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Dynamic testing of the efficiency of degassing wells as a means to reduce greenhouse gas emissions from landfills

Dynamiczne badanie wydajności studni degazacyjnych jako narzędzie do zmniejszania emisji gazów cieplarnianych na składowiskach odpadów

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ABSTRACT: The article was written as a continuation of the research on degassing wells in terms of their gas productivity in a landfill. Waste is one of the most serious threats to the environment. The term 'waste' means 'any substance or object which the holder discards, he intends to get rid of, or which he has been required to get rid of". The European Union, with the aim of ensuring a high quality of life and health of people through effective environmental protection, imposes on Poland very restrictive guidelines in the field of waste management. These guidelines include: waste prevention, preparation for re-use, recycling, other recovery methods, disposal. The waste goes to landfills, where it is collected. Landfills pose a very high threat to the natural environment because they emit pollutants into the atmosphere. The greatest threat is related to the organic matter contained in municipal waste, which during decomposition emits greenhouse gases such as CO_2 and CH_4. The amount of emitted gas can be reduced by equipping the landfill with a special installation for the production of landfill gas (biogas). Biogas is one of the alternative energy sources that can be used to produce electricity and heat. However, the installation itself is not enough, and the landfill must also be rationally managed to support biogas production. Within the mass of waste, optimal conditions should be created for the methanogenesis process to take place. Compacting or pouring waste into layers of earth may serve as examples. Both of these processes reduce the oxygen content in the stored material. However, the content of the organic fraction in the deposited waste has the most pronounced influence on the production of biogas. The article presents the results of research on the efficiency of degassing wells carried out in one of the active municipal landfills which was established in 2009. Five degassing wells located in different parts of the dump's canopy were subjected to our measurements.

Key words: biogas, landfill, degassing wells, renewable energy sources.

STRESZCZENIE: Artykuł powstał jako kontynuacja badań studni degazacyjnych pod kątem ich produktywności gazowej na składowisku odpadów komunalnych. Odpady są jednym z poważniejszych zagrożeń dla środowiska naturalnego. Pojęcie „odpad" oznacza „każdą substancję lub przedmiot, których posiadacz pozbywa się, zamierza się pozbyć, lub do których pozbycia został zobowiązany". Unia Europejska, mając na celu zapewnienie wysokiej jakości życia i zdrowia ludzi poprzez skuteczną ochronę środowiska, nakłada na Polskę bardzo restrykcyjne wytyczne w zakresie zagospodarowania odpadów. Na wytyczne te składają się: zapobieganie powstawaniu odpadów, przygotowanie do ponownego użycia, recykling, inne metody odzysku, unieszkodliwienie. Odpady trafiają na składowiska, gdzie są gromadzone. Składowiska odpadów stanowią bardzo duże zagrożenie dla środowiska naturalnego, ponieważ emitują do atmosfery zanieczyszczenia. Największe zagrożenie związane jest z materią organiczną zawartą w odpadach komunalnych, która w trakcie rozkładu emituje do atmosfery gazy cieplarniane, takie jak CO_2 i CH_4. Można ograniczyć ilość emitowanych gazów poprzez uzbrojenie składowiska w specjalną instalację do produkcji gazu składowiskowego (biogazu). Biogaz jest zaliczany do alternatywnych źródeł energii, które można wykorzystać do produkcji energii elektrycznej i cieplnej. Jednak sama instalacja nie wystarczy, należy również racjonalnie gospodarować składowiskiem w celu wsparcia produkcji biogazu. W masie odpadów należy stworzyć optymalne warunki do zachodzenia procesu metanogenezy. Przykładem może tu być kompaktowanie lub przesypywanie odpadów warstwami ziemi. Oba te procesy prowadzą do obniżenia zawartości tlenu w składowanym materiale. Największy wpływ na wytwarzanie biogazu ma jednak zawartość frakcji organicznej w składowanych odpadach. W artykule przedstawiono wyniki badań wydajności studni degazacyjnych przeprowadzonych na jednym z czynnych składowisk odpadów komunalnych, które powstało w 2009 roku. Pomiary zostały wykonane w pięciu studniach degazacyjnych, które były rozlokowane w różnych częściach czaszy składowiska.

Słowa kluczowe: biogaz, składowisko odpadów, otwory degazacyjne, odnawialne źródła energii.

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Introduction

The politics of the European Union is directed toward leaving behind/abandoning energy sources originating mainly from fossil fuels whose reserves are steadily being depleted and whose utilisation negatively influences the environment. The renewable energy sources (RES) are used as an alternative (The Ordinance of The Ministry of Economy, 2008; Zaleska-Bartosz, 2014), whose negative environmental impact is small, and whose reserves are renewed within a short period of time. The sun, wind, water, geothermal energy, biomass, biofluids, biofuels and biogas are listed amongst the RES. Biogas is a flammable gas which can be generated on landfills upon anaerobic decomposition of organic matter (fermentation). Fermentation is a set of anaerobic biochemical processes, in which organic matter (carbohydrates, proteins and fats, as well as their derivative compounds) is decomposed by means of microorganisms (Dudek and Zaleska-Bartosz, 2010; Dudek, 2012). Methane and carbon dioxide are the main constituents of biogas. The decomposition of organic matter proceeds in several phases, among which one can distinguish subsequently 4 main phases: hydrolysis, acidogenesis, acetogenesis and methanogenesis. Methane is created during the fourth phase as a result of the catabolic processes of methanogens, such as: the decomposition of acetic acid, reduction of CO_2 with H_2 participation, methylotrophic reactions. The fraction of methane in landfill gas varies, depending on the organic matter content and composition, but usually ranges from 40 to 60% (Zaleska-Bartosz, 2014). The landfill gas is generated in an autogenous manner on landfills of municipal waste. In order to prevent unnecessary emissions of landfill gas to the atmosphere, as well as to minimise the hazards resulting from the flammable and explosive properties of methane, it is necessary to furnish landfills with degassing systems, where the biogas is drawn by means of degassing wells and subsequently sent through piping to collecting stations (Kołodziejak and Zaleska-Bartosz, 2014). There are several factors influencing the biogas production:

- the content of organic fraction in the waste;
- the compacting and layering of wastes with the soil;
- moisture content in the waste – its value below 30% inhibits the methane production process, and below 15% stops the fermentation;
- aeration of wastes – which activates anaerobic microorganisms, accelerating the decomposition of organic matter;
- climatic controls, such as: volume and frequency of precipitations, air temperature, atmospheric pressure and hydrogeological conditions (Porowska and Gruszczyński, 2013).

The article was written as a continuation of the research on degassing wells in terms of their gas productivity in a landfill (Hebda i Kołodziejak, 2021). Within the second stage of works on active landfill, measurements of dynamic gas reception from the subsequently mentioned 5 degassing wells, located at various parts of the landfill, have been done. The obtained results were subjected to evaluation for the gas productivity of the landfill. The scope of performed work covered the following actions:

- performing tests of dynamic gas reception from the landfill on degassing wells (suction tests, characterising the capacity of a well);
- performing quantitative and qualitative determinations of gas constituents from degassing wells and determining the physical and chemical parameters of the gas in dynamic conditions;
- determining the type of gas obtainable from the wells at which the measurements have been done.

Testing equipment and testing methodology

The BIOGAS 5000 gas analyser by Geotechnical Instruments was used for measuring concentrations of main landfill gas constituents, for concentrations ranging from 0.1% v/v up to 100 [% v/v]. The analyses covered measurements of methane, carbon dioxide and oxygen. The measurements at the landfill site were performed by means of a set for dynamic gas collection tests (suction tests), composed of the following components:

- the side-channel fan of the SC30A300T type by Venture Industries Sp. z o.o., which is equipped with an inverter enabling regulation of the rotor speed;
- the rotor type gas-meter of the CGR-01 series, by COMON S.A. company, featuring a measurement range of 0–250 m^3/h;
- polyurethane flexible tubes, 63 mm in diameter, reinforced with steel wire.

The set for performing the productivity forecast verification on municipal waste landfill, is presented in Figure 1.

The testing methodology covered measurements of individual degassing wells, employing the active gas reception method. The method itself consists in pumping out gas at a specific flowrate and simultaneous measurements of its composition. The measurements on each of the tested wells were performed until the stream of pumped out gas was determined, for which the methane content has not been changing anymore. The parameters of the following gases were determined during the tests: CH_4, CO_2, O_2 and N_2.

Results of the tests

For each of the tested wells tables (Table 1–5) are shown, containing values of the streams and concentrations of main

Figure 1. The set for dynamical reception of landfill gas from a landfill
Rysunek 1. Zestaw do dynamicznego odbioru gazu wysypiskowego ze składowiska odpadów

biogas components, obtained during works being performed. The values have been also recalculated in order to determine the biogas parameters after the deduction of the air stream, being drawn through leakages. The capacity ranges for the individual wells and the average values of the stream magnitude and concentrations of main gas components, for which gas flow rates exhibiting stable methane contents were obtained, are marked with the colour green in the tables.

The degassing well No. 1 – located on the bank at the east side of the landfill.

Table 1. The results of concentration measurements of the main gas components and the gas stream, during active reception tests for the well No. 1
Tabela 1. Wyniki pomiarów stężeń głównych składników gazu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru dla studni nr 1

Time of measurement	Gas volume stream	Composition of captured gas				Gas volume stream without air	Composition of captured gas following air removal		
		CH_4	CO_2	O_2	N_2		CH_4	CO_2	N_2
[min]	[Nm^3/h]	[%]				[Nm^3/h]	[%]		
0	–	62.0	37.7	0.1	0.2	–	62.1	37.9	0.0
10	5.1	61.6	38.1	0.3	0.0	5.1	61.8	38.2	0.0
20	3.5	61.4	38.2	0.1	0.3	3.5	61.6	38.4	0.0
30	4.7	61.3	38.2	0.1	0.4	4.7	61.6	38.4	0.0
40	4.6	61.4	38.2	0.1	0.3	4.6	61.6	38.4	0.0
50	4.8	61.3	38.0	0.1	0.6	4.8	61.6	38.2	0.2
60	4.7	61.2	38.1	0.1	0.6	4.7	61.5	38.3	0.2
70	5.1	60.5	38.1	0.1	1.3	5.1	60.8	38.3	0.9
80	4.9	60.5	38.0	0.1	1.4	4.9	60.8	38.2	1.0
90	5.3	59.9	38.0	0.1	2.0	5.3	60.2	38.2	1.6
100	3.7	59.9	37.8	0.1	2.2	3.7	60.2	38.0	1.8
110	5.3	59.6	37.9	0.1	2.4	5.3	59.9	38.1	2.0
120	5.2	59.4	38.0	0.1	2.5	5.2	59.7	38.2	2.1
130	5.4	59.3	37.9	0.1	2.7	5.4	59.6	38.1	2.3
140	5.3	59.1	37.8	0.1	3.0	5.3	59.4	38.0	2.6
150	5.3	58.7	37.7	0.1	3.5	5.3	59.0	37.9	3.1
160	5.2	58.6	37.8	0.1	3.5	5.2	58.9	38.0	3.1
170	5.2	58.7	37.9	0.1	3.3	5.1	59.0	38.1	2.9
180	5.2	58.5	37.8	0.1	3.6	5.2	58.8	38.0	3.2
190	5.9	58.3	37.7	0.1	3.9	5.9	58.6	37.9	3.5
200	6.1	58.0	37.7	0.1	4.2	6.0	58.3	37.9	3.8

cont. Table 1/cd. Tabela 1

Time of measurement	Gas volume stream	Composition of captured gas				Gas volume stream without air	Composition of captured gas following air removal		
		CH_4	CO_2	O_2	N_2		CH_4	CO_2	N_2
[min]	[Nm³/h]	[%]				[Nm³/h]	[%]		
210	6.1	57.7	37.7	0.1	4.5	6.0	58.0	37.9	4.1
220	6.1	57.5	37.6	0.1	4.8	6.0	57.8	37.8	4.4
230	6.0	57.7	37.3	0.1	4.9	6.0	58.0	37.5	4.6
240	6.0	57.5	37.5	0.1	4.9	6.0	57.8	37.7	4.6
250	7.3	57.1	37.2	0.1	5.6	7.2	57.4	37.4	5.3
260	7.4	56.0	37.2	0.1	6.7	7.4	56.3	37.4	6.4
270	7.3	55.1	37.0	0.1	7.8	7.3	55.4	37.2	7.5
280	7.5	54.3	36.7	0.1	8.9	7.5	54.6	36.9	8.6
290	8.1	53.5	36.5	0.1	9.9	8.1	53.8	36.7	9.6
300	8.5	52.6	36.0	0.1	11.3	8.4	52.8	36.2	11.0
310	8.5	52.3	35.7	0.1	11.9	8.5	52.5	35.9	11.6
320	8.4	51.4	35.2	0.2	13.2	8.3	51.9	35.5	12.6
330	10.1	48.7	33.8	0.7	16.8	9.8	50.4	35.0	14.7
340	6.2	50.7	34.8	0.3	14.2	6.1	51.4	35.3	13.3
350	4.8	52.4	35.5	0.1	12.0	4.8	52.6	35.7	11.7
360	4.9	53.6	35.9	0.1	10.4	4.9	53.9	36.1	10.1
370	5.0	54.2	36.3	0.1	9.4	5.0	54.5	36.5	9.1
377	5.7	54.4	36.5	0.1	9.0	5.7	54.7	36.7	8.7
Average values for stable gas stream:						**5.1**	**56.4**	**37.1**	**6.5**

The tests performed on the well No. 1 showed a low capacity of the well, resulting probably from its location within wastes of lower organic matter content.

During measurements, the biogas flow was obtained at a 5.1 m³/h level and methane content was determined as 56.4% (Figure 2).

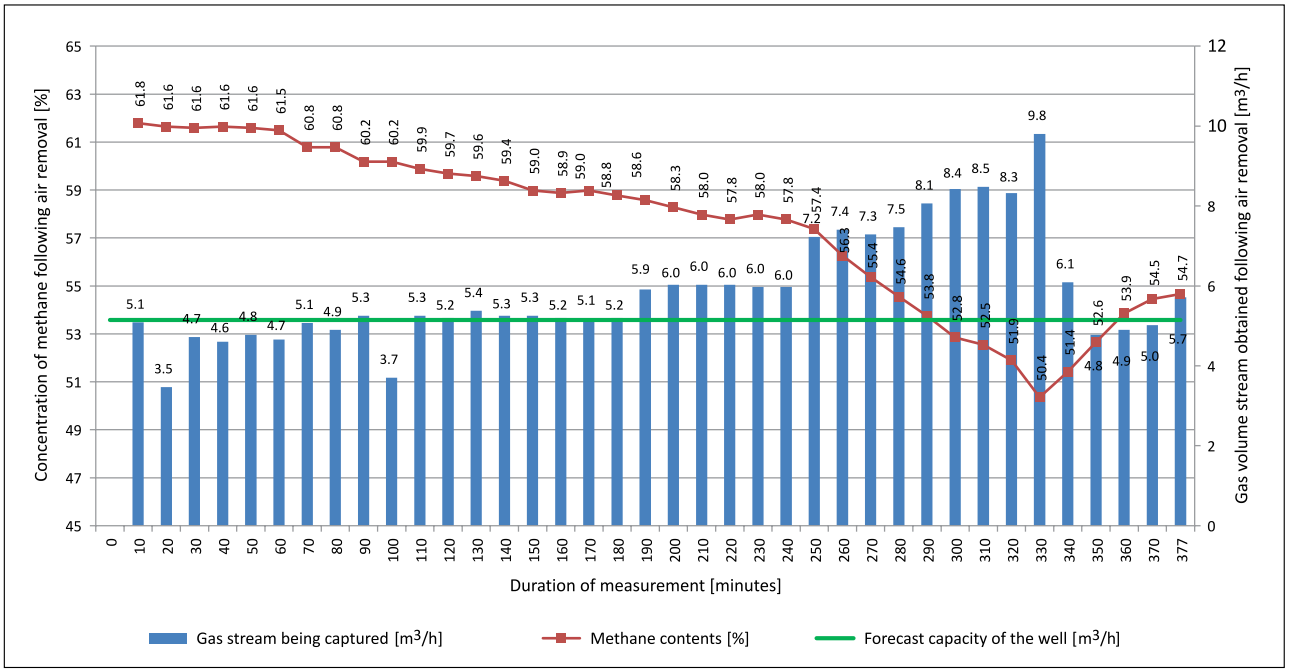

Figure 2. Measurement results of methane concentration and gas stream obtained during active reception tests on the well No. 1
Rysunek 2. Wyniki pomiarów stężeń metanu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru na studni nr 1

Degassing well No. 2 – located at the west part of the landfill, close to entry road on the landfill bowl.

Table 2. The results of concentration measurements of the main gas components and the gas stream, during active reception tests for the well No. 2

Tabela 2. Wyniki pomiarów stężeń głównych składników gazu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru dla studni nr 2

Time of measurement	Gas volume stream	Composition of captured gas				Gas volume stream without air	Composition of captured gas following air removal		
		CH_4	CO_2	O_2	N_2		CH_4	CO_2	N_2
[min]	[Nm^3/h]	[%]				[Nm^3/h]	[%]		
0	–	62.7	37.2	0.1	0.0	–	62.8	37.2	0.0
10	3.9	59.1	35.1	1.0	4.8	3.7	62.0	36.8	1.1
20	4.1	56.7	34.5	1.1	7.7	3.9	59.8	36.4	3.8
30	4.1	55.4	34.2	1.2	9.2	3.8	58.7	36.2	5.0
40	4.1	54.7	34.1	1.1	10.1	3.9	57.7	36.0	6.3
50	4.1	52.8	33.7	1.1	12.4	3.9	55.7	35.5	8.8
60	5.7	47.4	32.0	1.5	19.1	5.3	51.0	34.4	14.6
70	5.8	45.0	31.0	1.6	22.4	5.3	48.7	33.5	17.8
80	5.8	42.6	30.2	1.6	25.6	5.3	46.1	32.7	21.3
90	4.9	41.0	29.4	1.6	28.0	4.5	44.3	31.8	23.9
100	4.7	39.0	28.6	1.7	30.7	4.4	42.4	31.1	26.5
110	4.7	37.0	27.8	1.7	33.5	4.4	40.2	30.2	29.6
120	3.9	36.3	27.4	1.6	34.7	3.6	39.3	29.6	31.1
130	3.1	36.2	27.4	1.4	35.0	2.9	38.8	29.3	31.9
140	2.9	36.0	27.3	1.3	35.4	2.8	38.3	29.1	32.6
150	3.1	36.0	27.2	1.2	35.6	2.9	38.2	28.8	33.0
160	3.0	35.7	26.8	1.2	36.3	2.8	37.8	28.4	33.8
Average values for stable gas stream:						**2.9**	**38.4**	**29.1**	**32.5**

The tests performed on the well No. 2 showed a very low capacity, resulting most likely from the location within wastes of low organic matter contents. This suggests a decrease of the methane content with a simultaneous, relative low oxygen content – the gas is not being diluted by the air being drawn in. The gas stream obtained at stable methane contents (at 38.4% level) was 2.9 m^3/h (Figure 3).

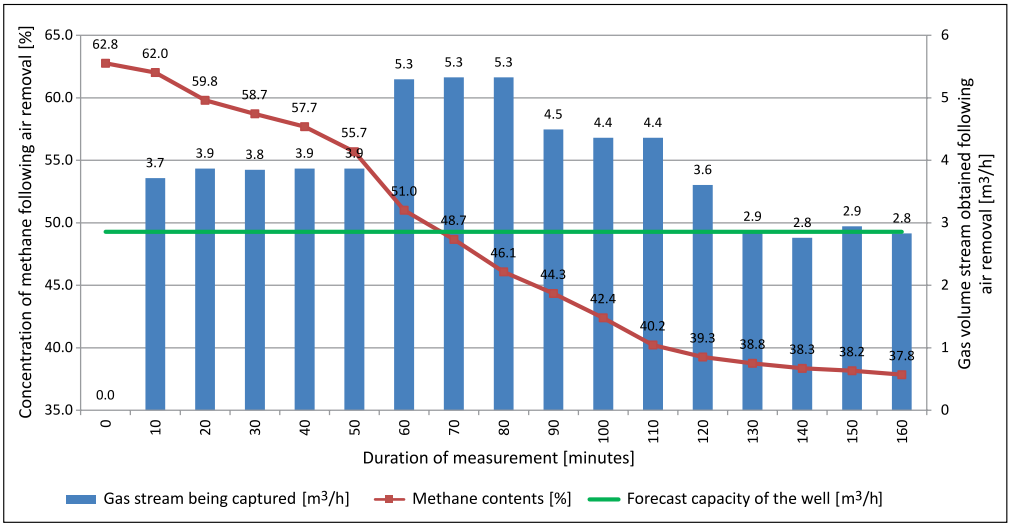

Figure 3. Measurement results of the methane concentration and gas stream obtained during active reception tests on the well No. 2

Rysunek 3. Wyniki pomiarów stężeń metanu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru na studni nr 2

Degassing well No. 3 – located in the south-east part of the landfill.

Table 3. The results of concentration measurements of the main gas components and the gas stream during active reception tests for the well No. 3

Tabela 3. Wyniki pomiarów stężeń głównych składników gazu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru dla studni nr 3

Time of measurement	Gas volume stream	Composition of captured gas				Gas volume stream without air	Composition of captured gas following air removal		
		CH_4	CO_2	O_2	N_2		CH_4	CO_2	N_2
[min]	[Nm^3/h]	[%]				[Nm^3/h]	[%]		
0	-	63.1	36.9	0.0	0.0	-	63.1	36.9	0.0
10	9.7	62.5	37.2	0.1	0.2	9.7	62.6	37.2	0.2
20	10.1	62.3	37.7	0.0	0.0	10.1	62.3	37.7	0.0
30	10.1	62.0	38.0	0.0	0.0	10.1	62.0	38.0	0.0
40	12.2	52.3	34.5	2.5	10.7	10.8	59.3	39.1	1.6
50	12.8	52.6	34.1	2.8	10.5	11.1	60.6	39.3	0.1
60	11.0	61.8	38.1	0.1	0.0	11.0	61.9	38.1	0.0
70	10.7	61.7	38.2	0.1	0.0	10.7	61.8	38.2	0.0
80	10.9	62.3	37.3	0.4	0.0	10.8	62.6	37.4	0.0
90	10.9	62.5	37.4	0.1	0.0	10.8	62.6	37.4	0.0
100	10.8	62.0	37.9	0.1	0.0	10.8	62.1	37.9	0.0
110	10.7	62.1	37.9	0.0	0.0	10.7	62.1	37.9	0.0
120	11.6	58.6	37.3	1.1	3.0	11.1	61.1	38.9	0.0
Average values for stable gas stream:						**10.8**	**62.3**	**37.7**	**0.0**

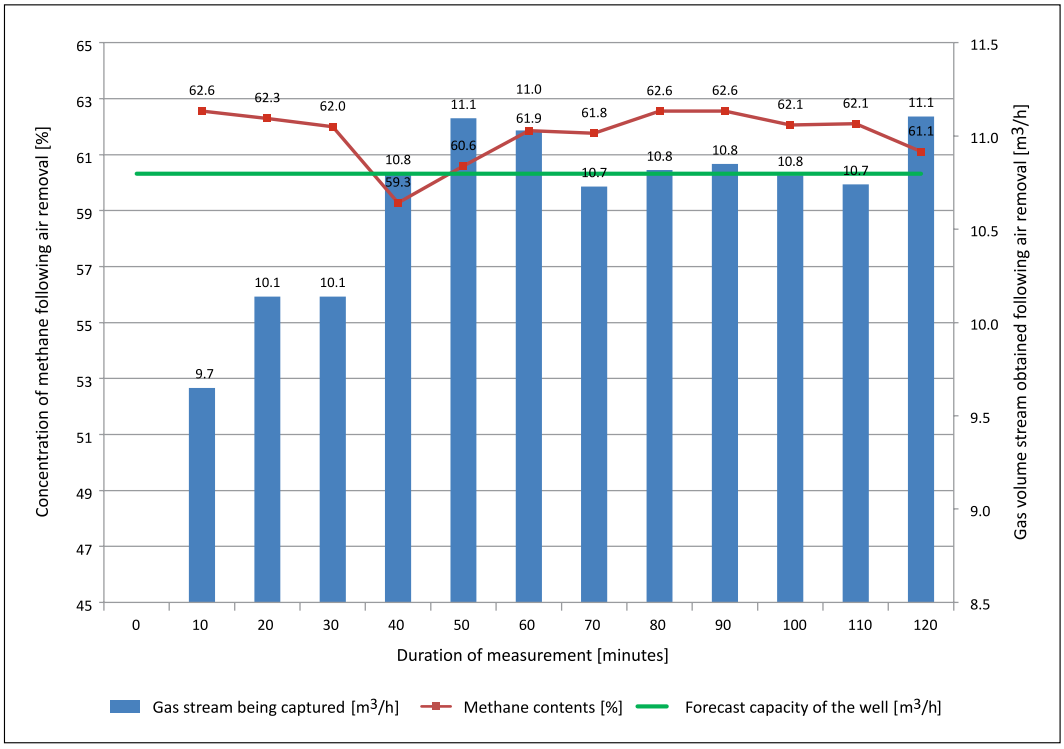

Figure 4. Measurement results of the methane concentration and gas stream obtained during active reception tests on the well No. 3

Rysunek 4. Wyniki pomiarów stężeń metanu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru na studni nr 3

Based on the analysis of the well No. 3, a very good sealing and gas capacity was found. The stream of biogas at stable methane contents (at 62.3% level) was 10.8 m^3/h (Figure 4).

Degassing well No. 4 – located in the south-east part of the landfill.

Table 4. The results of concentration measurements of the main gas components and the gas stream during active reception tests for the well No. 4

Tabela 4. Wyniki pomiarów stężeń głównych składników gazu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru dla studni nr 4

Time of measurement	Gas volume stream	Composition of captured gas				Gas volume stream without air	Composition of captured gas following air removal		
		CH_4	CO_2	O_2	N_2		CH_4	CO_2	N_2
[min]	[Nm^3/h]	[%]				[Nm^3/h]	[%]		
0	-	59.2	37.5	0.7	1.4	-	61.2	38.8	0.0
10	6.1	58.3	37.4	1.0	3.3	6.0	58.9	37.8	3.3
20	6.1	58.0	37.4	1.0	3.6	5.8	60.8	39.2	0.0
30	6.5	57.0	37.5	1.1	4.4	6.2	60.1	39.5	0.3
40	6.3	57.0	37.1	1.3	4.6	5.9	60.6	39.4	0.0
50	5.8	59.8	38.6	0.6	1.0	5.7	60.8	39.2	0.0
60	5.7	60.3	38.6	0.5	0.6	5.6	61.0	39.0	0.0
70	5.6	60.8	38.6	0.4	0.2	5.6	61.2	38.8	0.0
80	5.6	61.2	38.6	0.2	0.0	5.6	61.3	38.7	0.0
90	5.8	61.5	38.1	0.1	0.3	5.7	61.7	38.3	0.0
100	5.7	61.8	38.0	0.1	0.1	5.7	61.9	38.1	0.0
110	6.4	60.8	38.1	0.6	0.5	6.3	61.4	38.5	0.1
120	6.3	60.2	38.0	0.6	1.2	6.2	61.2	38.7	0.1
130	5.5	60.9	38.2	0.4	0.5	5.4	61.5	38.5	0.0
140	5.3	61.3	38.3	0.2	0.2	5.3	61.5	38.5	0.0
150	5.5	61.7	38.2	0.1	0.0	5.5	61.8	38.2	0.0
160	5.4	62.1	37.8	0.1	0.0	5.4	62.2	37.8	0.0
169	5.3	62.4	37.5	0.1	0.0	5.3	62.5	37.5	0.0
Average values for stable gas stream:						**5.7**	**61.6**	**38.4**	**0.0**

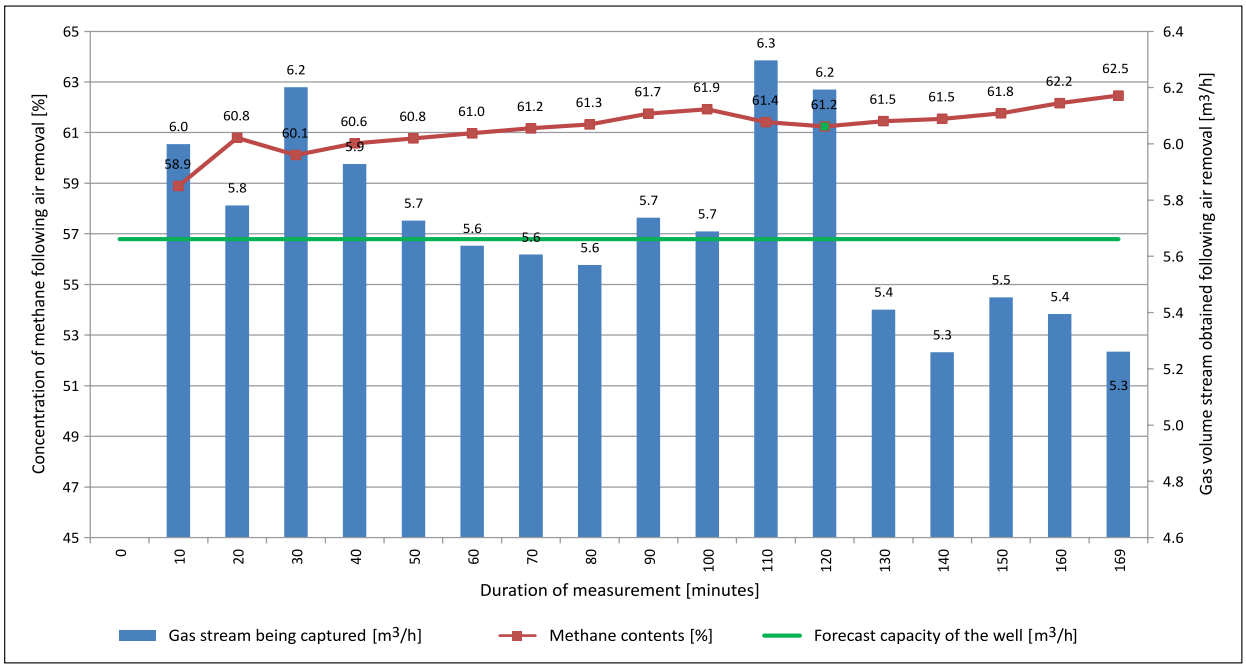

Figure 5. Measurement results of the methane concentration and gas stream obtained during active reception tests on the well No. 4

Rysunek 5. Wyniki pomiarów stężeń metanu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru na studni nr 4

The well No. 4 was characterised by a low capacity, amounting approx. to 6.7 m^3/h, resulting from the location within the wastes of a lower organic fraction content. The low oxygen level during measurements suggest sealing of the well is at a good level. The stable content of the methane was 61.6% (Figure 5).

Degassing well No. 5 – located in the central part of the landfill.

Table 5. The results of concentration measurements of the main gas components and the gas stream during active reception tests for the well No. 5

Tabela 5. Wyniki pomiarów stężeń głównych składników gazu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru dla studni nr 5

Time of measurement	Gas volume stream	Composition of captured gas				Gas volume stream without air	Composition of captured gas following air removal		
		CH_4	CO_2	O_2	N_2		CH_4	CO_2	N_2
[min]	[Nm^3/h]	[%]				[Nm^3/h]	[%]		
0	-	60.2	39.6	0.1	0.0	-	60.5	39.5	0.0
10	4.6	60.5	39.5	0.0	0.0	4.6	60.5	39.5	0.0
20	6.2	60.4	39.6	0.0	0.0	6.2	60.4	39.6	0.0
30	8.3	60.3	39.7	0.0	0.0	8.3	60.3	39.7	0.0
40	11.8	60.2	39.8	0.0	0.0	11.8	60.2	39.8	0.0
50	12.8	60.2	39.8	0.0	0.0	12.8	60.2	39.8	0.0
60	14.9	59.6	40.3	0.1	0.0	14.9	59.7	40.3	0.0
70	15.5	59.7	40.2	0.1	0.0	15.5	59.8	40.2	0.0
80	16.0	59.5	40.3	0.2	0.0	16.0	59.6	40.4	0.0
90	16.4	57.2	40.3	0.7	1.8	16.0	58.7	41.3	0.0
100	15.3	56.9	42.6	0.4	0.1	15.2	57.2	42.8	0.0
110	13.5	59.9	40.1	0.0	0.0	13.5	59.9	40.1	0.0
120	12.3	60.1	39.9	0.0	0.0	12.3	60.1	39.9	0.0
130	9.4	59.9	40.1	0.0	0.0	9.4	59.9	40.1	0.0
140	8.8	59.9	40.1	0.0	0.0	8.8	59.9	40.1	0.0
150	7.6	60.2	39.8	0.0	0.0	7.6	60.2	39.8	0.0
160	6.7	59.9	40.1	0.0	0.0	6.7	59.9	40.1	0.0
170	6.3	60.0	40.0	0.0	0.0	6.3	60.0	40.0	0.0
Average values for stable gas stream:						**12.3**	**60.2**	**39.8**	**0.0**

The well No. 5 revealed a very high capacity and very good sealing. The stream of biogas at stable methane contents (at 60.2% level) was 12.3 m^3/h (Figure 6).

Summary and conclusions

The work encompassed measurements of the dynamic gas reception from active municipal waste landfill, from 5 degassing wells (suction tests, characterising the capacity of these wells). Quantitative and qualitative determinations of the gas components were also performed in dynamic conditions, as well as the gas volume stream that was possible to be drawn from the wells covered by the testing programme.

The tests showed that analysed wells No. 3 and 5, that were located in the south-east and central parts of the landfill respectively, are pervious and suitable for further production. The wells in question, thanks to good sealing and a sufficient volume of deposited organic matter, were characterised by high biogas streams featuring stable methane contents, at the levels of 10.8 m^3/h and 12.3 m^3/h respectively, which in the case of the latter well is a good result. The concentration of methane in these wells amounted to, consecutively, 62.3% and 60.2% (the values after the air stream drawn through leakages has been removed).

The subsequent well from the tested set, the wells number 1 (located on the bank at the east side of the landfill) and number 4 (located at the south-east part of the landfill) were characterised by a lower capacity, at the levels 5.1 m^3/h and 5.7 m^3/h, respectively, with methane contents amounting to approx., 60%. The most probable reason for the lower capacity of these wells is their location within the mass of waste

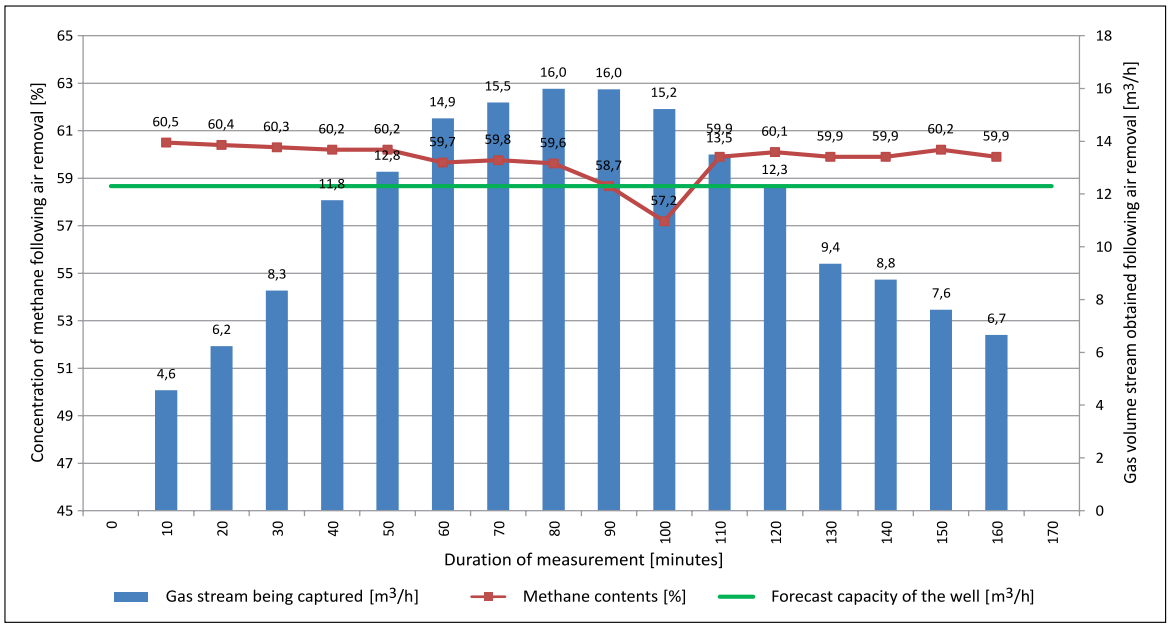

Figure 6. Measurement results of the methane concentration and gas stream obtained during active reception tests on the well No. 5
Rysunek 6. Wyniki pomiarów stężeń metanu oraz strumienia gazu otrzymane podczas testów aktywnego odbioru na studni nr 5

characterised by lower organic matter content. The well No. 2, located at the west part of the landfill, close to the entry road on the bowl of the landfill, has been found to be the worst as regards the gas capacity. The gas stream obtained during tests was 2.9 m^3/h with the methane content at the level of 38.4%. This situation most probably results from the location of the well within waste of low organic matter content. This suggests a decrease of the methane content with a simultaneous, relative low oxygen content – the gas is not being diluted by the air being drawn in.

The differences in the obtained values of the gas stream and methane concentrations are related to the non-uniform structure of the landfill deposit, hence varying the productivity of its individual parts. By creating optimal conditions for anaerobic bacteria growth, responsible for biogas production, we can directly contribute to an improvement of the landfill gas productivity and, in the long-term perspective, to increasing the volume and improving the quality of the gas being captured.

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Legal acts and normative documents

The Ordinance of The Minister of Economy of August, 14th, 2008, on the detailed scope of the obligation to obtain and present for remission certificates of origin, to remit the replacement fee, purchase of electric energy and heat produced in renewable energy sources and the obligation of confirming the data related to the amount of electric energy produced in such renewable energy sources (OJ L of 2008, No. 156, pos. 969).

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