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INVESTIGATION OF LANDFILL GAS OUTPUT FROM MUNICIPAL SOLID WASTE AT THE POLYGON

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Abstract. The aim of the work is to study the output of landfill gas from the MSW landfill site, decommissioned 10 years ago, to determine the possibility of its energy use. The results of calculations of the output of landfill gas from the site according to two methods, the results of instrumental measurements of the bio gas composition, conducted during five months are presented. A series of measurements makes it possible to estimate the composition of the landfill gas being allocated in the absence of sludge: CH₄ - 30 ... 32%; O₂ - 0 ... 2%; CO₂ - 40-60%; N₂ - 5 ... 30%; H₂S - 0 ... 30 mg / m³. Despite the lower methane content than in traditional bio gas, with regard to the energy potential, the landfill gas released at the experimental site allows it to be used provided that the combustion process is necessary.

The landfills, in which about 95% of all municipal solid waste (MSW) are located in Russia, are sources of pollution not only of soil and surface water, but also of the air basin [1]. In the body of the polygon under anaerobic conditions, as a result of the life activity of methanogenic bacteria, a landfill gas (bio gas) is formed, consisting of methane, carbon dioxide and nitrogen [2]. The greenhouse effect of methane is stronger than that of carbon dioxide, according to various estimates, from 25 times [3] to 84 times [4]. Therefore, at the waste treatment sites during operation and during their reclamation, measures should be envisaged for their degassing, which consists in the collection and utilization of landfill gas by incineration [5].

The aim of the work is to study the output of the landfill gas of the MSW polygon in Belgorod, operated by Ltd "TK Ekotrans", to determine the possibility of its energy use. Since projects on degassing of landfills are characterized by high cost, the work was provided with the maximum use of the production potential of Ltd "TK Ekotrans" in order to minimize the burden on consumers of services for removal and burial of MSW.

1. Calculation of the yield of MSW

To conduct degassing, part of the MSW landfill, located at st.Zarechenskaya, 85c, Streletskoe area, Belgorod region, Belgorod region (Figure 1) with the following characteristics:

Year of the beginning of functioning 2001;
 Year of the end of functioning 2006;
 The area of the site 1,5 hectares;
 Depth of 25 m;
 The average volume of exported waste 62 500 m³ / year.

To calculate the composition of MSW was adopted as follows:

The content of the organic component in the waste 55%



Organic waste content:.....	
fatty substances.....	2%
hydrocarbon-like substances.....	83%
protein substances.....	15%
Average Waste Humidity	47%

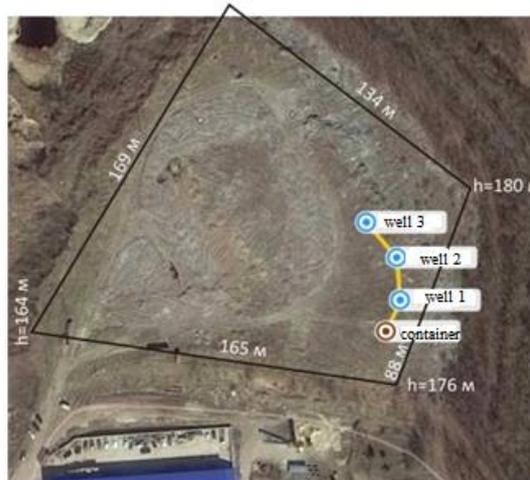


Figure 1. Landfill site for degassing with an experimental line of three wells

For the site, the theoretical yield of landfill gas was determined in accordance with [6] (procedure 1) and [7] (procedure 2), the results are shown in Fig. 2. The calculation of the bio gas yield for each method was carried out for a warm period and on an average for a year, the results obtained are consistent with other calculations given in [8, 9]. A period of active bio gas release was obtained for 17 years.

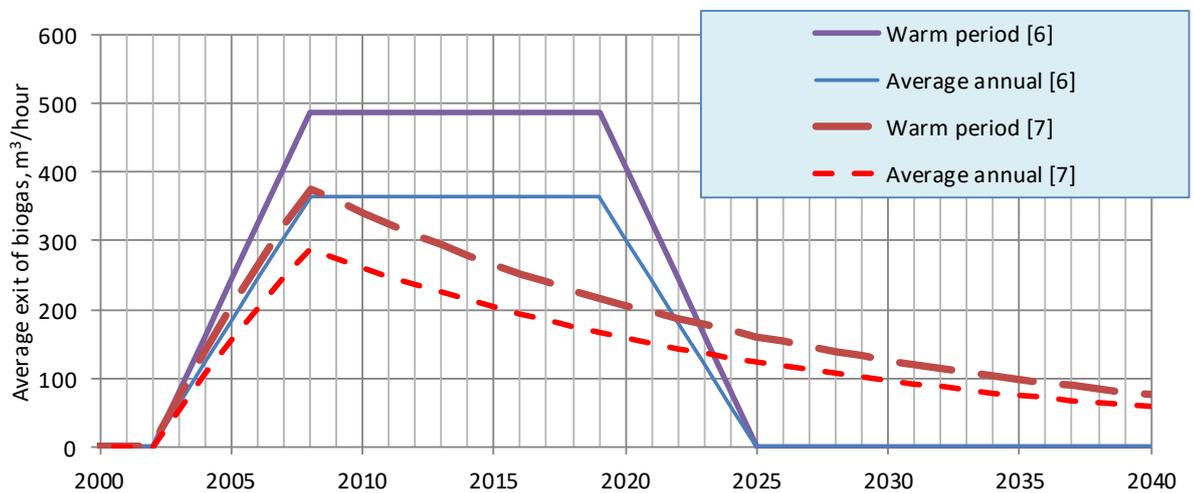


Figure 2. Forecast of bio gas output

2. Examination of the yield and composition of bio gas on the experimental line

For the study, three wells with a depth of 12 m (Fig. 3) were equipped with polyethylene perforated pipes with a diameter of 50 mm, produced by Ltd “TK Ekotrans” from polymer wastes (Figure 4).



Figure 3. Experimental well



Figure 4. Polyethylene perforated pipes of production Ltd “TK Ekotrans”

To measure the gas composition, a FARMEK FP34 gas analyzer with CH₄ (0-100%), CO₂ (0-2.5%), O₂ (0-30%), H₂S (0-100 mg / m³).

Measurements of the bio gas composition were initially made at the mouth of each well, while the results of the measurements were significantly affected by weather conditions - with increasing wind, the gas output from the wells increased significantly. In the period from June 20 to July 2, the site was sealed with clay, and three wells were combined with a gas gathering line. For gas removal at the end of the line, a non-oil plate-rotary vacuum pump Busch SecoSV 1005 D (flow rate 4.8 m³ / h, residual pressure 15 kPa) was installed in a specially equipped container).

The results of monitoring the composition of the landfill gas are shown in Fig. 5 and tab. 1. The composition of the gas is stable, after the discharge, the oxygen content does not exceed 5-10%, which shows that in the gas the oxygen impurities are not more than 25-50%. When the oxygen content is close to its theoretical content in the landfill gas (0-2%), the methane content is about 35% (Figure 6) The values obtained were less than the theoretical values (see Figure 1), which can be caused or transition of a polygon site to a stage of stable methano-genesis, or a difference in the MSW composition from the accepted.

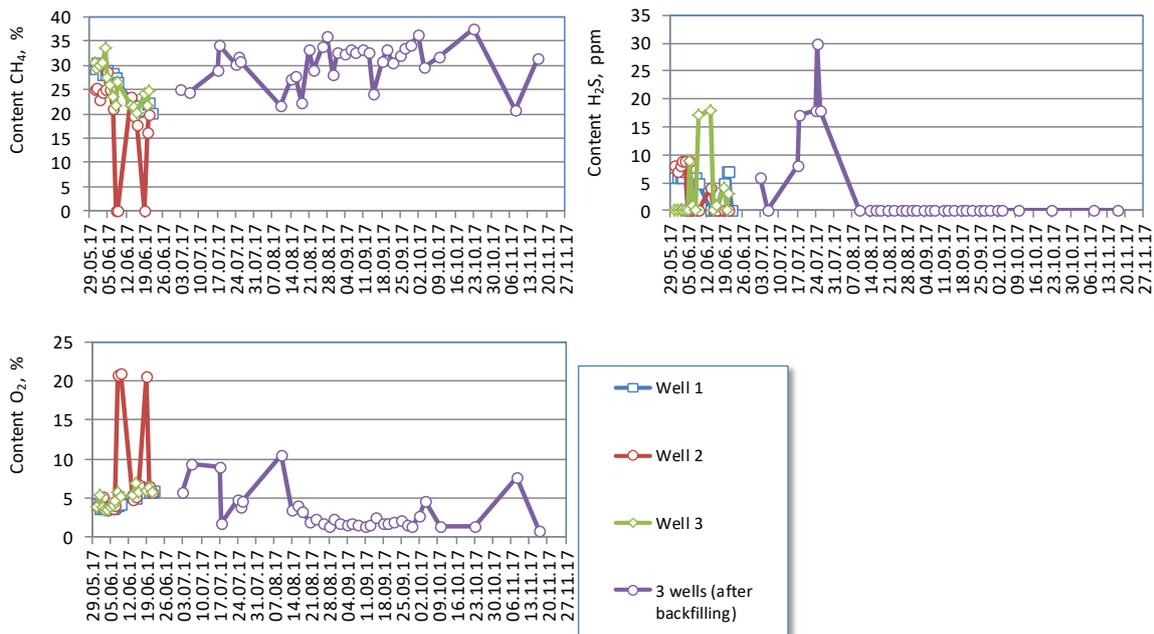
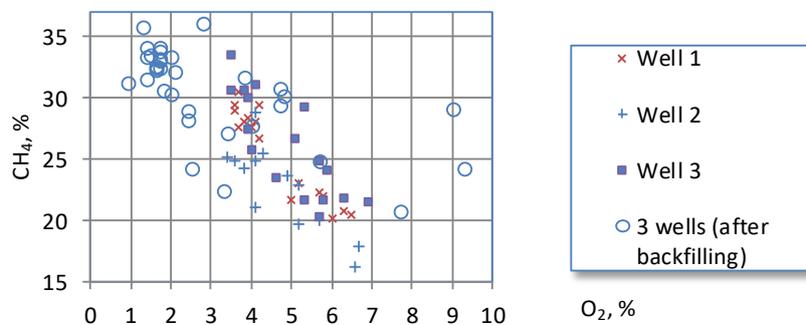


Figure 5. Monitoring of gas composition on the experimental line

Table 1. The average composition of landfill gas after the merger of three wells into one and the back filling with soil (31.05-17.11.2017, 51 meters)

Value	CH ₄ , %	O ₂ , %	H ₂ S, mg / m ³	CO ₂ , %	N ₂ , %
Minimum	20,8	0,9	0	–	–
Maximum	36,2	10,5	30	–	–
Average	30,3	3,2	2,9	–	–
Operation [7]					
clean biogas	55	0	0–20	45	0
biogas with air inflows	35–45	1–6		30–35	18–30
Biogas composition of the Samara testing site (gas analyzer data)	60,6	0,2	93	–	–

**Figure 6. Effect of sludge on methane content**

3. Determination of the energy potential of biogas

Utilization of biogas will be carried out by burning. Therefore, based on the data obtained, the calculation of combustion (tab. 2).

Table 2. Calculation of gas combustion ($\alpha = 1,2$)

Indicators	BiogaspolygonEcotrans	Naturalgas	Landfill gas of the polygon in Samara
Heat of combustion, kJ / m ³	10 740	36 322	21 695
Airconsumption, m ³ / m ³	3,31	11,63	6,91
Composition of combustion products, m ³ / m ³			
RO ₂	0,80	1,03	0,90
H ₂ O	0,60	2,00	1,21
N ₂	2,80	9,19	5,56
O ₂	0,14	0,49	0,29
Amount	4,34	12,70	7,96
Adiabaticcombustiontemperature, °C	1487	1763	1666

The results show that for bio gas from the experimental site the heat of combustion and the air volume required for burning are two times lower than that of the gas of the Samara polygon and three times lower than that of natural gas. The burning temperature of these gases differs by no more than 20%. This shows that the landfill gas from the experimental section can be simply burned in the atmosphere (for converting

methane to a much less harmful CO₂) [10], and is used in heat generation provided that the supply of the required amount of air is not more than the required volume for combustion.

According to the data of [11], when using bio gas as fuel, one has to face the following basic difficulties:

a) because of the high content of CO₂, the normal flame propagation velocity and its stability decrease, the burner control limits are narrowed;

b) because of the content of hydrogen sulfide, there is a problem of corrosion of burners, front plates of boilers, etc. (the service life of equipment is shortened).

Therefore, for low-calorie fuel, it is necessary to ensure good mixing with air, which is done with the help of swirlers or multi-channel burners [12].

4. Examination of the output of biogas from the production line

After confirming the possibility of burning bio gas on a part of the plot previously covered with clay, a bio gas collection line was constructed from 44 wells located 4 meters apart (Fig. 7). Wells were equipped with perforated pipes 50 mm in diameter, collectors for collecting bio gas are made of pipes with a diameter of 65 mm. After the lines were collected, a gas analysis was performed using the MRU Vario Plus gas analyzer equipped with sensors for determining the O₂, CO₂, CH₄ content (tab. 3).

Table 3. Composition of biogas, % (17.11.2017 year)

Place of sampling	O ₂	CO ₂	CH ₄
	5,25	23,8	26,4
Technological line (44 wells), in the absence of sludge	0,99	38,3	32,8
	1,42	38,3	32,8
Experimental line (3 wells)	0,85	57,8	32,8



Figure 7. A line for collecting biogas

The results of the measurements made it possible to determine the content of CO₂ in the landfill gas. Thus, the remainder in the landfill gas, ranging from 5 to 30% in different dimensions, and not determined by instrumental means, most likely consists of nitrogen N₂.

To conclude: A series of measurements of the bio gas composition of the experimental site, decommissioned 10 years ago, makes it possible to estimate the composition of the landfill gas being allocated in the absence of sludge: CH₄ - 30 ... 32%; O₂ - 0 ... 2%; CO₂ - 40-60%; H₂S - 0 ... 30 mg / m³. Supposedly, the remaining part in the gas, not determined by the instrumental method, N₂ - 5 ... 30%.

According to the energy potential, the landfill gas evolved in the experimental section is not inferior to natural gas or conventional gas with a large content of methane. But for sustainable combustion of gas it is necessary to ensure the supply of the appropriate amount of air, three times less than when burning natural gas, and intensive mixing of gas with air.

Acknowledgments

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