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BIOLOGICAL AND CHEMICAL OXYGEN DEMAND AS INDICATORS OF ORGANIC POLLUTION OF LEACHATE AND PIEZOMETRIC WATER FROM SEMI CONTROLLED, NON SANITARY LANDFILL IN NOVI SAD, SERBIA

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ABSTRACT: Landfill leachate is one of the most serious problems of municipal solid waste landfills. Leachate is generated as a result of the percolation of water and other liquid through any waste and the squeezing of the waste due to its weight. Since all natural waterways contain bacteria and nutrient, almost any waste compounds introduced into such waterways will initiate biochemical reactions. In August and September of 2008. Research was conducted to determine composition and quantity of waste that is disposed at semi controlled, non sanitary, municipal waste landfill in Novi Sad. The leachate samples and samples from piezometers were collected from collecting channel and 6 piezometers in municipal solid waste landfill in Novi Sad in January and May of 2010.
KEYWORDS: BOD_5, COD, landfill, leachate, waste

❖ INTRODUCTION

Landfill leachate is one of the most complex problems of municipal solid waste landfills. is generated as a result of the percolation of water through landfill body and the squeezing of the waste due to its weight, and it is contaminated with dissolved and suspended organic and inorganic compounds with different characteristics. Any oxidizable material present in a natural waterway or in an industrial wastewater will be oxidized both by biochemical (enzymatic) or chemical processes. The result is that the oxygen content of the water will be decreased. Basically, the reaction for biochemical oxidation may be written as:

Oxidizable material + enzymes + nutrient + O_2 →CO_2 + H_2O + oxidized inorganics such as NO_3^-, SO_4^{2-} and other residues

Oxygen consumption by reducing chemicals such as sulphides and nitrites is typified as follows:

$$S^{2-}{}_{(aq)} + 2\,O_2 \rightarrow SO_4{}^{2-}{}_{(aq)} \quad (1)$$

$$NO_2{}^-{}_{(aq)} + \frac{1}{2}O_2 \rightarrow NO_3{}^-{}_{(aq)} \quad (2)$$

Since all natural waterways contain nutrients and bacteria, their enzymes will initiate biochemical reactions of almost any waste compounds that are introduced into such waterways. Oxidizable chemicals (such as reducing chemicals) introduced into a natural water will similarly initiate chemical reactions. Both the BOD and COD tests are a measure of the relative oxygen-depletion effect of a waste contaminant.

Non sanitary, semi controlled municipal solid waste landfill in Novi Sad, Serbia was opened in 1964., but systematic land filling with reasonable amount of waste

Figure 1. Landfill in Novi Sad

begin in 1980. Landfill size is 56 acres, from which landfill body occupies 22 acres. At the landfill, there is about 2000000 m^3 of waste. Landfill is divided into 3 main fields (Figure 1): I, II and III field (III field is divided into two parts: *a* and *b*). Height of waste at some parts of landfill body is in range from 2.5 to 14 meters.

❖ METHODOLOGY

In August and September of 2008 research campaign was conducted to determine composition and quantity of waste that is disposed at landfill in Novi Sad. Figure 2 shows composition of municipal solid waste in Novi Sad.

The biggest part of waste from households and commercial sector is biodegradable, organic waste that is decomposed by microbiological and chemical mechanisms in landfill body (Figure 3).

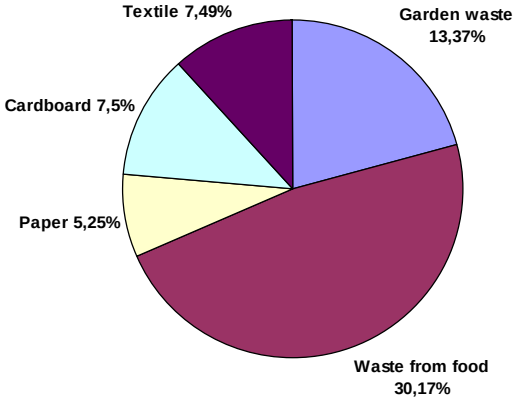

Figure 3. Waste composition of municipal solid waste in Novi Sad

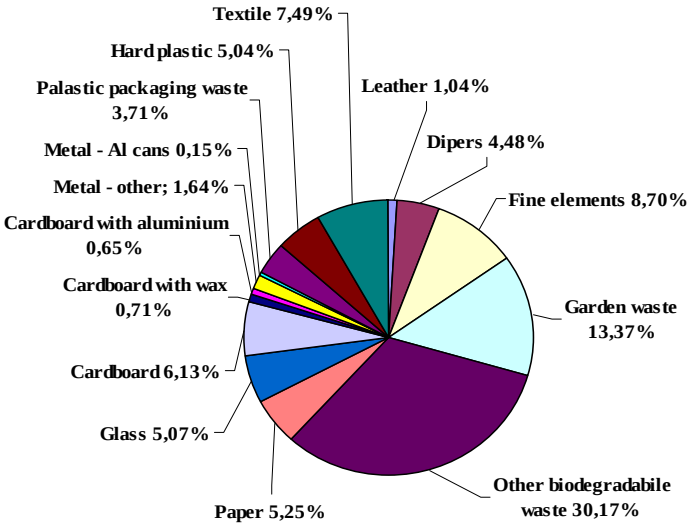

Figure 2. Composition of municipal solid waste in Novi Sad

Biodegradable waste consists of:

- **Garden waste**: grass, old dirt, flowers, branches, leaves,
- **Waste from food**: bread, meat, fruit, vegetables,
- **Paper**: old newspaper, journals, books, notebooks, letters, receipts…
- **Cardboard**: cardboard boxes, flat cardboard, packages for juices, yoghurt, milk, etc….
- **Textile**: nature fabrics (cotton, wool, …)

The biggest percentage of waste is biodegradable organic matter (Figure 2).

❖ FINAL RESULTS

The leachate samples and samples from piezometers were collected from collecting channel and 6 piezometers in municipal solid waste landfill in Novi Sad (Figure 4) in January and May of 2010. The samples were transported to the laboratory and analyzed immediately.

Figure 4. Sampling sites at landfill in Novi Sad

Biological oxygen demand (BOD_5) was determined using HACH BOD TRAK device. The sample is kept in a sealed container fitted with a pressure sensor. According to manufacturer specifications, lithium hydroxide is added in the container above the sample level as a substance which absorbs carbon dioxide. Oxygen is consumed and, as ammonia oxidation is inhibited, carbon dioxide is released. The total amount of gas, and thus the pressure, decreases because carbon dioxide is absorbed. From the drop of pressure, the sensor electronics computes and displays the consumed quantity of oxygen.

Chemical oxygen demand was determined using reagent test tubes in HACH DR5000 UV visible spectrophotometer. To perform the test, simply pipette water sample to a cuvette and leave it in a heater for 2 hours at 148°C. At the end of this period the intensity of colour in the solution is directly related to the COD value in the sample, and can be measured quickly, accuratly and easily.

The results for COD and BOD of the water samples are presented in Table 1.

Table 1. Results for COD and BOD of the water samples

No.	Parameter	Unit	Piezometers						Collecting channel		
			Pz1	Pz2	Pz3	Pz4	Pz5	Pz6	1	2	3
1.	Water temperature	ºC	8	12	9	10	8	12	3	3	3
2.	Ambiental air temperature	ºC	-1	0	0	-1	-1	-1	0	0	0
3.	BOD_5	mg/l	8	90	22	80	26	14	86	66	144
4.	COD	mg/l	21.3	443	44.9	88.1	60.2	34.6	429	593	714
Date of analysis: 25.01.2010.											
No.	Parameter	Unit	Piezometers						Collecting channel		
			Pz1	Pz2	Pz3	Pz4	Pz5	Pz6	1	2	3
1.	Water temperature	ºC	11	14	12	12	15	12.5	16	16	16
2.	Ambiental air temperature	ºC	20	20	20	20	20	19	20	20	20
3.	BOD_5	mg/l	8	85	23	21	15	9	102	90	120
4.	COD	mg/l	10.2	156	27.1	60.3	42.6	12.9	164	163	155
Date of analysis: 07.05.2010.											

Non sanitary, semi controlled municipal solid waste landfill in Novi Sad doesn't have impermeable barrier so contaminated leachate is leaking into the soil and could cause pollution of soil and groundwater. From Figure 5 and Figure 6 it can be seen that most contaminated piezometer is P2 with BOD values from 85 – 90 mg/l, and COD values from 156 – 443 mg/l. This piezometer is located downstream from landfill body and suffers most of the contamination (Figure 4). Also there is noticeable difference in BOD and COD values obtained in January and May.

The values for BOD and COD are lower in May than in January. This can be explained as the consequence of seasonal temperature and precipitation variations and hydrological characteristics. Rain and snow melting are causing dilution of leachate and lower BOD and COD values. Also, because there was lot of rain in this period the groundwater level is much higher than in January 2010.

COD values for collecting channels were in range from 155 – 714 mg/l. The collecting channels are located downstream of landfill body and they are collecting leachate water from landfill but also they collect atmospheric water (rain, snow) and groundwater. Having this in mind, the real values for COD and BOD of leachate is much higher than measured values.

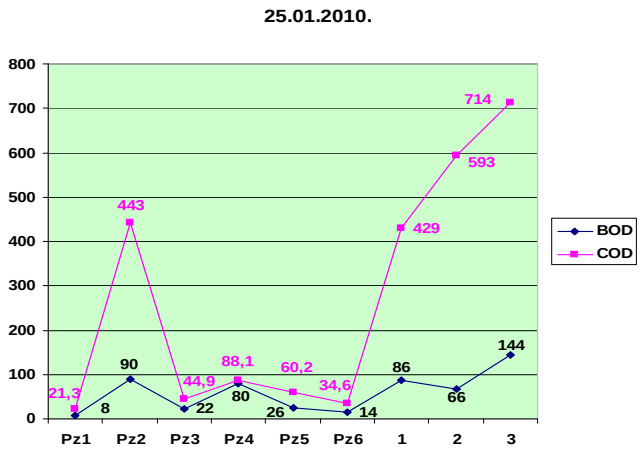

Figure 5. Values for BOD and COD from January 2010

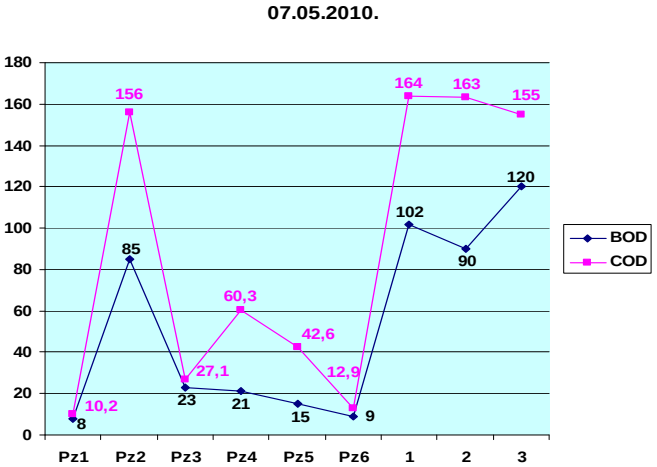

Figure 6. Values for BOD and COD from May 2010

BOD values for collecting channels were in range from 66 – 144 mg/l. These high values of BOD show great organic pollution of leachate water with biodegradable organic matter.

❖ CONCLUSION

Landfilling is still one of the most used methods for waste disposal. One of the biggest problems with landfills is highly contaminated leachate that is produced in landfill body. In Vojvodina region (northern part of Serbia), there is only one sanitary landfill that has impermeable bottom membrane and leachate collection system (landfill in Kikinda). From obtained results of BOD_5 and COD it can be concluded that the leachate from landfill in Novi Sad is contaminating soil and groundwater *in*

continuus. The most contaminated piezometer is P2 that is located downstream from landfill body and suffers most of the contamination. The groundwater level in this part of landfill is very high so there is justified concern for spreading of contamination. Because leachate is very toxic (high content of heavy metals, organic matter and pathogenic microorganisms) it is necessary for landfill to be sanitary (impermeable bottom liner, leachate collection system, on-site wastewater treatment facility…) for prevention of further soil, groundwater and contamination of surrounding environment.

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