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GAS ANALYSIS OF MUNICIPAL LANDFILL EMISSIONS

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ABSTRACT. The article presents a method of measurements and analysis of gas emissions from municipal landfills, especially for the nonconforming ones. Based on measurements made from Pata Rat landfill, Cluj-Napoca, a methodology is presented for interpreting the results in order to assess the current energetic potential of the deposit. Experimental data are the main basis for determining the energetic potential of the deposit. Applying the methodology of setting the stage energy deposit, shows that the best period for using Pata Rat landfill was exceeded, but the methane concentration and the flow rate, resulted from the last measurements, indicates that the site should continue to be monitored in terms of gas emissions.

Keywords: *landfill, gas emissions, gas analysis*

INTRODUCTION

The European Municipal waste management system of our days, according to European documents [1-3], faces a situation caused by increased of stored waste volume (because 49% are stored, 18% incinerated and 43% recycled or composted). In EU there is a greater distribution of landfilling compared to other waste treatments. Thus, there are states storing in 90%, while others are storing less than 10%.

Landfills with historical significance were built before the adoption of regulations which set restrictions on avoiding implementation of environmental impact of leachate and landfill gas. Many of these sites are now sources of pollution by leakage. Particularly, landfill gas can be dangerous because its main component, methane, can reach explosive concentrations. This problem is accentuated by many large landfills built near residential areas, or, sometimes, residential neighborhoods were built on or near closed landfills. On the other hand, methane gas from landfills is also a "greenhouse gas", which leads to global warming and it is approximately 30 times more harmful than carbon dioxide.

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In terms of energy recovery are important phases are phase fourth and fifth. Based on this, we will analyze the gas emissions from the municipal landfill Pata Rat, Cluj-Napoca.

The issue of waste disposal has two aspects: the recovery of potential energy and solving environmental problems in terms of emissions. This paper aims to determine the energy potential for the deposits with historical significance. This goal is achieved by monitoring gaseous emissions.

RESULTS AND DISCUSSION

The landfill "Pata Rat" located near Cluj – Napoca, was open in 1973 and has been designed and sized, considering a period of 30 years for exploitation. Basically, storage capacity was exceeded, considering 2003 as the deadline year for the operation of the landfill. However, according to Government Decision 349 of 2005, closing date was fixed for 16.07.2010. The deposit area is 8.94 ha. Minimum distance from residential areas is 1.5 km.

Table 1. Experimental data

Measurement points	Depth [cm]	CH_4 [%]	CO_2 [%]	O_2 [%]	H_2S [ppm]	CO [ppm]	Bal [%]
P001	60	0.2	69.2	1.1	29	500	29.5
P002	60	50.7	67.1	0	33	500	0
P003	60	24.8	45.7	0	0	526	29.5
P004	60	47.5	65.3	0	500	500	0
P005	60	52.8	65.2	0	500	183	0
P006	60	52.7	65.3	0	500	209	0
P007	60	43	62.7	0	500	296	0
P008	60	16.7	42.4	0	33	500	40.9
P009	60	11,9	34,1	1,3	0	46	54.7
P010	60	42.4	63.8	0.5	9	200	9
P011	60	45.5	56.6	0	156	73	0
P012	60	48.7	68.4	0.1	1	183	0
P013	60	51.3	64.7	0.5	122	388	0
P014	60	54	61.1	0.7	4	34	0
P015	60	44.3	56.7	1.5	500	478	0
P016	60	25	54.2	5.5	19	78	15.3
P017	60	34.6	86.6	0.1	87	276	0
P018	60	51.1	62.6	1,1	500	500	0
P019	60	39.7	76.8	0.3	500	473	0
P020	60	62	46.2	3.1	38	36	0
P021	60	1.8	20.6	8.7	9	77	68.9
P022	60	45.4	54.4	0.2	500	91	0
P023	60	0	12.6	11.7	5	2	75.7
P024	60	10.3	3.6	9.9	19	500	76.2

Measurements were made in the research program VALENDEM, during a period of three years, 2009 – 2011. The first measurements were explorers, following the determination of potential energy.

In the beginning, in 2009, a set of data was obtained. For this purpose on the deposit surface were chosen some points (Fig. 1) placed at equal distances from each other. Then we did the measurements with GA 2000.

The obtained experimental data are presented in Table 1. Table contains results obtained in 20.11.2009, when weather conditions were: sky clear, temperature 15 °C and atmospheric pressure of 986 mbar.

The distribution charts of methane, carbon dioxide, oxygen, hydrogen sulfide and carbon monoxide are represented in Figure 1.

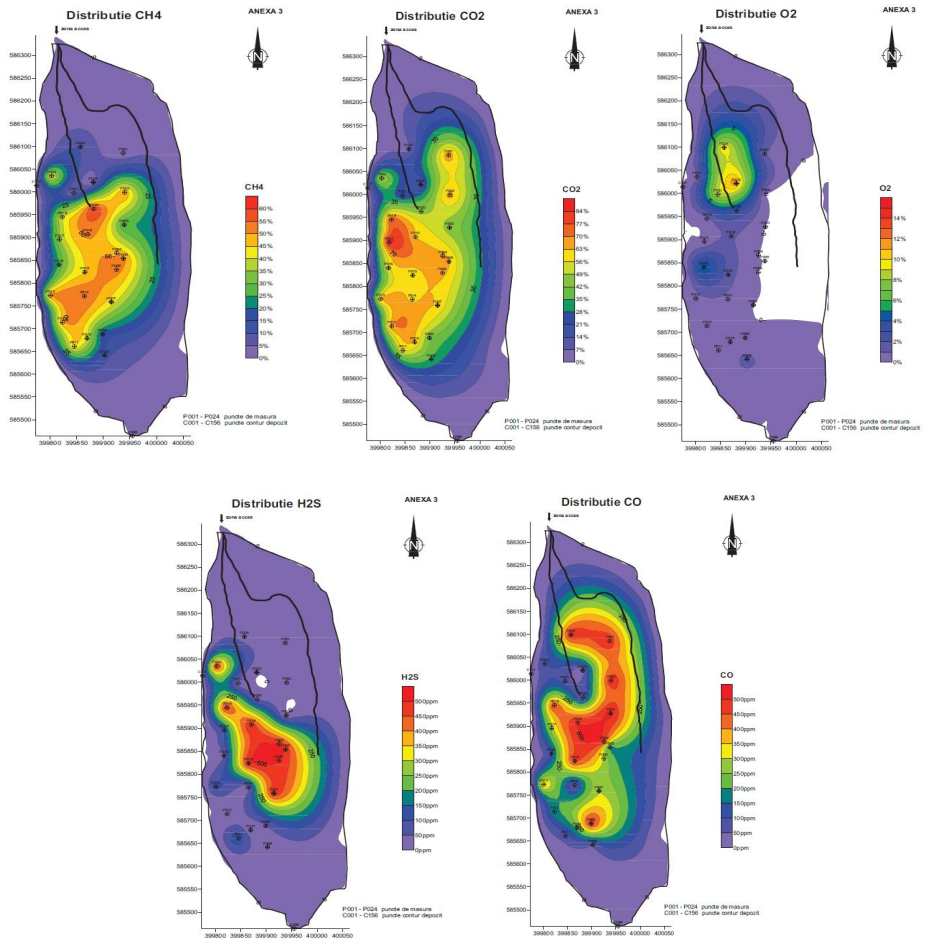

Figure 1. Experimental points and gas distribution maps.

In order to determine the energy capacity of Pata Rat landfill in Cluj-Napoca, measurements were executive in April 2011. The obtained values are detailed in Table 2.

Table 2. Experimental data obtained at the municipal landfill Pata Rat

DAY: 04.04.2011			**WEATHER CONDITIONS: Clear, sunny, light wind, low precipitation**									
No.	**Hour**	**Ext. temp. [°C]**	**Drill. temp. [°C]**	**Pres. atmos. [mbar]**	**Rel. pres. [mbar]**	**Q [l/h]**	**CH_4 [%]**	**CO_2 [%]**	**O_2 [%]**	**Bal. [%]**	**H_2S [ppm]**	**CO [ppm]**
1	$15^{\underline{00}}$	17.5	12.3	969	0.19	0.3	72.5	20.6	0.9	6.0	53	5
2	$17^{\underline{00}}$	16	12.4	969	0.23	0.2	71.6	21.3	0.7	6.4	39	4
DAY: 05.04.2011			**WEATHER CONDITIONS: Partly cloudy, light wind**									
1	$8^{\underline{00}}$	8.3	11.6	972	0.14	0.3	69.3	22.5	1.2	7.0	29	2
2	$10^{\underline{00}}$	12.7	11.9	972	0.01	0.3	70.4	22.0	1.1	6.5	46	3
3	$12^{\underline{00}}$	15.9	12.1	972	0.11	0.4	71.2	23.9	0.8	4.1	38	1
4	$14^{\underline{00}}$	17.4	12.4	972	0.14	0.4	72.8	23.1	0.3	3.8	27	3
5	$16^{\underline{00}}$	18.6	12.3	973	0.09	0.3	70.6	22.1	1.1	6.2	32	4
6	$18^{\underline{00}}$	19.2	12.3	973	0.11	0.2	69.8	23.2	1.9	5.1	41	2
DAY: 06.04.2011			**WEATHER CONDITIONS: Variable, mostly clear, light wind**									
1	$8^{\underline{00}}$	8.6	11,8	979	0.23	0.3	72.6	20.6	0.4	6.4	69	5
2	$10^{\underline{00}}$	13.1	12.0	979	0.09	0.3	71.5	22.2	0.5	5.8	87	2
3	$12^{\underline{00}}$	16.2	12.1	979	0.06	0.4	70.2	21.8	0.8	7.2	101	3
4	$14^{\underline{00}}$	17.6	12.3	979	0.12	0.2	71.9	22.9	0.3	4.9	72	3
5	$16^{\underline{00}}$	18.9	12.5	979	0.14	0.3	70.9	23.9	1.4	3.8	56	2
6	$18^{\underline{00}}$	20.1	12.3	979	0.11	0.3	71.2	23.1	0.6	5.1	62	3
DATA: 07.04.2011			**WEATHER CONDITIONS: Clear, sunny**									
1	$8^{\underline{00}}$	8.8	11.4	975	0.28	0.4	71.3	22.4	0.8	5.5	71	4

For measurements made in April 2011, where possible, averages were made for each day, obtaining the average value of the day. These are presented in Table 3.

Table 3. Average values of the day

Average	**Drilling temperature t_f [°C]**	**Atmospheric pressure p_a [mbar]**	**Flow Q [l/h]**	**Methane C_{CH4} [%]**
M1 - 04.04.11	16.75	969.00	0.250	72.050
M2 - 05.04.11	15.35	972.33	0.316	70.683
M3 - 06.04.11	15.75	979.00	0.300	71.383
Monthly average	15.95	973.44	0.289	71.372

Graphical representations of variation measures determined in a series of three days in April are as follows: flow - Figure 2, the methane concentration - Figure 3.

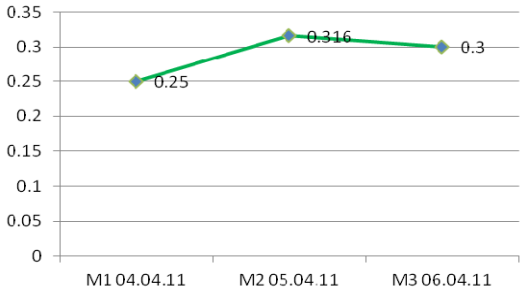

Figure 2. Average gas flow variation in April 2011 [l/h].

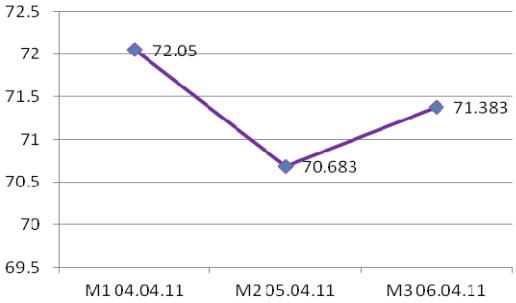

Figure 3. Methane average concentration variation in April 2011 [%].

Similarly, measurement results were processed in 2010 and 2011. The results average values of all measurements in the July 2010 - June 2011 interval are presented in Table 4.

Table 4. Average values for measurements in July 2010 - June 2011

Average	**Drilling temperature t_f [ºC]**	**Atmospheric pressure p_a [mbar]**	**Flow Q [l/h]**	**Methane C_{CH4} [%]**
Monthly average for July 2010	20.445	973.9	0.286	74.662
Monthly average for September 2010	18	982.4	0.299	73.804
Monthly average for April 2011	15.95	973.443	0.289	71.372

Average	Drilling temperature t_f [ºC]	Atmospheric pressure p_a [mbar]	Flow Q [l/h]	Methane C_{CH4} [%]
Monthly average for June 2011	21.46	977.222	0.254	68.388
Average	**18.963**	**976.741**	**0.282**	**72.056**

Graphical representation of values variation measured and expressed as the mean intervals are depicted as follows: average hourly flow of landfill gas - Figure 4, the average concentration of methane - Figure 5.

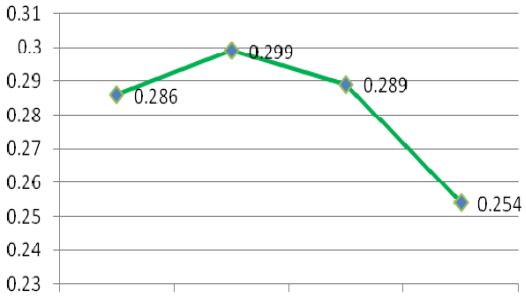

Figure 4. Measurements variations of hourly landfill gas flow for the period July 2010 - June 2011 [l/h]

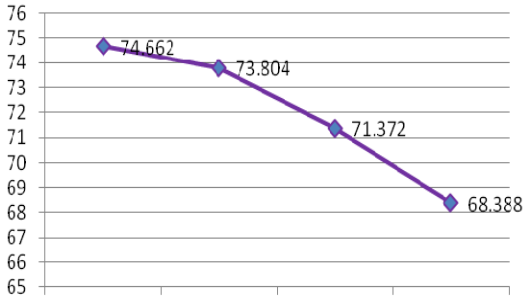

Figure 5. Variation of the average methane concentration measurements during July 2010 - June 2011 [%]

EXPERIMENTAL SECTION

To determine the composition of landfill gas in order to estimate their energy potential, preliminary experiments have been set on landfill gas characterization. Measurements were done during 2010-2011.

In order to determine the energy potential of the landfill gas emission from Pata Rat gaseous samples were collected from 24 drilling points (P001 to P024). A drilling in diameter of 160 mm was performed until a depth of 10 m. Perforated PVC tubes was introduced, for a good capture of landfill gas. On the surface, on the end of the tube, a concrete collar stiffener was made and a valve cover set at the end to install the gas composition meter GA 2000. Drilling position on landfill surface was determined using a GPS device and its coordinates are: N46° 46.075'; E23° 41.270'. Figure 6 shows the system for the gas capture in Pata Rat municipal landfill.

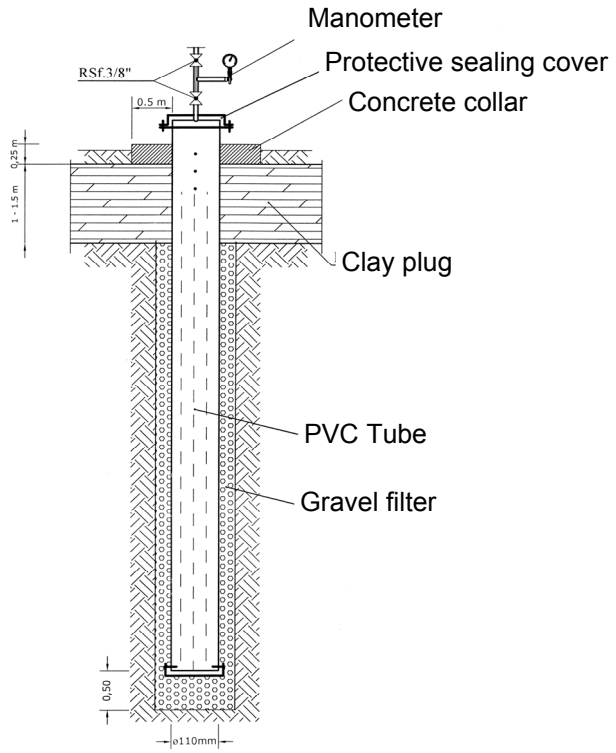

Figure 6. Gas captures equipment on Pata Rat municipal landfill.

CONCLUSIONS

In this paper, gas monitoring and analysis activities can lead to a methodology for measuring and proper interpretation of the data. Therefore, the monitoring of non-compliant landfills should include the following actions: Establishment of municipal landfill surface contour; Establishment of the exploratory measurement points set, so that they have an equal distance from each other and from the contour; Recording space and time of preliminary

measurements to determine the gas concentration of methane, carbon dioxide, oxygen, hydrogen sulfide and carbon monoxide; Interpretation of results and determination of the maximum energy potential area; Drilling coordinates definition in order to capture the landfill gas; Achieving drilling and attachment system for the capture and characterization of landfill gas; Making measurements at intervals determined; Quantification and interpretation of data to characterize landfill gas and the conditions under which measurements were made; Interpretation for a given range, in our case 3 years, for the measurements results; Interpretation of experimental data for the energy status of the deposit. The Methodology for determining the energy state is based on time tracking evolution of two quantities, namely methane flow and concentration. From Figure 4, results that maximum flow was measured in September 2010, the decrease being confirmed by measurements made in April and June 2011. Also, analyzing the variation of methane concentration (figure 5) it is observed that methane has a constantly decreasing evolution from June 2010 to June 2011.

Therefore, a methodology for assessing energy capacity of the landfill should include the following: Performing measurements for flow and methane concentration in the landfill gas for a given time interval; Quantifying the evolution in time of flow and methane concentration of the landfill gas; Determining the gas evolution and distribution.

In terms of applied methodologies we can say that Pata Rat deposit is beyond maximum levels of methane (gas flow and concentration).

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