THE IMPACT OF CLUJ-NAPOCA MUNICIPAL LANDFILL ON ZĂPODIE STREAM WATER QUALITY

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ABSTRACT. - The impact of Cluj-Napoca municipal landfill on Zăpodie stream water quality. Zăpodie stream is subjected to pollution with organic matter, nutrients, heavy metals, due to leakage and seepage of leachate from landfill platform in Cluj-Napoca. For determining the quality of the Zăpodie stream we analyzed several physico-chemical indicators such as pH, TDS, EC, ORP and salinity during January-May 2012. Furthermore, we performed a physico-chemical analysis of the leachate so we can correlate with qualitative results obtained for Zăpodie stream. In addition we also measured the leachate concentrations of Zn, Cu, Cd, cations (Na^{2+}, Ca^{2+}, Mg^{2+}) and anions (SO_4^{2-}, Cl^-, PO_4^{3-}). Ramp leakage exceeded the MAC (maximal admitted concentration) mentioned in NTPA 001/2005 and HG 352/2005 for Ca^{2+} and SO_4^{2-} and both can cause a possible pollution of mineral nature. For the case of heavy metals, Zn exceeded the values set by NTPA 001/2005. A biological analysis of stream water was also performed in order to monitor the activity and biological load in a polluted environment. After analysis we detected a water pollution indicator species, namely UNIRAMIA-insects: Chironomus.

Keywords: Zăpodie stream, waste, landfill leachate, water quality

1. INTRODUCTION

The municipal landfill of Cluj-Napoca is situated in the city's built-up buil-up area, at 1.5 km distance from the Someşeni district, on the road to Pata commune. The landfill is located on the western slope of the Zăpodie stream a right tributary of the Someşul Mic River. The landfill occupies an area of 8.96 ha.

Topographically the landfill surface is irregular, with waste deposit heights ranging from 3 to 10 m; the dump slopes exceed 45°, forming embankments which descend to the stream which carries the unstable wastes.

In the southern part where they no longer store waste the slopes and the top surface seem to be already stable due to slower mineralization and compaction process.

In the north, where they still deposit waste, the landfill has an irregular aspect. The Pata Rât Municipal landfill is a class b non-hazardous landfill (Fig. 1) Here are stored approximately 400.000 m³ waste/year; the amount is estimated at approximately 1.2 m³/year/person. From economic agents are collected about

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80.000 m³/year, non-household waste (resulting from demolition, excavation and other industrial waste) reach 275.000 m³/year, while street waste reaches 70.000 m³/year.

The landfill represented over the years a source of water pollution, both to the surface water, represented by the Zăpodie stream and to the groundwater (Fig. 2). This is sustained by the fact that the waste are treated improperly and their decomposition products, are washed by the precipitation into the soil and affect the groundwater, and also by the inadequately chosen location, particularly the distance from the Zăpodie stream which ranges from 2 to 10 m.

Fig.1. ***Pata Rât landfill northern side***

The problems which contributed to the water pollution were mainly due to:

- poor landfill operation, accumulating approximately 7.5 million tons of mixed household and industrial waste until 1994, (reusable – unusable, industrial – domestic, flammable – incombustible, organic - inert, large, medium and various powders), which lead to accumulation of a variety of pollutants in the surface and ground waters (Mihăiescu, 2004)

- poor geo-physical stability –resulting in a waste hill, on the surface of the deposit, with a height of 10 to 15 m, which led to detachment and sliding of a portions of the stored material and the waste reached the stream. In case of strong precipitation, all of the water, from the landfill is led by two torrents under the existing deposits, which could lead to a slip of the landfill over the Zăpodie stream and the communal road.

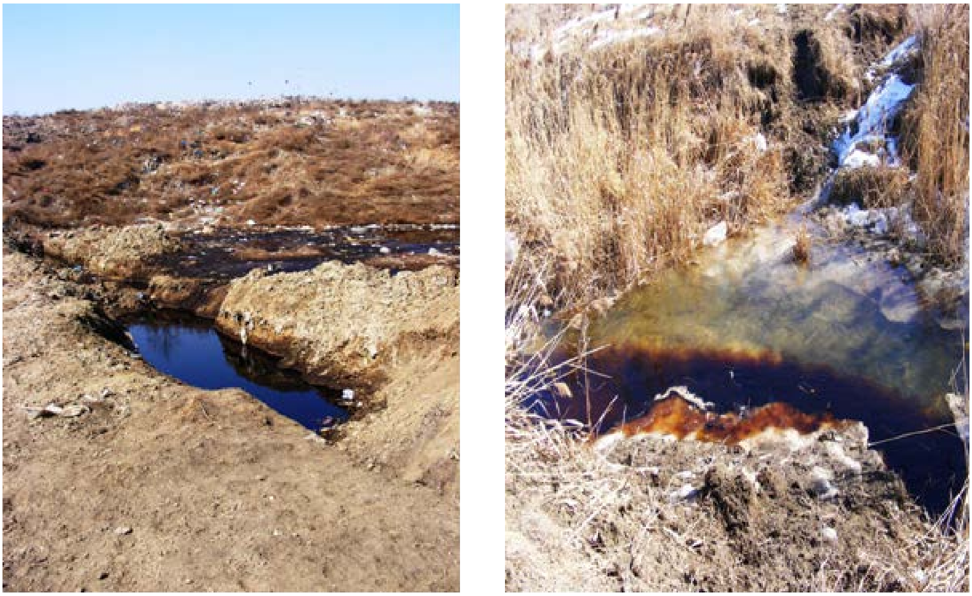

Fig. 2. ***Leachate concentration and its leakage into the Zăpodie stream***

2. MATERIAL AND METHODS

In selecting the water sampling points there were taken into account some general principles to reflect the reality on the ground. If case of the physico-chemical samples, it was taken into account that they have to be collected from the stream, one sample upstream and one downstream and also in close proximity to the point pollution sources. Samples were taken at 30 cm under water, in accordance with the provisions in force.

Fig.3. ***Zăpodie stream's water physico-chemical sampling points map***

For the biological sampling it was taken into account that they must avoid certain structures (bridges, embankments) or the immediate vicinity of point pollution sources. Biological sampling requires a relatively uniform "orography" (relative straight stream, the existence of mud and stones, the avoidance of silting and grassed areas). To emphasize the water quality dependent ecosystem biodiversity, the sample points of the biological material were chosen to include the 3 ecological zones of the stream: crenon, rithron and potamon.

As physico-chemical parameters there were chosen the following indicators: pH, TDS, EC, ORP and salinity, and for leachate anions, cations and heavy metals.

From the field survey, 6 points were selected for sampling; their layout is shown in Figure 3:

P_1 - upstream from the confluence with the stream (left tributary)

P_2 - after the confluence with the stream

P_3 - leachate

P_4 - after the confluence with the leachate

P_5 - after the landfill

P_6 - approximately 200 m after the landfill

For the biological sampling we have selected 3 sample points (P1, P4, P6). The samples were taken from downstream to upstream.

Sampling period. Sampling was done from January to May 2012. Monitoring of physical-chemical parameters consisted of monthly sampling, exception in March when there have been taken two samples. Biological monitoring consisted of one sample in May.

a. **Water samples for physico-chemical analysis**. Water samples were collected in polyethylene bottles of 250 ml, equipped with a lid, filled to maximum and they were analyzed in the faculty laboratories as follows:

- For clean water, the tests were run at the latest at 72 hours after harvest;
- Medium polluted waters, up to 48 hours after harvest;
- Polluted waters, up to 12 hours from the sample harvest.

Until the analysis, the samples were stored in a refrigerator at 5 °C. (Roşu, 2007).

Determination of physico-chemical parameters were performed using a device called WTW Inolab 720. For the study of heavy metals in the collected leachate, from the Pata Rât landfills perimeter, we used the atomic absorption spectrometry (AAS) determination method. Anions and cations determination, in the leachate sample, was performed using the Dionex ICS 1500 Ion Chromatography.

b. **Water samples for biological analyses**. We used plastic bottles (1000-2000 ml) with lids, buckets for washing the sludge and "concentration" of the samples, sieves, plastic trays, tweezers, brushes.

Sampling itself implied the existence of a sieve for the water samples, a beaker and a metal sieve attached to the telescopic rod (6m). From each sample point on the shore, there were taken 5 samples, that included stirred water and sludge, and finally after washing and concentration, a volume of 2000 cm³ has been taken. After sampling the sludge the sieve was passed 5 times through the plants on the bank.

3. RESULTS AND DISCUSSION

From the analyses one can observe that the Zăpodie stream pH values vary between 7.47 and 8.11 which indicates slightly alkaline waters (Table 1), falling within the limits imposed by the 161/2006 Governmental Order regarding the surface waters.

Zăpodie stream's water conductivity (EC) presented values between 2660 µS/cm and 21,500 µS/cm, a value which is far above the allowable 1000 µS/cm, according to the state standard 7722-84 (Vigh, 2008). This characteristic indicates s heavily polluted water.

The TDS (total dissolved solids) presented values between 1700 mg/l and 13,750 mg/l, which indicate strongly polluted waters with organic and inorganic impurities. In fresh water the TDS value can range between 300 and 500 mg/l (Réti et all., 2011, Roşu, 2007).

Table 1. ***Measured values for pH, EC and TDS indicators***

Chemical indicator	Luna / Probe	P1	P2	P4	P5	P6
pH MAC_{min}=6.5 MAC_{max}=8.5	I	7.63	7.69	7.47	7.54	7.53
	II	7.62	7.52	7.66	7.66	7.62
	III a.	7.94	7.94	7.83	7.72	7.54
	III b.	7.48	7.73	7.97	7.92	7.98
	IV	7.61	7.69	8.10	7.51	8.11
	V	7.81	7.93	7.82	7.77	7.57
EC (µS/cm)	I	6000	21500	7500	7500	8000
	II	5700	5800	11200	14500	15600
	III a.	5450	5470	6150	6050	6100
	III b.	2720	2750	3660	3050	3050
	IV	3780	3500	3990	4480	4500
	V	3370	3200	3700	4300	4700
TDS (mg/l)	I	4000	13750	5000	5500	5700
	II	3800	3850	7200	9300	9970
	III a.	3500	3490	4000	3900	3940
	III b.	1700	1700	2380	2000	2000
	IV	2280	2370	2500	2800	2800
	V	2150	2050	2370	2750	2990

MAC – maximum acceptable concentration

Legislation does not provide standards for conductivity, TDS and salinity in natural or wastewater, although total dissolved solids cause toxicity by increasing the salinity and changing the ionic composition of water.

For the leachate besides the pH, TDS, EC indicators there were conducted additional analyzes for anions and cations shown in Table 2.

Analyses showed some exceedance of the quality indicators (Table 2). There is significant exceedance in the mineral loading measured by the following indicators Ca^{2+}, Mg^{2+}, Na^{2+}, Cl^{-}, SO_4^{2-}, PO_4^{3-} and some metals measured by the Zn, Cu, Cd** indicators. These loads are transmitted to the Zăpodie stream's because they can also be found in the hyporheic zones waters.

With regard to leachate it has a pH between 8.01 to 8.79 pH units, with a strongly alkaline reaction, which is usually typical for these type of deposits in the first two years of operation, after which the pH should decrease. There is exceedance at the pH in early April 2012, according to the 001/2005 TFWP (Technical Framework for Water Protection) during the melting process and when the precipitations are missing. The leachate pH may determine the solubility and biological availability of the chemical components like the heavy metals (copper, cadmium and others).

Table 2. ***Leachate investigated parameters***

Indicator	UM	Date						Limits**
		27.01	**18.02**	**03.03**	**17.03**	**01.04**	**01.05**	
pH	Unit. pH	8,01	8,1	7,98	8,2	**8,79***	8,17	6,5-8,5
ORP	mV	-59,2	-63	-58	-72,2	-101	-68,2	-
EC	µS/cm	23200	20500	7760	21800	23800	23400	-
TDS	mg/L	14850	13110	4895	14960	15232	14976	-
Salinity	‰	14,1	12,3	4,3	13,1	14,4	14,1	-
Temperature	°C	24,5	23,6	24,5	22,6	22,3	18,9	35
Ca^{2+}	mg/l	**311***	**342**	**351**	**329**	**322**	**323**	300
Mg^{2+}	mg/l	29	33	35	28	29	30	100
Na^{2+}	mg/l	432	464	471	453	429	424	-
Cl^{-}	mg/l	317	363	340	325	320	357	500
SO_4^{2}	mg/l	**719***	**748**	**721**	**689**	**694**	**699**	600
PO_4^{3}	mg/l	9,3	9,7	9,1	8,8	8,8	8,9	-

* Values exceeding MAC,

**MAC conform the 001/2005 TFWP from the 352/2005Governmental decision

The high concentration of $Ca^{2+}$and Mg^{2+} ions in the leachate can have negative effects on the Zăpodie stream aquatic fauna. Also, Ca^{2+}, Mg^{2+} and Na^{2+} in surface water form dicarbonates, nitrates, sulfates, or chlorides. Mg^{2+} that for some bacteria represent a growth factor is also the reason for the black-brown color of the collected leachate.

SO_4^{2-} are common in wastewater, at the leachate confluence zone with the surface water the water toxicity reaches the highest values. Regarding chlorides and phosphates they are indicators of water pollution; phosphates may originate from certain detergents and are responsible for eutrophication.

Table 3. **H*eavy metals concentration in leachate***

Indicator	UM	Values					MAC TFWP 001/2005
		27.01	18.02	03.03	17.03	01.04	
Zn	mg/l	**0,748***	**0,821**	**0,785**	**0,733**	**0,767**	0,5
Cu	mg/l	0,083	0,096	0,087	0,08	0,082	0,1
Cd	mg/l	0,007	0,008	0,007	0,006	0,007	0,2

* Amounts above the MAC

The leachate heavy metals, have a toxic action on the surface water ecosystems and aquatic organisms in terms of bioaccumulation and the inhibiting of biotic and purification processes. Zinc's toxicity for aquatic creatures is influenced by factors like pH, temperature, water hardness and dissolved oxygen. Zinc has been shown to be toxic to some plants. In case of Cd and Cu the TFWP 001/2005 values are not exceeded, but Cu values are very close to the limits allowed by law. Copper salts inhibit plant photosynthesis by up to 70% in 48 hours at a 0.1 mg/l concentration.

Analysis of the biological material showed the presence of 3 systematic categories, characteristic to the aquatic ecosystem, belonging to different Animalia regnum (ANNELIDA, CRUSTACEA and URINAMIA INSECTA) presented in Table 4.

Table 4. ***Systematic aquatic organisms' categories identified during testing (May, 2012)***

Phylum	Systematic infraphylum categories (classes, orders, families, genera) dominant and representative for the highlighted phylum
ANNELIDA	**Oligochaeta (Lumbricidae)**
CRUSTACEA	***Cyclops***
UNIRAMIA - INSECTA	**TRICHOPTERA (Hydropsyche sp.)**
	DIPTERA (Chironomus sp.)

Biological analysis showed that species characteristic to clean water (oligosaprobic and β-mezosaprobic) belong to the phylum CRUSTACEA: *Cyclops*.

From the species present in polluted (filthy) waters analyses revealed the phylum UNIRAMIA-*INSECTA*: Chironomus.

4. CONCLUSION

The lixiviant from the landfill surface has a significant metal load, but we cannot speak of heavy metal pollution only in case of zinc we could identify some exceeding.

Factors that influence toxicity is water hardness (hard water toxicity is lower due to calcium ions competition) and hydrogen ion concentration (pH decreases toxicity due to competition with H^+ ions). Metal content is directly influenced by the pH value. The more basic is the pH the smaller is the metal content.

Due to the low number of individual species, listed above, it was not possible to correlate biological data results with physico-chemical parameters of the water.

In conclusion the high levels of some parameters, in the leachate, indicate the water polluting characteristics of the landfill to the Zăpodie stream waters, demanding the collection and treatment of leachate from the landfill surface. The present-day and recommended technical solutions for the drainage, collection and leachate treatment, produced by the landfill, are: drainage layer, drainage collector network, buffer tank and leachate treatment plant.

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