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THE HEAVY METALS IMPACT ON SURFACE WATER AND SOIL IN THE NON-SANITARY MUNICIPAL LANDFILL "PATA RÂT"– CLUJ-NAPOCA

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ABSTRACT. This study proposes to investigate the environmental impact caused by heavy metal contamination on soil and surface water from the non-sanitary waste municipal landfill "Pata Rat" from Cluj-Napoca Romania. The samples were analyzed with atomic absorption spectrometer (AAS). The evaluation of the analysis results proves that there is high pollution in soil with some heavy metals (Pb, Cu). The heavy metals content was investigated also in water samples from Zapodie stream that flows near the landfill and in leachate collected from the same landfill.

The overall view of the study presents a recent evaluation of the pollution with heavy metals attributed to the exploitation of the landfill for over 37 years, and establishes the influence and the transfer mode on environmental contamination.

Keywords: *waste storage, landfill, heavy metals, AAS, pollution, environmental impact*

INTRODUCTION

From the many environmental problems is no doubt that waste is a major problem. The quantities of the generated waste are increasing in an alert way from year to year and the impact on the environment and communities is growing larger. The municipal waste management is a big responsibility primarily for government authorities and for the population.

The municipal waste depositing on the ground is not the most acceptable solution because of the adverse environmental impacts, however it was and is still used. In the EU the amount of the municipal waste stored in landfills has decreased with more than 25% since 1995. The negative effects of the landfills are the formation of methane gas emissions and the production of a leachate

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(150 m3/day) [1]. As a comparison, in the United States, the waste storage remains the predominant method of disposal of the municipal solid waste (MSW), approximately 50% of MSW generated is stored in landfills [2].

In Romania, almost all the municipal waste is discharged in landfills more or less suitable in terms of the environmental protection. The simple storage of the waste was a widespread practice in the past and the municipal waste was discharged in natural pits or simply lies on land, without taking any measurements to protect the environment. This simple storage system is dangerous for public hygiene, unsightly and no environmentally friendly.

The old waste landfills built in Romania in the '70 and '80 do not comply with new regulations imposed by the European Commission. Most of these landfills have been closed or are closing. But the impact on the environment caused by them still exists. This fact had determined the Romanian governmental authorities to provide legislative measures that need to be taken post closure for at least 30 years and actions to reduce their pollution. Notwithstanding, by derogation, the application of the Directive 1999/31/EC, the conditions for water control and leaching management, soil and water, gas control and stability shall not apply in Romania until 16 July 2017, to a number of 101 of existing municipal landfills of waste. Beginning with 2006, Romania has reduced step by step the waste quantity from 101 non-sanitary landfills. In this context in "Pata Rat" landfill the storage activity ceased on 16 July 2010, in accordance with the Accession Treaty and GD 349/2005 [3].

"Pata Rat", the biggest municipal landfill of the Cluj County, located on the road linking the village Pata and Cluj-Napoca city was put into the operation in 1973 and was designed to a capacity of 3.5 million tons on an area of approximately 9 ha and 30 years of operation [4].

At the present it covers about 18 ha of land at a distance varying between 2-10 m from Zapodie stream.

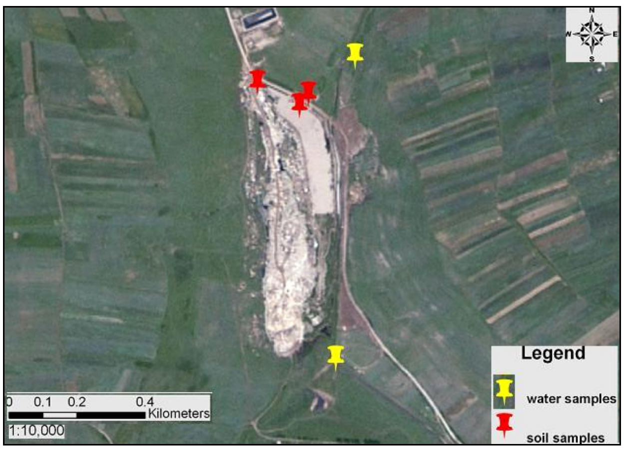

Figure 1. The non-sanitary landfill „Pata Rat" of Cluj-Napoca city location

According to the monitoring data, during 37 years of operation, about 10 million of tons of municipal and industrial waste were stored without prior separation or treatment. The waste storage in these conditions has led to changes in the environmen and since 2005 exceeded the designed capacity [5].

RESULTS AND DISCUSSION

The environmental impact assessment of the heavy metals from "Pata Rat" landfill was made on the basis of measurements of the parameters from the leachate, water and soil, which revealed changes of the physical and chemical parameters, compared with normal and threshold values [6].

The heavy metals concentrations found in the soil samples are as follows in the Table 1.

Table 1. Heavy metals concentration in the soil samples

Sample	Geografical coordinates	Cd mg/kg	Cr mg/kg	Cu mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
Ss_1	N 46°46'07,7"; E 23°41'12,4"	0.46	15.3	19.9	20.0	54.7	33.4
Ss_2	N 46°46’05,6"; E 23°41'18,3"	0.26	8.62	14.9	15.4	54.3	25.2
Ss_3	N 46°46'06,7"; E 23°41'19,5"	0.27	8.98	32.3	15.7	96.7	47.8
NV		**1**	**30**	**20**	**20**	**20**	**100**
AT		**3**	**100**	**100**	**75**	**50**	**300**
IT		**5**	**300**	**200**	**150**	**100**	**600**

Legend: Ss - soil sample, NV - normal value, AT – alert threshold, IT – intervention threshold, according to the Decree No 756 of the Government of November 3 of 1997

The results proved that in the soil, Cu displays higher concentrations, than normal value specified in the national legislation, but lower than the alert threshold, whilst Cd, Zn and Cr, concentrations are below the normal values. The Pb values are higher than the alert thresold indicating its impact on soil. The obtained results in soil increased in the following order: Pb > Cu > Ni > Cr > Zn > Cd regarding the overpass the normal values. The explanation for the high concentration of lead is given by its tendency to link with iron oxides and carbonates and remaining in the upper soil layers [7]. As other studies have shown, it appears that the solubility of heavy metals is low because MSW is a good adsorbent matrix. [8].

The leachate is a liquid waste generated during the storage of the solid waste activities by: the ingress / percolating the rain water into / through the body of the landfill, the separation of the water contained in the waste stored and the decomposition of the stored biodegradable waste [9]. The leachate can be loaded with organic and inorganic compounds, metals, etc., requiring collection and treatment. The chemical composition of the leachate may be influenced by the nature of the existing waste on the landfill. In the case of the simple storage without waterproofing base of the landfill, such as the Pata Rat the leachate flows into the soil under the landfill, and infiltrate into the deep water.

Table 2 shows the heavy metals concentration in the leachate sample from the Pata Rat landfill in comparison with the limits allowed by the legislation.

Table 2. Heavy metals concentration in the leachate sample

Heavy metals	Concentration mg/dm^3	Admissible limit values according to the Decree no.188/2002 NTPA 001
Cr	0.64	1.0
Pb	0.10	0.2
Ni	0.13	0.2
Cd	0.07	0.3
Cu	0.14*	0.1
Zn	0.07	0.1

Legend: * values which are higher than the admissible limit values set by the Romanian legislation

The leachate analysis results show that heavy metal pollution is not an issue, except for Cu. However, it must be considered that the leachate is collected just from the third part of the landfill, while the other part doesn't have collection pipelines. The low concentrations of heavy metals found in leachate is due to the adsorption capability of the landfill layers. It was proved the tendency of Cu to combine in the form of sulphates with high mobility in soil and to be trained by the water storage [10, 11]. The biggest part of the leachate flows under the landfill for non-sanitary landfills. Even it is naturally refined, it is possible that a part of the hazardous substances reach the groundwater layer. The filtration degree of the soil and the retention of the hazardous substances from the leachate depends on the porosity, the ion exchange capacity and the retention capacity for the dissolved substances. The soil which contain clay will blok more the dissolved substances than the soil with big porosity [12].

The heavy metals content was investigated also in water samples from Zapodie stream that flows near the landfill in order to determine its ecological status, according to the Decree No 161 of the Government of 16th February 2006, used for the assessment and classification of the surface waters.

Table 3 presents the concentration of the heavy metals in the samples collected upstream and downstream of the landfill.

Table 3. Heavy metals concentration in the water samples

Sample	Geografical coordinates	Cd µg/l	Cr µg/l	Cu µg/l	Ni µg/l	Pb µg/l	Zn µg/l
Sw_1 downstream	N 46°46'10,4" ; E 23°41'25.9"	5.16	43.0	17.6	233	3.08	257
Sw_2 upstream	N 46°48'58" ; E 24°01'43"	4.71	40.8	13.8	230	2.01	20.3

Legend: Sw water sample

Table 4 presents the clasification of the streams regarding the ecological status, from the point of view of the metal contamination.

Table 4. Clasification of the stream regarding the ecological status, according to the the analyzed metal content (S_{w1} (■), S_{w2} (●))

No.	Metal	Class I very good	Class II good	Class III moderate	Class IV weak	Class V bad
1	Cd				●	■
2	Cr		■●			
3	Cu	■●				
4	Ni					■●
5	Zn	■●				
6	Pb	■●				

Legend: Sw water sample: Sw_1 downstream, Sw_2 upstream

Water analysis results shows a bad quality for Cd, Ni, which indicate a high pollution of these metals. For Cu, Pb and Zn the results support a quality class I, and for Cr a quality class II. Although according to the assessment of the water quality in the Environmental Status Report 2010 [13], Zapodie stream was classified into the quality class V (bad), being determined by physical and chemical elements: oxygen regime, nutrients and salinity.

The obtained results highlight that in Zapodie stream has not reached a high concentration of heavy metals, which indicate that the transfer of the heavy metals from the landfill body into the nearby stream was made in a small measure. This can be explained by the fulfillment of the requirements settled by the Environmental Authority in the Environmental Notification for the closure, from 2003, by: fitting slope and cover with gravel the slope from the stream side, drainage channels and retention tanks for the leachate arrangement of Zapodie stream.

CONCLUSIONS

It has been shown that the greatest impact on soil near the landfill is caused by Pb for which must be taken measures to prevent the further soil pollution and monitor the pollution source, according to the Decree No 756 of the Romanian Government. Copper ranks on second place in terms of the concentration in the soil over the normal value, while the concentrations of Cd, Zn, Cr, Ni in the soil did not exceed the normal values. In the leachate were found overruns just for Cu, and in the surface water were found overruns for Cd and for Zn. From these results, we conclude that the source of the water pollution with heavy metals, may belong of other pollution sources and not to the landfill.

The evaluation of heavy metal pollution of the water stream from the landfill area reveals an ecological status, class IV and V for cadmium and for nickel, and for its reducing should to be taken additional measures, such as stricter controls according to the measures specified in European legislation are that should be imposed on pollution sources.

The transfer of heavy metals from the landfill body into the leachate, soil and nearby water course was done in small measure.

Although heavy metals concentrations exceeded the normal values provided by law, the environmental pollution of the studied matrices (soil, water) is below the expectations, considering that the landfill is a non-sanitary one and it has been used for 37 years.

EXPERIMENTAL SECTION

The metals from the soil can be strongly bounded or complexed. The sum of total forms represents the total metal content in the soil. The forms under which the metal can be found depends on the nature of the soil, pH and on the presence of the humic matter content [14].

The soil is characterized by the existing heavy metals, which depends on soil type and its composition and by soil contamination with these metals provided by human activity [15]. The soil samples were collected in December 2010, the leachate sampling was collected in January 2010 and the surface water samples were collected in March 2010, all in a rainy period.The soil sampling was carried out in plastic bags with a plastic spatula. Before sampling, the vegetal top layer was removed on an area of 15x20 cm. The samples were taken from a depth of 10-15 cm.

In order to determine the concentration of heavy metals, the atomic absorption spectrometer ZeEnit 700 was used. The atomic absorbtion spectrometer ZeEnit 700 is using to microelements determinations from sollution (the flame is using for mg/l determinations and the grafit furnace for μg/l determinations).

The collected soil samples were mineralized according to ISO 11466, by extraction with aqua regia. Water samples collected for heavy metal analysis were filtrated and acidified with HNO_3 65%, at site, to a pH of about 3.5 to prevent the precipitation of the heavy metal ions and the retention of these on the vessel wall. The leachate was collected in tightly closed glass or plastic bottles from the collection basin existing at the landfill base. For each metal, the device has an other error of measurement, but the maximum error is plus / minus 5%.

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