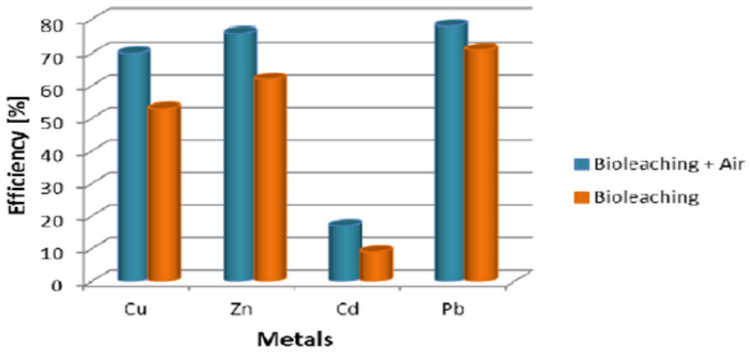

Fig. 2. *Efficiency of metals extraction when by in situ bioleaching and aerated bioleaching was applied (Sur et al., 2016)*

Chemical methods include, among others, soil washing and soil flushing. Soil washing is one of the few treatment alternatives for the elimination of heavy metals from highly contaminated soils such the ones from mining areas, which can be applied to pilot/full-scale field remediation (Dermont et al., 2008) being feasible also to remove toxic metals attached to the fine particles of soil. Also, cost varies between 75->150$/ton. Torres et al. (2012) demonstrated that Cd, Zn, and Cu could be washed with efficiencies up to 85.9%, 85.4%, and 81.5% respectively.

Over the past years, scientists have tried to optimize the extraction of heavy metals from contaminated soils by chemical leaching using different extractants. These chemical agents (synthetic and organic acids, bases, surfactants, alcohols, chelating agents and cyclodextrins) are used to transfer metal from contaminated soil to the aqueous solution (Guemiza et al., 2017).

All these soil washing extractants have been developed on a case-by-case basis depending on the contaminant type at a particular site. Removal efficiency of heavy metals depends on the type of the extractant used, contaminant type, presence of other contaminants and on the characteristics of the soil.

Despite the proven efficiency of acid extraction (more than 90%- figure 3) in full-scale applications for non-calcareous soils, strong acids attack and degrade the soil crystalline structure at extended contact times.

Thus, strong acids have been considerate inappropriate to remove heavy metals from soil (Wang at al., 2013).

For less damaging washes, organic acids and chelating agents are often suggested as alternatives to straight mineral acid use (Wuana and Okieimen, 2011).

The most used and studied chelating agents are: EDTA (ethylenediaminetetraacetic acid), NTA (nitrilotriacetic acid) and DTPA (diethylenetriaminepentaacetic acid) due to their effectiveness and low cost.

However it was reported that using EDTA for soil washing may destabilize the soil aggregate stability, and mobilize colloids and fine particles (Karthika et al., 2016).

Thus, in recent years biodegradable chelating agents such as EDDS ([S,S]ethylenediaminedisuccinic acid, which is a stereoisomer of EDTA), IDSA (iminodisuccinic acid), NTA (nitrilotriacetic acid), ASP (2-Amino-3-sulfhydrylpropanoic acid) and MGDA (methylglycinediacetic acid) have received increasing attention (Liu et al., 2015; Karthika et al., 2016).

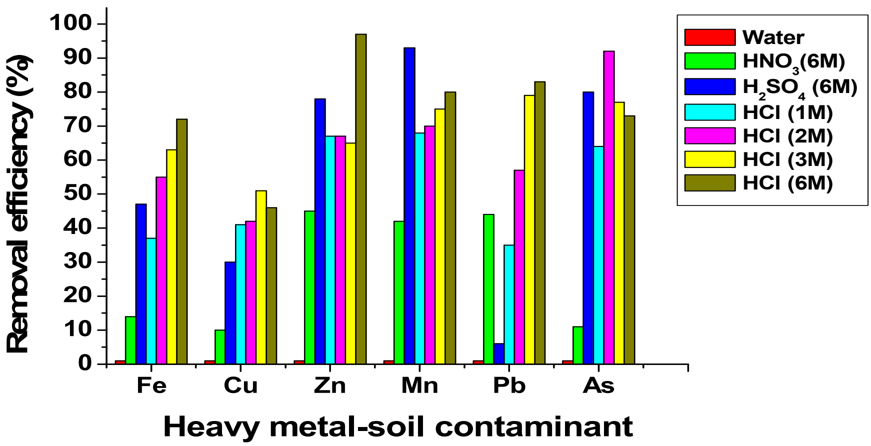

Fig. 3. *Removal efficiency of heavy metals from soil using acids as washing agents (according to Moutsatsou et al., 2006)*

Extraction of metals in the soil by washing with trisodium salt of EthyleneDiamine-Disuccinic acid (Na_3EDDS) was investigated by Eng. Maria Szanto (Prodan) under scientific coordination of Prof. Dr. Eng. Valer Micle. There were used: soil samples taken from the vicinity of S.C. Sometra Copşa Mică, an area highly polluted with heavy metals due to metallurgical activities.

Soil samples were subjected to washing with Na_3EDDS for 2, 4, 6, respectively 8 hours, the Na_3EDDS solution concentration was 0.4, 0.5 and 0.6 [%] (Szanto (Prodan), 2012).Results have shown that extraction of metals by washing with Na_3EDDS has a very high yield: 85.54 % for Cu; 98.91 % for Zn; 97.59 % for Pb; 100 % for Cd, when treating soil for 8 hours and using a concentration of 0.6 % Na_3EDDS (for Cu, Zn and Pb) and a concentration of 0.4 % Na_3EDDS (for Cd). Concentration of Pb in soil (figure 4) was below alert threshold , according to Order 756/97, when treating soil for 8 hours and using 0.5% Na_3EDSS.

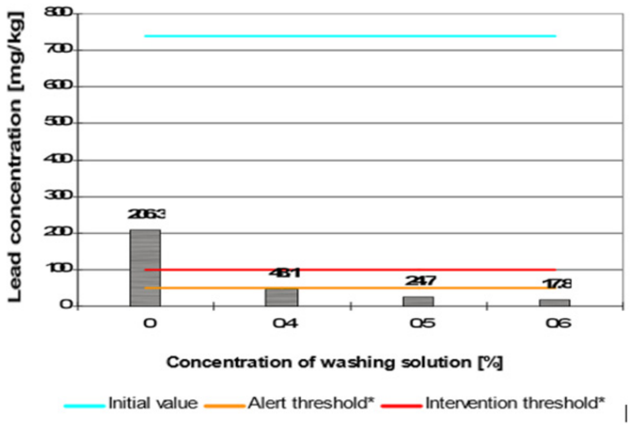

Fig. 4. *Lead concentration in the soil after Na3EDDS treatment for 8 hours (Szanto (Prodan) et al., 2012)*

Although high efficiencies were obtained in case of Cu, Zn, Pb, Cr, Ni and Cd when soil is washed with above chelating agents, it was reported that these are toxic and carcinogenic (Jiang et al., 2011).

Considering all above limitations of the previous long-term used technologies, nowadays there is a need to develop and investigate other inexpensive methods that may be efficient, eco-friendly and without posing risk to human health for remediating highly heavy metal contaminanted soil.

NEW APROACHES REGARDING REMEDIATION METHODS OF HEAVY METALS CONTAMINATED SOILS FROM MINING AREAS

The overall objective of any soil remediation approach is to create a final solution that is protective of human health and the environment (Wuana and Okieimen, 2011). None of the options available nowadays retain the healthy state of the soil being in the same time efficient and inexpensive. Thus, there is a need to increase research on this field. Some attempts, described below, were made until today on this line.

Soil washing. Currently, research is performed in the field of optimizing soil washing, increase efficiency on multi metal contaminated soils and reducing costs. Rinsing steps and repeated washing are conducted to improve the removal efficiency of heavy metals which can reduce the consumption of washing agents and the washing costs (Torres et al., 2012). Similarly, combined use of different extractants also improves heavy metals washing efficiency especially for multi-metal contaminated soils (Guo et al., 2016). For example, Wei et al. (2016) reported that phosphoric- oxalic acid-Na_2EDTA order based soil washing enhanced heavy metals removal efficiency by 41.9% for As and 89.6% for Cd.

On the other hand, investigations regarding efficiency of using other substances as reagents in removing heavy metals through soil washing is now conducted.

On this line, few studies have investigated chitosan and humic acids (that are natural constituents of the soil) to extract heavy metals from highly heavy metal polluted soil (Kulikowska et al, 2015a; Boechat et al., 2016; Jiang et al., 2011; Meng et al., 2017; Gusiatin et al., 2017). Nowadays cheaper sources of humic substances are under research. Kulikowska et al. (2015a) investigated the effectiveness of using humic substances extracted from sewage sludge compost for remediating soil polluted with heavy metals through soil washing.

The results indicated that under optimum conditions, a single washing removed 80.7% of Cu and 69.1% of Cd from polluted soil. The same research team revealed in another study that percent of metal removal from soils when humic substances from compost were used was 79.1–82.6%, 51.5–71.8%, 44.8–47.6%, 35.4–46.1%, 27.9–35.8% in case of Cd, Cu, Pb, Ni and Zn, respectively (Kulikowska et al., 2015b). Also, it was reported by Meng et al. (2017) that humic substances being environmentally benign, can improve soil physical, chemical, and biological properties leading to a healthy state of the soil.

Combined Remediation. Combined remediation has gained, over the last years, much attention of researchers from all over the world and involves two or more different types of physical, chemical, or biological remediation technologies. The combination of diverse technologies can not only overcome the problems caused by using any one technology alone, but also take advantages of all and enhance the remediation efficiency (Song et al., 2017).

Therefore, batch experiments (flow diagram of the experiments is illustrated in figure 5) were conducted in order to determine the effectiveness of *washing process combined with sieving* to remediate soil from an abandoned mine in China (Liao et al., 2016).

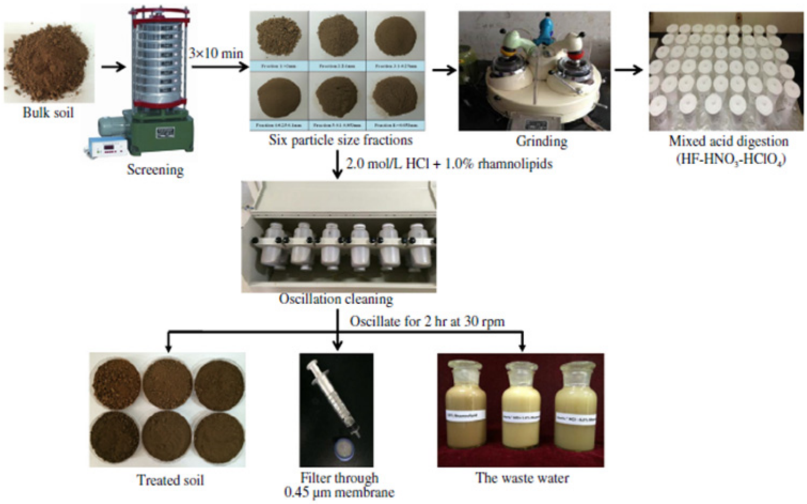

Fig. 5. *Flow diagram of the experiments conducted in order to determine the effectiveness of washing process combined with sieving (Liao et al., 2016)*

Results of the experiments (table 2) indicated that larger particle size did not necessarily result in greater removal efficiency for arsenic and heavy metals. The highest removal efficiencies by washing for Pb, Cd, Zn, and As were obtained in the fraction of >2 mm. However, the small particle size fractions can also achieve high heavy metal removal efficiencies. Compared with the original efficiency, the equivalent efficiencies for Pb, Cd, and Zn had been enhanced, whereas the equivalent efficiencies for As and Cu were lower (Liao et al., 2016).

Table 2. *Removal efficiency of the variously sized soil (Liao et al., 2016)*

Soil particle size	Pb	Cd	Zn	Cr	As	Cu
>2 mm	87.4%	87.3%	76.5%	10.4%	45.5%	64.9%
1–2 mm	74.7%	80.0%	66.7%	37.1%	26.5%	61.7%
0.25–1 mm	84.3%	80.6%	67.4%	25.0%	21.8%	65.5%
0.1–0.25 mm	84.3%	81.7%	60.9%	34.7%	23.5%	65.3%
0.053–0.1 mm	85.4%	78.1%	60.7%	25.9%	10.2%	62.4%
<0.053 mm	87.2%	79.5%	66.0%	25.1%	27.2%	66.6%

Chelate-Assisted (Induced) Phytoextraction. The use of biodegradable chelants (NTA, EDTA and EDSS) in improving the uptake of metals by plants and in limiting the leaching of metals from soil has become an attractive field of research.

When the chelating agent is applied to the soil, metal-chelant complexes are formed and taken up by the plant, mostly through a passive apoplastic pathway. Several previous studies showed significant increase in plant accumulation of Pb, Cd, Ni, Cu, and Zn from contaminated soil in the presence of synthetic chelates (Khalid et al., 2017). Also, it was reported that tartaric, acetic, malic, citric and oxalic acids, that are natural root exudates, can also be used for heavy metals phytoextration as an alternative to persistent synthetic chelates (Abbas et al., 2015).

Moreover, phytoremediation of heavy metals contaminated soils was ameliorated by adding exogenous humic substances, thus making contaminants more available to phytoextraction (Floris et al., 2017).

Chelate-assisted phytoextraction of heavy metals from soil has not gained considerable acceptance because of its high leaching risk, relatively low efficiency and high cost.

Microbial assisted phytoremediation. Recently, it was reported that inoculation of Burkholderia sp. (Z-90) enhanced heavy metals removal efficiency in soil by 31% for Pb, 32% for As, 44% for Zn, 37% for Cd, 52% for Mn and 24% for Cu (Yang et al., 2016; Ma et al., 2015) reported that Sedum plumbizincicola significantly enhanced Cd uptake (43%), whereas Bacillus sp. (E1S2) enhanced the Zn accumulation (18%) in Sedum plumbizincicola.

Modified plants. Another field of research refers to the possibility to create an *ideal plant species* for clean-up of heavy metals contaminated soil through the *introduction of foreign resistant genes*. Several researchers have proposed that establishing ideal crop hyper accumulator in the future can be an ideal choice due to its feasibility and applicability in the field of which current emphasis is scarce. By mean of genetic engineering, ability of a plant to accumulate, translocate and detoxify heavy metals can be significantly enhanced (Khalid et al., 2017).

Interestingly, in the last few years, the possibility of planting metal hyper accumulator crops over a low-grade ore body or mineralized soil, and then harvesting and incinerating the biomass to produce a commercial bio-ore has been proposed though this is usually reserved for use with precious metals. This process called *phytomining* offers the possibility of exploiting ore bodies that are otherwise uneconomic to mine, and its effect on the environment is minimal when compared with erosion caused by opencast mining (Wuana and Okieimen, 2011).

Ultrasonic combined with mechanical soil washing process. The effect of high-power ultrasound on the conventional mechanical soil washing process was investigated in a large lab-scale 28 kHz sonoreactor by Park and Son (2017) in order to remove heavy metals from soil. Results obtained indicated that removal efficiencies were enhanced with 70%, 140% and 55% in case of Cu, Pb and Zn, respectively.

CONCLUSIONS

Nowadays, remediating a highly metal-contaminated soil, containing slags and sulphur compound waste as a result of mining and metallurgical activities it is a challenge for researches from all over the world.

Available technologies have limitations considering efficiency in highly heavy metal contaminated soils, cost involved and environmental and health risk.

In this case, using combined technologies (described on this paper) based on natural low-cost materials, could be a feasible, inexpensive and efficient solution that could overcome the problems caused by using any one technology.

Inspite all of these, research and development actions are still needed for emerging technologies to achieve a healthy state of the soil and to bring them to the market place for full-scale implementation.

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STUDIA UBB AMBIENTUM, LXIII, 1, 2018, pp. 33-42
(RECOMMENDED CITATION)
DOI:10.24193/subbambientum.2018.1.03

INVESTIGATING THE LEVEL OF FIRE SAFETY AT PRISONS IN HUNGARY

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ABSTRACT. In Hungary fire-fighting duties are generally fulfilled by fire services operating within the framework of the unified organization of disaster management. To increase efficiency this might change in specific cases, furthermore other organisations can also fulfill fire-fighting duties. The reason behind this is that sometimes fire-fighters arrive at the scene with a considerable delay therefore people located in the area have to start fire-fighting with the utilization of special equipment to minimize damage. Such occasions are when disasters or fires are to be managed during mass events, affrays or inside prisons. Method: The author applied the current legislation of Hungary, interviewed some of the managers working in the Prison Service as well as utilized his previous experience in fire-fighting. The study describes the current state of the Hungarian prisons, depicts the characteristics and the current changes of the fire safety training received by the prison personnel. Are shown examples regarding cases where the arrival of fire-fighters cannot be achieved under the professionally accepted time limit of 15 minutes. A cell fire with a fatal outcome is also described in the paper. The complicated situation faced by the prison personnel in case of fire is also addressed. The author tries to assist in the improvement of the educational syllabus as well as in the perfecting of the knowledge of the personnel.

Key words*: fire-fighting, fire, mass event, affray, prison*

INTRODUCTION

Nowadays the education of fire-fighting teams in correctional centres can be regarded as rather deficient. The staff working in different numbers and with different level of competence in the different type of penal institutions is responsible for carrying out the evacuation and the first steps of fire-fighting in case of fire. Those institutions that cannot be reached by fire engines in 15 minutes in every case are in a difficult situation. Since the beginning of 2014 fireman major Attila Kirov and correctional major Antal Ladányi began to develop the education material for the personnel, the transfer of basic knowledge necessary to carry out their duties and they began their instruction. Unfortunately, no similar central educational syllabus was developed up till that time. The importance of education was also justified by the prison fire in Zalaegerszeg in 2003, which caused the loss of human life.

The fire safety of penitentiaries functioning on the area of Hungary is in a special situation. In addition to the first, second and third grade prisons there are two special institutions, the Institute of Psychiatry and Judicial Observation and the Central Hospital of the Detention Centre of Tököl where the installation of fire alarm systems and the tactics of fire-fighting entail specific requirements and safety rules resulting from the detention. On the area of Hungary 1 regional organizations with special priority, 8 regional organizations and 12 local ones operate. Nowadays 20000 people are kept under detention, which means that the prisons are 135 % full.

Most of the institutions of the Hungarian prison system was established at the turn of the 20th century or earlier, (Állampuszta in 1886, Kecskemét in 1904, Balassagyarmat in 1847, Pécs in 1884), and the 'new' prisons founded at the time of the classical communism were built in the middle of the country because of national security, for example Baracska founded in 1953, Tököl in 1963, Kalocsa in 1950 or Pálhalma in 1951. According to the rules of the placement of convicts every prisoner should be put in a separate cell. However the old prisons are characterized by cells for many people, so it is insolvable. In the penal institution of Pálhalma there are even cells for 30 persons, meanwhile the other prisons contain four-person cells.

Actual situation of penal execution institutes

The fire protection system of prisons in terms of disaster management coverage is limited because of the so-called "white spots"[1].

The Constitution, under Article II, in Hungary every human being has the inherent right to life and basic human dignity, which means it can be specified level of emergency fire protection, regardless of whether that person's resulting penalty is deprivation of liberty or pre-trial detention. There are 4 penal execution institutes in the area of the country, which due to distance would be achieved after the alert by the first firefighter units in fifteen minutes or more. The four institutions mentioned are: Állampuszta Penal Execution Institution, Közép-Dunántúli National Penal Execution Institution in Baracska, Márianosztra Jail and Prison, and Tiszalök National Penal Execution Institution (Lőrincz and Nagy, 1997).

5/2014 NDGDM Tactical Fire Regulations (*BM OKF, 2014).* VI. section describes that the time for locking process is 10 minutes. If you add the time of arrival to this, we can say that there is an institution, which after the events fire alarm a firefighter units start the action after 40 minutes (minimum) (http://bv.gov.hu/bv-intezetek).

CASE STUDIES

Állampuszta Penal Execution Institution. The institute's basic mission is related task of the pre-trial detention, as well as the adult male prison inmates and prison imprisonment. The capacity of the institute is 814 people, mainly men with final judgment and adult prisoners spend in their sentence. The institute is semi-open nature, which means that the inmates work in agricultural units located next to the institute, which is carried out within cooperation with Állampuszta Agriculture and Commerce Ltd. The Ltd. deals of agricultural production, livestock and crops in storage. These activities are classified low risk rating in terms of disaster management.

[1] white spots: The term white spots implies that reaching the areas of firefighter units cannot be solved within 15 minutes.

Közép-Dunántúli National Penal Execution Institution. The Közép-Dunántúli National Penal Execution Institution is national sphere of penal institution, seat in the Baracska Annamajor and Székesfehérvár and Martonvasar sites.

The Baracska facility is located in Fejér County, between Baracska and Pettend settlements, 3 km away from the main road 7. The tasks of the facility are implementation of adult men under penitentiary, prison and detention center stage, as well as implementing rules more lenient punishment of imprisonment, furthermore the implementation of adult men residing in Budapest, Pest County and Komárom-Esztergom County strangulation. The facility provides placement for over 1,000 inmates. The Annamajor Agriculture Ltd. deals crop production, animal husbandry and bakeries. These activities in terms of disaster risk classification are in medium-risk level.

The facility in Székesfehérvár is located in the same building with the city police, the district court, the tribunal, as well as the county and city prosecutor's office. The basic task of the facility is implementing the pre-trial detention in Fejér and Komárom-Esztergom County, furthermore regarding the implementation of incarceration in Fejér County. The object ensures the placement of nearly 200 people.

The Martonvásár facility in Martonvásár territory, is located separately from the occupied area, approx. 200 meters from the M7 motorway. After standing idle for more than 10 years and after the renovations of facility there was a ceremony on 23rd March 2015. The facility allows 126 low security-risk detained placement, who work outside.

Márianosztra Jail and Prison. The institute's core business is state task. The scope determined by special appointment with the tasks of the pre-trial detention, the statutory imprisonment, and tasks of the adult male prison inmates and prison-grade execution of imprisonment. Within these tasks, of course, the activities related to especially in the detention security, employment and provision of healthcare. For the inmates housed at the institute it gives priority to engage in successful integration into society, promoting employment, education, vocational training and work regularly. A business organization in the field of the institute Ltd. NOSTRA employs the majority of convicts. The products manufactured here (eg.: a variety of wood and paper products, etc.) are made to order. Some of the convicts are participating in financial form in the provision of the institutions, maintenance and operation of the work. Some of them perform custom work outside the institution, of course, keep in mind the security of the detention. Great emphasis is placed on continued to expand of the employment opportunities for inmates housed in the institute, create new jobs, the internal reserves by exploring, or developing external relations. The capacity of the institute is 481 people. The Ltd. based on the mid-range of activities classified disaster risk rating.

Tiszalök National Penal Execution Institution. The institute's main task is the implementation of 700 persons, a man convicted of imprisonment imposed in adult prison, jail and prison gear punishment. The Tiszalök National Penal Execution Institution often received the name "fortress", referring to its monumental nature. The 113 638 m^2 plot situated complex of buildings along next to the main road, the aerial photographs are rather outlined it from the landscape. The floor area of housing parts is 5540 m^2. The living areas are two and three-storey buildings in which has cells for one, two and three-person placement. A total of living space is 14 380 m^2, with a building of jail together. The main pillar of the employment in the institute is film-selection which takes place in the production halls. This part of the area is 1191 m^2.

In accordance with the legal provisions in the penal institutions fires extinguished when the expected arrival 10-20 minutes at the scene after the alarm the alert level need to be III priority, which means 3,5-4 fire swarm (figure 1). If the expected arrival on the scene beyond 20 minutes, so in the case of 4,5-6 fire swarm alarm should be imposed. In these alert levels based on the national averages to achieve these institutions in III. priority event can be 34, 43 minutes, while the IV. priority event 56 minutes. Already difficult to reach the institutions by the four fire department a high possibility of the formation of special situations, the cooperating closely with them a limited company. If only taken the average time to arrive based on what almost quarter of an hour, feel free to say that even a short-circuit caused a fire can surely will cause major damage in a paper, cloth or wooden materials manufacturing and processing plant (Restás et al., 2015).

The speed and the sudden position of the fire spread is not only means a loss of production in the near future, but also result the possibility to give a chance inmates to escape also. If like a disaster management patrol duty to fulfil in the area, or the Ltd. or the institute has facility fire department personnel assigned from its own facility, you can reach the legislators are anxious that all distressed people in the territory of the country would receive help within 25 minutes, after the formation of the fire as soon as possible would curb the flames (Szepesi et al., 2003). However, while there is a jail or prison, which the intervention in the first stage is 40 minutes, and a Ltd. operates in the field with further risk factors, then not safe to stay in the area. The specified time of arrive with regard to conclude that there is a high responsibility working in the field of institute, as tens of minutes only themselves to rely on curbing harmful flames, and the preservation of human life and physical integrity.

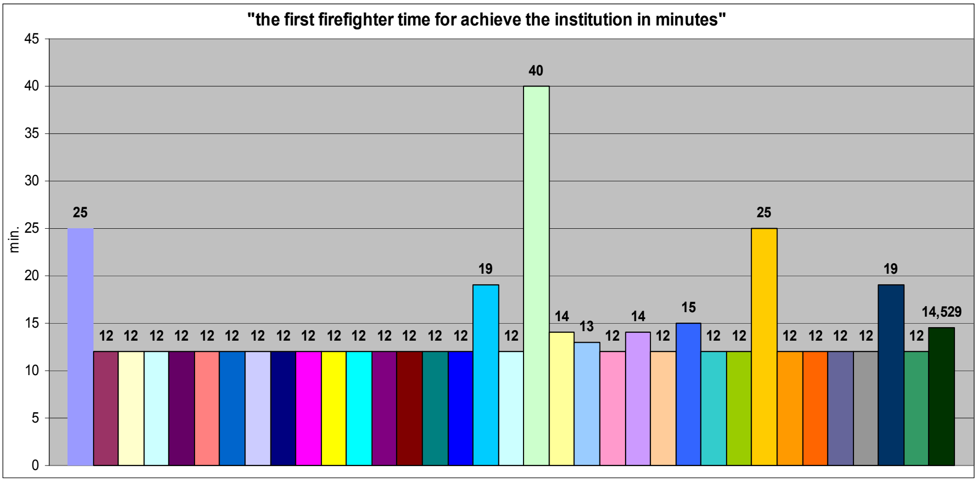

Fig. 1. *The first firefighter time for achieve the institution in minutes.*
Source: Péter Horváth 2017.

At present, for the penitentiary institutions in these areas facility firefighter help or fire protection car are not available, what would include other insurance and options. Nowadays in prisons the provided education for staff include only the back up from the cells, and life saving (Bleszity et al., 2014). Only laic way, to prevent the further spread of fire wall fire hydrants and dry powder fire extinguishers can be used, witch based on the regulations not allowed to use for inmates about security reasons. The possibility of escape of prisoners during the occurring event, fire, transfer or technical rescue need to be taken into account. You often hear about riots and escape attempts in other countries around the world, where tried to use the harmful effects of the fire (Sachs, 2012). If you do not intent to take highest risk of developing of the fire, it will also be counted the commercial companies operating in the prisons, where apparel, industrial, agricultural and other products manufacturing, warehousing is going on, which is not negligible in terms of fire hazard. At one occurring event the institute staff and prisoners in the area shall carry out the first steps of controlling the fire. Taking into account the entry delay time caused by the fire departments distance from the institution, thus the arrival of the primary responding fire units and the locks, concluded that there is not properly trained and equipped staff, the fire may have serious financial and personal sacrifice.

Factors affecting the effectiveness of remediation and save lives:

- the elapsed time between the formation of the incident and the intervention,
- availability of appropriate staff and tools (devices),
- the qualification level of intervention and skill of participants.

DISCUSSIONS

„FIRES WITHIN THE GRIDS”. Fires caused by detained persons can happen several times during the period of deprivation of liberty. The resulting fires formed by the smoke burden of burn the cloth, mattresses and blankets posed a major threat. The modular training system that is required to staff to contain a basic intervention skills of fire events, and the possibilities of rescue of an unconscious person. Teaching of this knowledge is very important, since 2003 in Zalaegerszeg, Zala County Prison a prison fire was demanded human life. The stock of Zalaegerszeg Municipal Fire Department has been contained the fire in the cell.

The service's commander and the first team arrived at the burning cell to rescue an indoors stayed prisoner. The prison guards could not reach the cell due to the high temperature of the heat so that the detainee dead before the arrival of firefighters. Due to the firefighter’s report informed me about the situation, after the opening of the door backdraft phenomenon also occurred, which would have endangered the lives of untrained prison guards who opened the cell door (Restás, 2015). The burning of the thick leather-covered rubber room generated health damaging dense smoke. The flames and the mass volume of smoke of burning materials in the cell was justified the evacuation of prisoners from that level and higher levels. In total 141 prisoners escape had been implemented during the vaccination (Fejes, 2003).

This special intervention in such places, the question is the safety of fire brigades as well. The new Professional Firefighters Tactical Command require due to the reduction of threats, that the fire units in all cases accompanied by a penitentiary person who is equipped with coercive means to maintain security (Restás, 2014a). However, the guards also need to wear respiratory protection apparatus against poisonous gases and vapours (Pántya, 2011). The penitentiary institutions are usually equipped with a small amount of AGA SPIROMATIC 316 (steel bottle) devices, which is practiced to wear and use just in a few places in the country. In case of an occurring fire in the application of rapid and skill level use of respiratory protection will greatly help in the safety of the intervention, as well as to the rescue of prisoners from the cells.

TRAINING OF PRISON STAFF. In the first half of 2014 the Prison Service Headquarters and the Disaster Management Training Centre has developed a common training syllabus for the prison employees. So far, four classes acquainted with the new training syllabus, which has been designed in the spirit of collective thinking. The main theme of the current education was the rescue from the cells, as well as the instructors deal generated during transportation of detainees and the difficulties of fire accidents. In March 2015 was the first rescue simulation in the area of Hatvan-Nagygombos (a captive carrier car accident), which until then was unknown for fire and rescue personnel (Restás, 2014b).

At Prison Service use circle delivery like a routine operation, which the detainees are moved between different institutions. All this, in many different types and capacity of the vehicle used to get up to fifty people at same time can be transported. Due to the special design of transport equipment, there are few and small rescue apertures. In the last 20 years, near Budapest had two roll-over, one was an accident, the second time the vehicle slanted the side because of the strong wind. Such an accident the behavior of inmates is unpredictable, there is a collaborative person, but there are people who immediately take advantage of this excellent opportunity and trying to escape (K.G.H.N., 2015).

A special vehicle suffered a road accident in Budapest, at Budaörsi-Alkotás- Hegyalja crossroads, that supports the legitimacy and necessity of training.

CONCLUSIONS

Between law enforcement agencies other institutions few and more can be found, which has extremely difficult fire situation, due to the geographical location and of production manufacturers and warehousing tasks in the field. I recommend the purchase of fire-fighting cars to the fields, as well as a continued training of prison staff, as far as possible a basic firefighter skills training for the greater number of service achievers. For more options I see the installation disaster sentinel posts (patrols) in the environment of the affected areas, which solution would be to reduce the country's "white spots".

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STUDIA UBB AMBIENTUM, LXIII, 1, 2018, pp. 43-48
(RECOMMENDED CITATION)
DOI:10.24193/subbambientum.2018.1.04

THE IMPORTANCE OF WASTE INCINERATION

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ABSTRACT. The problem of waste incineration has become more and more important lately. Protecting the environment, increasing the amount of waste produced by both industrial and household consumers has led to the implementation of precise directives as well as increased investment to improve this process.

Waste incineration is a thermal process of waste disposal by oxidation at very high temperatures. In the next period, waste producers will be required to deploy and implement solutions in order to be able to safely incinerate the waste for the local population.

Due to growing concern, the incineration benefits have also increased in this segment: environmental pollution is very low due to combustion gases treatment; reducing the volume of waste stored; complete neutralization of waste; after combustion, thermal energy can be used for various purposes; reducing transport costs with the location of an incinerator close to the one that produces them.

An advanced incinerator technology allows the burning of all types of waste. With a growing population and growing consumption, the issue of waste management will become increasingly important and will be a real challenge to have a healthy and clean environment.

Key words: *environment, incineration, waste*

INTRODUCTION

Waste in the current society is products that result in increasing amounts of human activity and which, if not properly managed, can lead to soil, subsoil, water and air pollution.

Waste appears as an inevitable consequence of human activities, but their management has become more and more important in recent times. Waste treatment processes known to date are: waste incineration, co-incineration of waste and pyrolysis (thermal decomposition at high and no air temperatures) of waste. The most important thermal process is waste incineration.

Priority is that uncontrolled waste deposits are replaced as soon as possible by management that leads to product lifecycle through recycling - reuse, along with the construction of sanitary ware or other treatment methods.

Efforts must be directed both towards incineration, composting or organic decomposition, as well as to reduction and reuse or recycling.

Starting from the international priority in the field of waste management, namely the reduction of the amount of waste stored in ecological deposits, the solution of their incineration has been advanced, technology by which the waste loses 70% of the initial volume in organic incinerators, as shown in figure 1.

However, incineration is a very widespread process and its contribution to reducing the amount of waste to be stored and energy resulting from the combustion process cannot be omitted.

Waste incineration - the last phase of the waste management process and is mainly aimed at reducing the volume of waste to be stored and so reducing its environmental impact. If these wastes also have a high calorific value, then the process becomes profitable (Bara, 2004).

Fig. 1. *Organic incinerator model*

THE ADVANTAGES OF WASTE INCINERATION

Of all methods of thermal waste treatment, incineration has the following advantages:

- Versatility and modularity (can be used in all applications and can be of any dimension);
- The lowest costs for implementation;
- Exploitation and cheap maintenance.

As common advantages of heat treatment vs. other types of waste management:

- Energy recovery and reuse;
- Biosecurity;
- Prevention of pollution of water, soils;
- Elegant solution, used in all developed economies.

Another advantage is that incineration is a fast way of waste treatment, and very large quantities can be destroyed in a relatively short time.

The amount of solid material resulting from combustion represents only 15-20% of the initial weight of the waste, leading to the reduction of the land areas required for storage and their use for other purposes (Cismaru and Gabor, 2004).

WASTE INCINERATION

According to data presented by some market operators, Romania produces about 267 million tons of waste per year. It should be noted that about 670 000 tons are dangerous. The burning of solid waste ensures on the one hand the reduction of their volume and weight (up to 5-15% of the values introduced in the process) as well as the potential toxicity and, on the other hand, the recovery of their energy in the form of hot water, steam or electricity (*http://www.zf.ro/eveniment/romania-produce-anual-267-milioane-tone-deseuri-din-care-670-000-tone-super-periculos-15799778*).

The incineration plant is considered to be any technical, stationary or mobile unit and equipment for the thermal treatment of waste, with or without the recovery of the resulting combustion heat. Figure 2 shows how to assemble an incinerator and figure 3, the main waste incineration chamber, part of an organic incinerator.

Due to the technology available today, almost all waste producers can buy or rent an incinerator, so that transport and possible hazards to the population, especially with regard to hazardous waste, are eliminated.

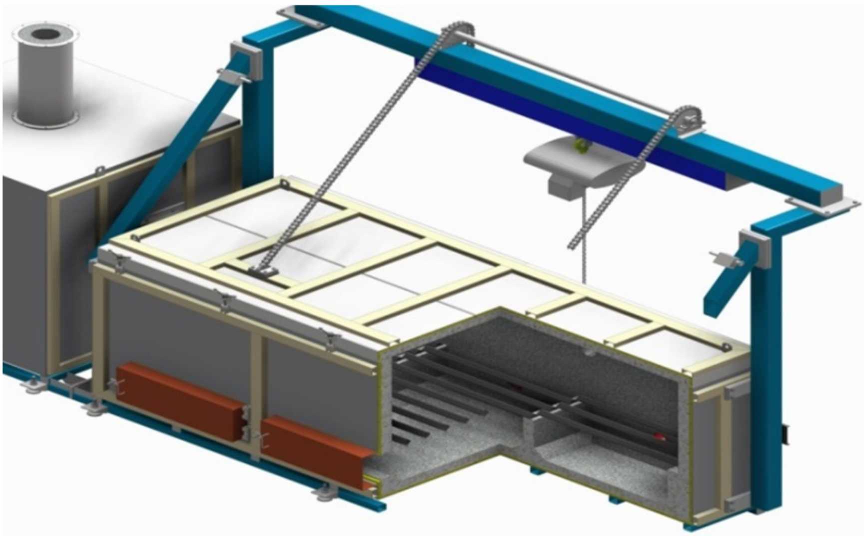

Fig. 2. *Incinerator assembly model*

Fig. 3. *The combustion chamber*

Also thanks to the technology, incinerators can be provided with heat recovery or even with gas treatment plants resulting from incineration. In order to ensure sustainable economic growth in the EU, resources need to be used in a smarter and more sustainable way. It is clear that the linear growth model that our country has relied on in the past is no longer adapted to the needs of today's modern societies and to the globalized world, and that is why another model of economic growth, namely the circular economy model (europa.eu/rapid/press-release_MEMO-15-6204_ro.pdf)

To facilitate the transition to a more circular economy, the European Commission proposes a package of measures including measures to review waste legislation as well as a comprehensive action plan, thus drawing a concrete mission for the European Commission. Waste proposals set a clear and ambitious vision in the long run to increase recycling and reduce disposal, while proposing concrete measures to overcome the obstacles on the ground for improving waste management, also taking into account the different situations in the Member States.

By moving to a circular economy, cost reductions and job creation will be achieved. This may be possible by preventing waste generation, ecodesign, re-use and other similar measures. Total annual greenhouse gas emissions would be reduced by 2-4% (europa.eu/rapid/press-release_MEMO-15-6204_ro.pdf).

Even if the transition to a circular economy is a priority of the European Union with increasing consumption, the resulting waste will be increasing and incineration will be an optimal solution (Tofan et al., 2017).

CONCLUSIONS

Waste incineration is a viable solution for protecting the environment. The advantages of the technology used provide the possibility of creating more and more efficient systems and installations.

At the same time, a stricter and more effective regulation of the legislation in the field will lead to an intensification of the implementation of waste incineration technology.

Acknowledgements

This paper was possible with the help of the Doctoral School from the Technical University in Cluj-Napoca.

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STUDIA UBB AMBIENTUM, LXIII, 1, 2018, pp. 49-59
(RECOMMENDED CITATION)
DOI:10.24193/subbambientum.2018.1.05

DETERMINATION OF THE MONTHLY VARIATION OF RADON ACTIVITY CONCENTRATION IN SOIL

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ABSTRACT. The aim of this study was to assess the monthly variation of radon concentration in soil. Besides the radon concentration in soil, the measured parameters were soil permeability, air temperature, pressure, humidity and wind speed. The measurements were conducted for seven months, from December to June. For the soil permeability measurements RadonJok device was used and for determination of radon activity concentration in the soil it was used the Luk-3C device, equipped with scintillation cells. The highest radon concentration was measured in June (48 kBq m^{-3}). Due to precipitations, on the soil surface a water film was created and as a result the radon could not diffuse into the atmosphere. Because of high permeability, a lower radon concentration was measured on April, which was 17 kBq m^{-3}. The permeability favored radon diffusion which decreased its quantity in soil. The highest radon potential was determined to be in June. The lowest was determined to be in April, when the soil permeability was at its highest value. The radon index was medium for January to May and high for June.

Key words: *radon in soil, monthly variation, radon potential, radon index.*

INTRODUCTION

Radon (Rn-222) is one of the most studied elements at this moment and, as a result of epidemiological studies; it was classified as the second cause of lung cancer, after smoking (WHO, 2009). Radon is colorless; it has no smell or taste.

Radon is highly mobile and cannot be fixed by chemical reactions. Since radon sources continuously emit this gas, systematic measurements are required to determine areas with increased radon potential (Niță et al., 2010). The resulting products from the disintegration of Rn-222 are attached to aerosol particles. Lungs inhalation of these particles causes an increase in internal exposure of the human body and may result in a higher incidence of lung cancer (Mikšová & Barnet, 2002).

Radon migration from the place of formation to atmosphere, water and houses, depends on certain factors such as soil porosity and humidity, pressure and temperature difference between two environments (soil, atmosphere and water).

The radon exhalation from the soil involves two processes: the emission and the transportation of radon through diffusion and convection (Alharbi et al., 2006). The two processes are affected by several factors including soil properties such as moisture, porosity, permeability and soil grain (Tauner, 1964).

MATERIALS AND METHODS

The determination of radon activity concentration in soil

The measurements of radon activity concentration in soil were performed with the LUK-3C device, shown in figure 1. The device is based on scattering detection technique through Lucas cells. The method for determining the concentration of radon activity is detailed by Cosma et al., 2013.

Fig. 1. *LUK-3C device*

The determination of the radon potential in soil

In order to determine the radon potential in soil, both radon activity concentration and soil permeability measurements are necessary. Soil permeability is very important in the process of transporting the gas through the soil. This largely influences radon flow or exhalation and, in the present case, it was determined with the help of Radon Jok device (figure 2). The base of soil permeability determination is Darcy equation (I):

$$Q = F \cdot \left(\frac{k}{\mu}\right) \cdot \Delta p \qquad \text{(I)}$$

Q – the air flow through the extraction tube ($m^3 \cdot s^{-1}$), **F** – extraction tube shape factor (m), **k** – soil permeability (m^2), **μ** - dynamic air viscosity (Pa·s), **Δp** – pressure difference between the soil surface and the active soil area (Pa).

For the calculation of the shape factor (**F**) of the probe from equation (I), the following relation is used (II):

$$F = \frac{2 \cdot \pi \cdot L}{\ln \{2 \cdot L \cdot [\frac{(4 \cdot D - L)}{(4 \cdot D + L)}]^{1/2} / d\}} \qquad \text{(II)}$$

L – the active surface length (m), **d** – the diameter of the active surface (m), **D** – the depth of the extraction tube (m).
The determination of soil permeability is calculated according to the equation (III) (Radon Jok manual):

$$k = \frac{V \cdot \mu}{F \cdot \Delta p \cdot t} \qquad \text{(III)}$$

V – volume of the expandable cell of Radon Jok device (2 · 10-3 m3), μ - dynamic air viscosity (Pa·s), at 10ºC, μ = 1,75 · 10-5, F – extraction tube shape factor (m), t – the time in which the cell is expanded to maximum (s).Δp – pressure difference between the soil surface and the active soil area (Pa).

The upper detection limit of the Radon Jok device is 1.8 x 10 -11 m2, and it does not have a lower limit (Mikšová & Barnet, 2002). The upper part of the Radon Jok device is equipped with an expandable air cell with a volume of 2 x 10-3 m3. On the upper part, the air cell is equipped with a tap connected to the air extraction probe from the soil. On the lower part of the cell there is a calibrated metal rod equipped at the end of it with the weights needed to expand the air cell filled with air extracted from the soil. With the help of these two weights the pressure difference is determined. The pressure difference is 2160 Pa when using a single weight and 3750 Pa when using both weights, in order to determine soil permeability. The lower part of the device is equipped with a tripod so that the device will stand in a straight position for proper use. Once the tap is open, the Radon Jok begins measuring the time required to fill the expandable cell. The resulting time is the time (t) from equation (III).

Radon Potential is calculated according to the equation (IV) (Neznal, et al., 2004):

$$R.P. = \frac{3th\ quartile\ from\ Radon\ Activity\ Concentration - 1}{-\log(3th\ quartile\ from\ soil\ permeability) - 10} \qquad \text{(IV)}$$

Radon Index is ***LOW*** for Radon Potential (R.P.) <10, ***MEDIUM*** for 10 ≤ R.P. < 35 and ***HIGH*** for R.P. ≥ 35.

Fig. 2. *Radon Jok device.*

RESULTS AND DISCUSSIONS

In order to evaluate the monthly variation of radon activity concentration in soil, a set of measurements was made during a period of six months (December - June) within the Faculty of Environmental Sciences and Engineering yard. In this study, it was taken into account the meteorological conditions (air temperature, atmospheric pressure, relative humidity and wind speed), soil permeability and radon activity concentration in five points on an area of 10 m^2 in order to observe the spatial distribution of radon activity.

Table 1 presents the meteorological situation during the determination of the radon activity concentrations in the selected points, and also the concentration values of radon activity in soil. In December the maximum concentration was 45.5 kBq m^{-3} and the minimum concentration was 24.8 kBq m^{-3}. In January, the radon concentration in soil was lower than in December. In February, the highest average of radon activity concentrations from the entire study was obtained (35.2 kBq m^{-3}). Low concentrations of radon activity were recorded in April and in two measuring points the concentrations could not be determined. The main cause was the high soil moisture concentration. Soil permeability was determined since February, when soil moisture was reduced.

Table 1. *The activity of radon in the soil on a period of six months*

Months	***T (ºC)***	***P (mb)***	***H (%)***	***Wind speed (m s⁻¹)***	***Soil perm. (m²)***	*Radon Concentration* ***(kBq m⁻³)***				
						Measuring points				
						1	**2**	**3**	**4**	**5**
December	2.2	952.4	85	0.4	-	26.6	27.6	45.5	24.8	30.8
January	10.1	958.9	99	3.6	-	20.4	26.1	27.0	22.1	24.6
February	14.1	950.7	45	2	$2.23 \cdot 10^{-12}$	29.0	40.9	43.2	32.8	29.9
March	10.5	954.2	42	2	$6.23 \cdot 10^{-12}$	10.1	22.0	32.2	35.2	22.6
April	14.2	976.7	35	4.0	$9.42 \cdot 10^{-12}$	-	-	20.4	16.7	12.7
May	20.3	971.3	50	0.5	$6.38 \cdot 10^{-12}$	10.0	11.9	42.1	29.2	20.3
June	23.3	967.5	50	1.5	$5.25 \cdot 10^{-12}$	43.8	42.3	52.2	46.4	53.7

T – Temperature; **P** – atmospheric pressure; **H** – relative humidity; **Soil perm.** – Soil permeability.

The Spearman correlation coefficient shown a good negative correlation between the radon activity concentration in soil and atmospheric pressure (r = -0.83), respectively a moderate correlation with wind velocity (r = -0.75).

Table 1 and figure 3 show the evolution of the radon activity concentrations in soil during this study, respectively the atmospheric pressure. The explanation of the high radon concentration in soil on the cold period is that in the three months (December, January and February), the precipitation is often short-lived, maintaining the soil pores saturated with water making the radon unable to pass through the pores so that the radon concentration increases. In the warm season, the soil moisture is reduced, the pores of the soil are devoid of water and radon diffuses and reaches the atmosphere, lowering the concentration of radon in the soil (Taipale and Winqvist 1985; Cosma and Jurcuţ, 1996).

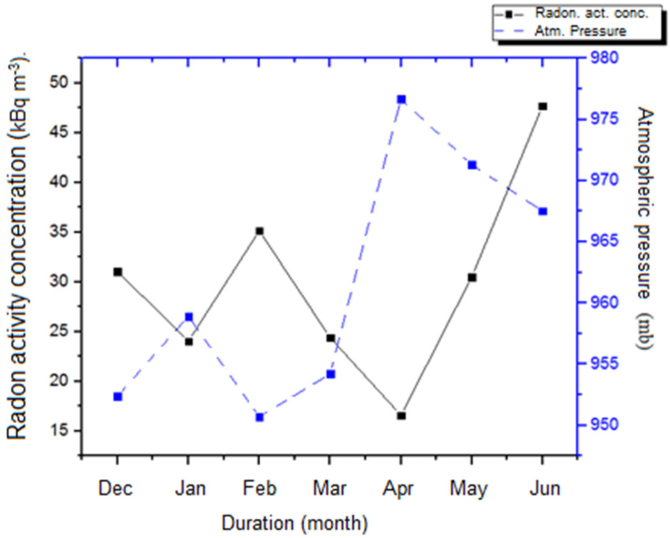

Fig. 3. *The variation of radon activity concentration in soil and atmospheric pressure for the monitored period.*

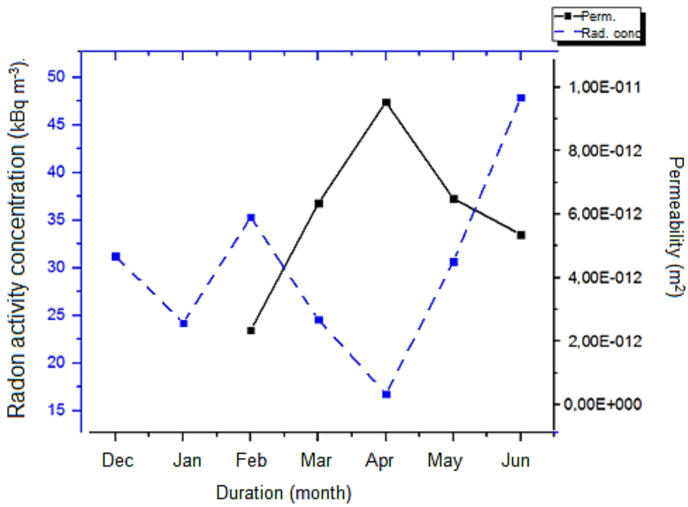

Fig. 4. *Variation of soil permeability and soil radon concentration for the monitored period.*

Figure 4 shows the permeability of the soil and the concentration of radon activity in the soil for the study period. Analyzing this graph, it can be observed that radon concentration variation depends on soil permeability. For example, in April, when soil permeability is increased, radon activity in soil was at its lowest concentration of 16.58 kBq m^{-3}. In January and February, when the soil permeability is low, the concentration of radon activity in the soil was at its highest concentration 35.15 kBq m^{-3}.

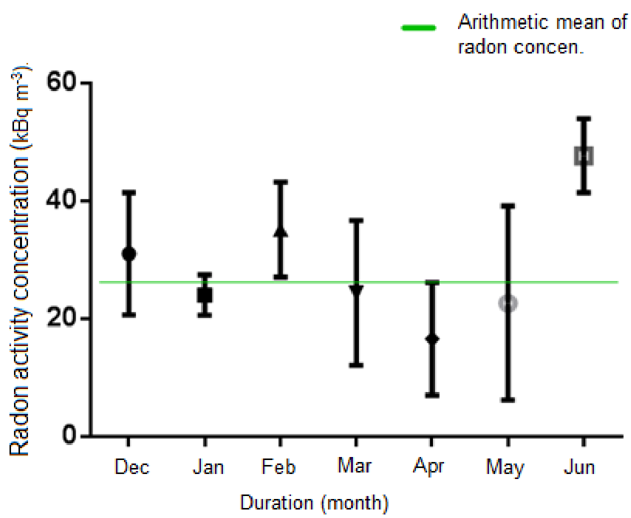

Fig. 5. *Arithmetic mean of radon concentration with confidence interval of 95%*

Figure 5 shows the concentration of radon activity with a confidence interval of 95%. It can be noticed that, except for June, all 95% confidence intervals contain the average of all measurements. The arithmetic mean obtained in June can be considered an outlier because the measurements took place under different conditions (heavy rainfall). Therefore, in case of determining the radon activity concentration in soil, it is recommended to carry out measurements at several points and to determine the 95% confidence interval, along with the recommendation not to perform measurements in periods of heavy rainfall.

Table 2. *The radon potential (R.P) and the radon index (R.I) determined in soil calculated with radon activity concentration and soil permeability*

Month	*D* ***(m)***	*Rn Conc.* ***(kBq m^{-3})***	*K* ***(m^2)***	*R.P.*	*R.I.*
December	0.8	31.1	-	-	-
January	0.8	24.0	-	-	-
February	0.8	35.2	$2.23 \cdot 10^{-12}$	24	MEDIUM
March	0.6	24.4	$6.23 \cdot 10^{-12}$	26	MEDIUM
April	0.8	16.6	$9.42 \cdot 10^{-12}$	18	MEDIUM
May	0.8	30.5	$6.38 \cdot 10^{-12}$	31	MEDIUM
June	0.8	47.7	$5.25 \cdot 10^{-12}$	43	HIGH

Table 2 shows the highest radon potential which was determined in June and the lowest in April, when the soil permeability was highest. The radon index was medium from February to May and high in June. Although variations in radon concentration in soil are high (16.58 – 47.7 kBq m^{-3}), from the perspective of radon index, with the exception of June, the same category (Medium) was found. As such, it is recommended that, along with radon concentration in soil, the soil permeability to be also calculated, in order to assess the radon potential and radon index which are essential for the identification of "hot" areas in terms of radon activity concentration.

CONCLUSIONS

This paper aimed primarily to assessing the variation of radon activity concentration in soil. In addition, weather conditions were taken into account when determining the concentration (air temperature, atmospheric pressure, air humidity and wind speed). The meteorological information is available on the web site of the National Meteorological Administration (*www.meteoromania.ro*).

The highest average concentration of radon activity in soil was determined in June (47.7 kBq m^{-3}), due to the abundant rainfall creating a water film through which radon could not diffuse, thus accumulating in the soil. In April, when the lowest concentration of radon activity was recorded, soil permeability was at it's the highest throughout the study.

Acknowledgement

This study is supported by the project ID P_37_229, Contract Nr. 22/01.09.2016, with the title ”Smart Systems for Public Safety through Control and Mitigation of Residential Radon linked with Energy Efficiency Optimization of Buildings in Romanian Major Urban Agglomerations SMART-RAD-EN” of the POC Programme.

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STUDIA UBB AMBIENTUM, LXIII, 1, 2018, pp. 61-71
(RECOMMENDED CITATION)
DOI:10.24193/subbambientum.2018.1.06

ANALYZE OF THE PHYSICAL-CHEMICAL PROPERTIES OF THE SOIL IN THE AREA POSTA RAT / TURDA

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ABSTRACT. The most important contaminated areas from Cluj County are the uncontrolled HCH scrap deposits from Turda city, which appeared as a result of the industrial activity of the former Chemical Plant Turda. Over the years, were identified 4 locations in the area. The four contaminated locations situated in the area of Turda city Sum up to 60000 tons of HCH polluted soil are. One of these zones is the Posta Rat area (40000 m^2) which is situated on the left bank of Aries River. The objective of this paper is to carry out experimental researches in order to establish the physical-chemical properties of the soil from Posta Rat area, soil contaminated with HCH (hexachlorocyclohexane). The texture, structure, humidity and pH are the main analysis performed in order to determine the optimum cleaning technologies for the deteriorated soil as a result of the activity of the Chemical Plant in Turda. The results of the physical-chemical analysis can point out the most suitable cleaning soil solution, because as a result of the study, the characteristics of the soil are known, being much easier to identify the applicability limits of the cleaning solutions.

Key words: *humidity, Posta Rat, pH, structure, texture*.

INTRODUCTION

The environment decay and pollution comprises changes in the quality of the environment. Any material or substance introduced artificially into the biosphere or that exists in natural conditions and induces negative modifications of the quality of the environment represents a pollutant (Munteanu et al., 2011).

The most important contaminated areas from Cluj County are the uncontrolled HCH scrap deposits from Turda city, which appeared as a result of the industrial activity of the former Chemical Plant Turda (Prodan, 2012).

At the Chemical Plant from Turda, founded in 1911, was produced starting with 1950 an insecticide called hexachlorocyclohexane (HCH) and after 1960 a liquid insecticide dichlorodiphenyltrichloroethane (DDT) – 400 tons/year. In 1979 the production of HCH was stopped but until that moment in Turda was created several chemical residues deposits as a result of the production process of this insecticide (Prodan, 2012).

Over the years, were identified 4 locations in the area (RPM, 2010). The four contaminated locations situated in the area of Turda city (approximatively 7 ha) sum up to 60.000 tons of HCH polluted soil are (Prodan, 2012):

1. Right bank of Aries river (4000 m^2);
2. Right bank of Aries river – construction site SC Constructorul Turda (24000 m^2);
3. Left bank of Aries river – Posta Rat area (40000 m^2);
4. National Road DN 1 km 440/700 – Mihai Viteazu village (5000 m^2).

The HCH production of Turda Chemical Plant resulted in obtaining significant quantities of dangerous waste built from other isomers of this substance.

From the technological production process of HCH results waste in a ratio of approximately 3 times bigger than the active part. As a percentage, approximately 25 % was obtained gamma active isomer and the rest of 75 % inactive isomers which were deposited in an uncontrolled way. So, as a result of the technological process, resulted a quantity much bigger of inactive product dumped uncontrolled, thus significantly deteriorating the environment (RPM, 2010).

The problem of these contaminated areas is difficult to handle due to the fact that Turda Chemical Plant seized completely its activity, and the goal of cleaning them is left in the responsibility of the local public administration (Gabrian, 2013).

The scope of this paper is to analyze the physical-chemical properties of the soil in order to investigate the optimum cleaning technology of the deteriorated soil as a result of the activity of Turda Chemical Plant.

MATERIALS AND METHODS

From Posta Rat area were taken 3 soil samples (figure 1) from different depths, according with table 1.

Gathering of the soil samples assigned to physical-chemical analysis was made according with the methodological norms mentioned in STAS 7184/1-84 and processed further on according with SR ISO 10381-6:1997 standard and respectively SR ISO 11464:1998 (STAS 7184/1, SR ISO 10381-6, SR ISO 11464).

Sampling point 1 is located in the north-west part, towards the limit of the studied area, near a local residence (46,566718N; 23,814856E). In the depth of the soil profile was observed the existence of the same soil type, cement looking, and the presence of HCH could be seen clearly (white-grey color).

Sampling point 2 is located in the central part of the area towards the south (46,565711N; 23,814951E). Nearby were found coniferous threes among which well delimited zones which were not covered by any type of vegetation. The aspect of the soil from this point is very similar with point 1, cement looking and with visible traces of HCH.

Sampling point 3 is located in the central area towards east (46,566165N; 23,815801E). In this point the vegetation is much denser, but the traces of HCH are similarly visible.

The soil samples taken were analyzed from physical-chemical point of view in order to establish the main characteristics which will influence the choice of most suitable cleaning method of Posta Rat area. The analyzed characteristics are: humidity, pH, structure and texture.

The analysis of the samples was made in the Laboratory of soil cleaning methods and equipment from the *Department Environmental Engineering and Sustainable Development Entrepreneurship* of the Faculty of Material and Environment Engineering, Technical University of Cluj-Napoca.

Fig. 1. *Sampling points*

Table 1. *Soil samples from different depths*

Depth [cm]	Point 1	Point 2	Point 3
0 – 10	P1	P2	P3
30 – 40	P1'	P2'	P3'
60 – 70	P1"	P2"	P3"

The analysis of the samples was made in the Laboratory of soil cleaning methods and equipment from the *Department Environmental Engineering and Sustainable Development Entrepreneurship* of the Faculty of Material and Environment Engineering, Technical University of Cluj-Napoca.

Humidity determination was made using gravimetric method accordingly with the methodological norms from STAS 7184/9-79 and processed accordingly with SR ISO 11465 norms (STAS 7184/9, SR ISO 11465).

pH determination was made using potentiometric method accordingly with the methodological norms from STAS 7184/13-88 and processed accordingly with SR ISO 10390 norms (STAS 7184/13, SR ISO 10390).

Soil structure determination from Posta Rat area was made using Sekera method. The method consists in dispersing in water soil aggregates and comparing the results with the models presented in an auxiliary board (Micle and Berar, 2012).

Texture determination was expressed through the ratio of mass content of the main components: clay, dust, sand, ballast and boulder using RETSCH AS 200 bolter equipment (Micle and Sur, 2012).

EXPERIMENTAL

Soil humidity determination

In order to determine the actual humidity was used the gravimetric method which consisted in weighing with analytic KERN scale 100g of each soil sample. The samples were introduced in Binder FD 53 stove, at 105 °C temperature and maintained up to complete evaporation of the physical bonded water (4 hours).

pH determination

For this analysis was weighted 5g of soil/sample over which was added 100 ml of distilled water and stirred in order to homogenize. pH measurements were made with WTW MULTILINE IDS multiparameter.

Soil structure determination

From each soil sample were selected 10 soil aggregates with the diameter of about 1 cm. These soil samples were put in a Petri basin/bowl on a filter paper previously moisten in distilled water. The soil samples were allowed for 3 minutes to absorb the water from the filter paper. After the 3 minutes have passed, distilled water was added up to a certain level above the aggregates. The samples prepared using this method were rested for 10 minutes, after that were rotated in the table plan three times without being lifted from the table in the clockwise sense. Next step was to gentle drain the water surplus, after which each sample was extracted on a white sheet of paper and the result is compared with the models from the auxiliary board.

Texture determination

In order to determine the texture of the soil, were weighted 500 g of soil/sample using the analytic scale. The weighted soil was introduced in the RETSCH bolter equipment, which has 11 bolters with the diameter of: 0,8; 0,6; 0,44; 0,32; 0,20; 0,16; 0,15; 0,071; 0,063; 0,056; 0,040 [mm], and the soil which remained of each bolter was weighted. Based on the soil mass remained on each bolter were determined the structural mass fractions found in the studied soil.

RESULTS AND DISCUSSIONS

Soil humidity

According with the results obtained (figure 2) it can be seen that the soil from the studied area contains a high quantity of physical bonded water in its mass. This thing is clearly observed due to the fact that the majority of the samples have a humidity percent of over 80 %. Sampling point 3 registered lower values (60 – 80 %).

pH

The results of the pH determination process show that the soil in the investigated area has a strong basic behavior/composition (much higher that limit value of 7), and its basic composition grows constantly with respect to the depth of the soil (figure 3).

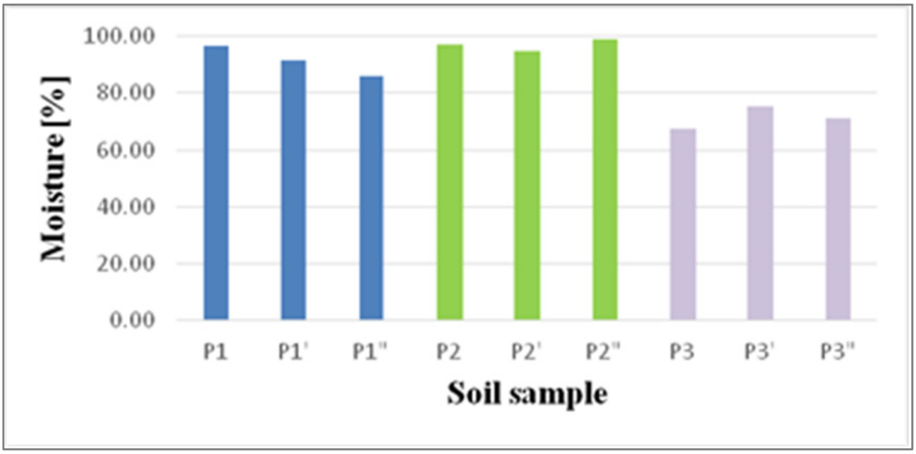

Fig. 2. *Soil humidity from Poşta Rât area*

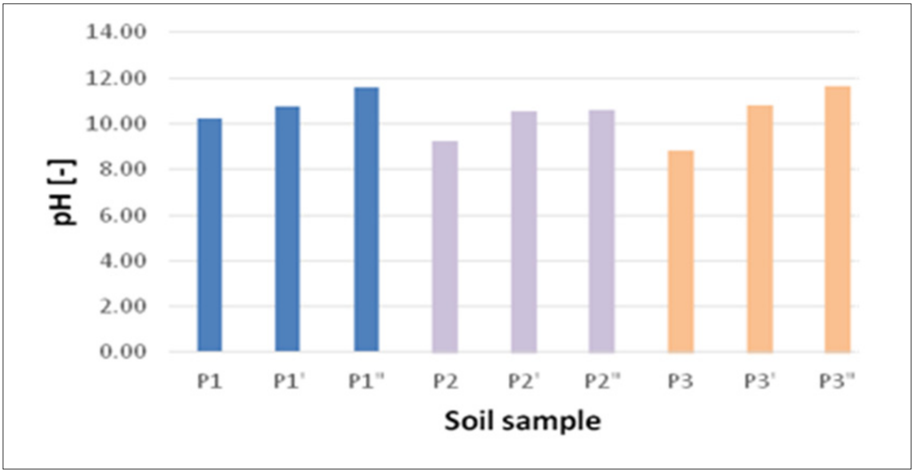

Fig. 3. *pH variation in the soil profile*

Structure

On all three sampling points was noticed the same behavior of the soil in depth plan. The results obtained in the samples of sampling point 1 are shown in figure 4.

Analyzing each sample was observed the variation on depth of the structure type, thus the samples taken from the same depth had the same structure, no matter the sampling point. As a conclusion it can be said that the soil situated at 0 – 10 cm depth is partially structured, the one at 30 – 40 cm is relatively well structured and the soil from 60 – 70 cm depth is very well structured.

a) b) c)

Fig. 4. *Structure determination –sampling point 1:*
a) 0 – 10 cm; b) 30 – 40 cm; c) 60 – 70 cm.

Texture

The results of the texture analysis show the fact that coarse sand fraction are found predominantly, followed by middle sand and a small proportion of fine sand (figure 5).

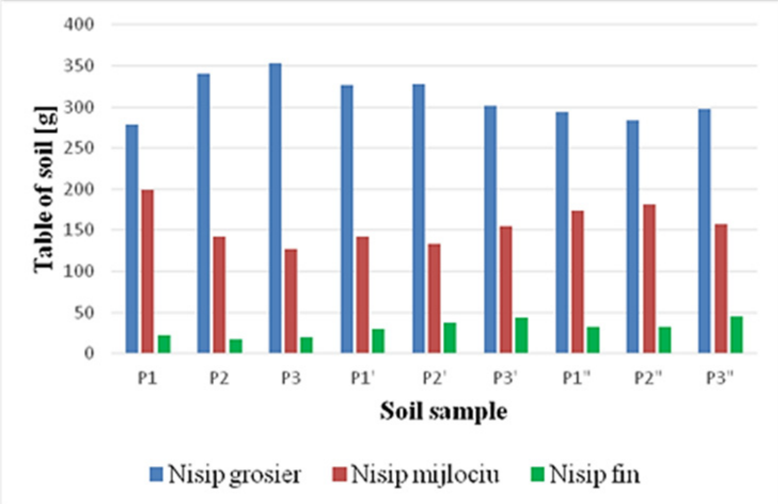

Fig. 5. *Structural fractions of the analyzed soil*

The texture of the soil has a direct influence in the soil permeability and this property is important in determining the cleaning method. Function the component type were determined the following permeability classes (table 2) (Micle, 2009).

According with the bibliography, correlated with the textural specialty results, the soil from the analyzed area has a relative high permeability being formed mainly from coarse sand and middle sand.

Table 2. *Depending on the state of permeability of the soil in the textural (Micle, 2009)*

Nr. crt.	Component type	Permeability [m/s]	Permeability class
1	Clay	$<10^{-9}$	Impermeable soil
2	Dust	$<10^{-7}$	Slightly permeable soil
3	Fine sand	$<10^{-4}$	Permeable soil
4	Middle sand	$<10^{-3}$	Soil with satisfactory permeability
5	Coarse sand	$<10^{-2}$	Permeable soil
6	Ballast	<1	Soil with good permeability
7	Bolder	<10	Very permeable soil

CONCLUSIONS

The insertion in the natural environment of some anthropic made substances or even natural ones has a direct influence in the bio-physical and chemical balance of the respective habitat. The danger is bigger when the inserted substances have hazardous properties like HCH. Inactive HCH has its origin in the production of HCH pesticide in Turda Chemical Plant, but were also produced significant quantities of waste which contain other isomers of this substance. The waste thus obtained was deposited wrongly on different areas in the vicinity of Turda city.

It was noticed the fact that on the entire contaminated area surface exist traces of soil mixed with HCH, due to the direct unloading of waste resulted from the technological production process of HCH at Turda Chemical Plant.

It is obvious that the emplacement nests a significant quantity of waste present in this area for a long time due to the fact that the soil has cemented and absorbed HCH and a relatively high depth (over 70 cm).

It was noticed also the presence of HCH in the soil profile, both at the surface and also in depth, the soil having the same color, texture, structure and behavior during the study in all sampling points.

The analyzed soil indicates that coarse sand is predominant, followed by middle sand and a small proportion of fine sand, having a basic pH.

The results of the physical-chemical analysis can point out the most suitable cleaning soil solution, because as a result of the study, the characteristics of the soil are known, being much easier to identify the applicability limits of the cleaning solutions.

Acknowledgements

The results presented in this paper were obtained with the support of the Technical University of Cluj-Napoca through the research Contract no. 1990/12.07.2017, Internal Competition CICDI-2017 (Project BIOSOLIX).

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*** STAS 7184/13-88 *Soluri. Determinarea pH-ului.*

*** SR ISO 10390/1999 *Calitatea solului. Determinarea pH-ului.*