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FIRST STEP TO URBAN MINING RESTORATION OF GAS WELLS IN MUNICIPAL WASTE DEPOSITS AND REACTIVATION OF GAS PRODUCTION

17.1. INTRODUCTION TO RESTORATION OF GAS WELLS IN MUNICIPAL WASTE DEPOSITS

Municipal waste deposits consist of about more than 20% of organic waste which is able to react biologically and chemically. If oxygen is absent, this organic waste produces methane (CH_4) and carbon dioxide (CO_2) in the ratio 60% to 30%. To suck these gases out of the landfill, gas wells either are growing with the deposit or are drilled later in the filled and covered deposit. Common for both well types is that they have filter pipes all over their length. These filter pipes are surrounded by coarse gravel (normally 16/32) in a diameter of 600 to 1,000 mm.

Sucking of these gas wells produces low pressure inside the landfill. Atmospheric air will be sucked over the surface of the covered landfill inside the waste deposit. Near to the surface the oxygen reacts with organic material and produces CO_2, water and energy. Because of this humidity and heat anaerobic bacteria start to produce methane. The result is a high energetic gas which contains about 50 to 60 vol. -% of $CH_4$and up to 30% of CO_2. This gas can be used in power plants to produce electricity and heat.

After some time the whole organic material in the layers near to the surface of the landfill will be changed into CO_2, water and energy. From this time on the gas well will suck atmospheric air in the first meters from the surface. This low energetic gas cannot be used in power plants anymore.

At this point the sucking will be stopped. Because oftimesof no sucking,the lower layers produce enough gas that the sucking can be started again until the content of methanewill decrease again. For a period of timethese gas wells will be used attimes.But they no more will deliver continuously gas ofhigh quality. Later onthese wells will be abandoned completely, though there is still organic material inside the landfill, producing methane. This can be seen and measured at the surface of the landfill (Fig. 17.1). Where the landfill gas is not sucked from underground it will produce gas pressure and escape to atmosphere somewhere else.

Fig. 17.1 a+b Bubbles of methane at the surface of a landfill and measuring of gas on the surface of another landfill (LUBW 2008)

17.2 UNDERSTANDING OFTHE SYSTEM

Normal gas wells are filtered and sucked over their whole length (Fig. 17.2). Most of the gas is sucked near to the surface and near to the gas wells itself (light colored areas in Figure 17.2) [1]. In the rest of the landfill there is no low pressure and no sucking (dark colored areas in Figure 17.2). In most cases the gas in the light colored areas is mixed with atmospheric air, in some cases the content of atmospheric air is nearly 100%.

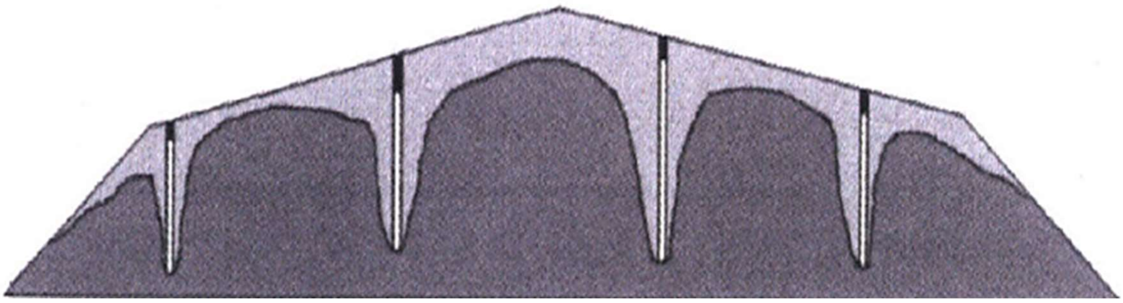

Fig. 17.2 Gas winning standard procedure (Kanitz& Forsting 2004)

Bysucking and measuring in deep zones it is possible to show that there is still organic material producing new landfill gas with a high percentage of methane, but with a very low production rate. In most cases the temperature in these areas (dark colored in Figure 17.2) is too low for anaerobe bacteria. Only in few cases these areas are although too dry for bacteria or chemical reactions.

Byrestoration of the gas wells and only filtering and sucking in deep parts the expected gas flow should look like in Figure 17.3. Bythe aerobic processes near to the surface the inner part of the landfill will be heated up to 30° to 40°C, which is a comfortable temperature for anaerobic bacteria. The quality of the gas from the deep sucking wells is suitable forrunning power plants.

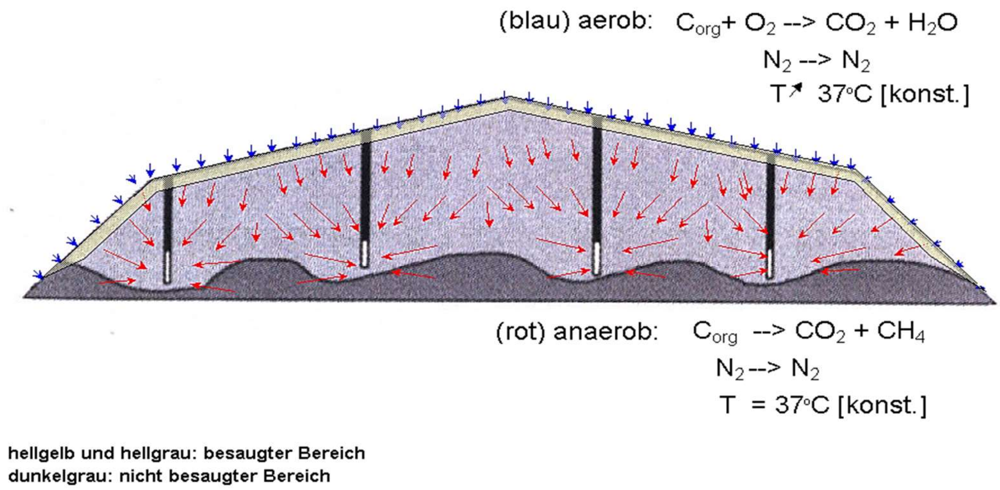

Fig. 17.3 Gas flow in landfills with deep sucking wells 1 (expected) (4)

Because of the aerobic processes near to the surface the border between aerobic and anaerobic processes will move from the surface downwards to the sucking point (Fig. 17.4). The area at the top of the landfill will become inert and will not show any chemical reactions anymore. The time between Figure 17.3 and Figure 17.4 may last more than ten years.

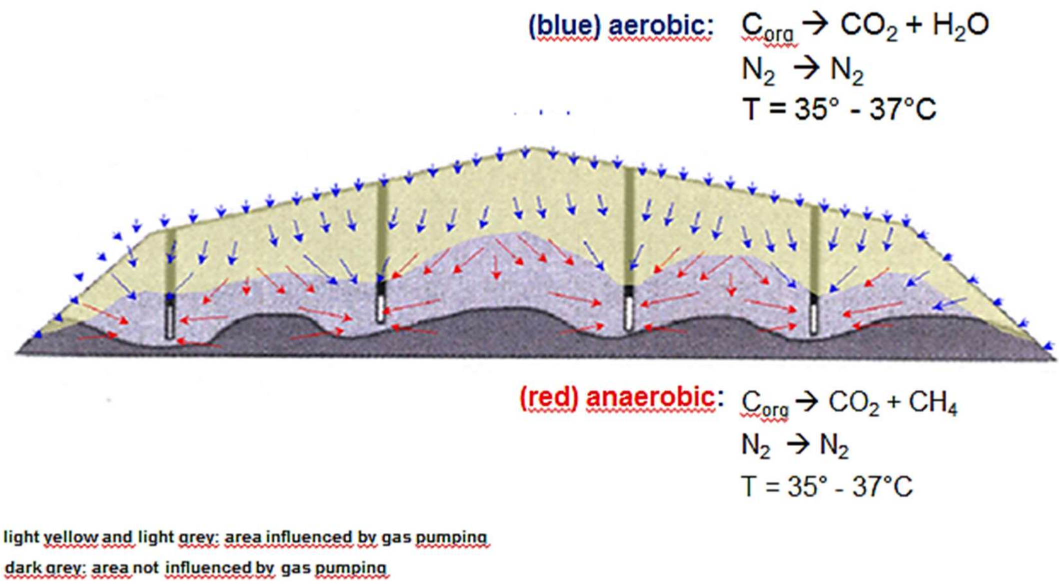

Fig. 17.4 Gas flow in landfills with deep sucking wells 2 (expected) (4)

17.3 PRACTICE OF RESTORATION OF GAS WELLS

To restore a gas well with leakages inside a landfill means that the leakage should be closed. If possible, the gravel filter around the leakage should be closed too. Normally there is a drill hole inside the landfill with a filter pipe in the center and coarse gravel around. A normal diameter of this system maybe between 60 and 100 cm. The gravel has a pore volume of about 40%. These pores are to be closed.

To destroy a gas well on a municipal waste deposit causes costs to drill a new gas well. Therefore the first step was to try such a restoration in a laboratory, to simulate the situation in a landfill. In the laboratory test such a system was implemented and then the pores in the gravel were foamed (Fig. 17.5 and Fig. 17.6).

Fig. 17.5 a+b Model of a gas well in the laboratory

Fig. 17.6 a+b Foam body of a restored gas well in the laboratory test

With this proved system five gas wells with leakages in the waste deposit of Celje, Slovenia, should be restored to deliver better gas qualities.

17.4 RESTORATION OF FIVE GAS WELLS ON LANDFILL CELJE

In April 2014 the team from TH Georg Agricola, Prof. Dr. Frank Otto, Cand.-Ing. Daniel Synnatzschke and Dipl.-Chem. Jürgen Kanitz, started the first phase of gas well restoration on Celje municipal waste deposit, supported by Ljubljana University, Prof. Dr. Joze Kortnik. In this phase the well heads were opened and the pipes were prepared for test sucking and measuring (Fig. 17.7).

Fig. 17.7 a+b Opening and preparing a well head for measurement

The measuring itself took place in different depths to localize potentialleakages (Fig. 17.8).

Fig. 17.8 a+b Sucking from the top and measuring in different depths

One example of this measurement is shown in Table 17.1 and the corresponding Figure 17.9.

The important issue is the decreasing content of oxygen in the first four meters of the well parallel to the increasing content of methane. In this part the well V 3/2 had a leakage which had to be closed. For this well foaming was planned for the first four meters from the top in two steps with 25 liters foam in each step. Especially in this well the first step between minus 4.0 m and minus 2.8 m was successful. The second step between minus 2.8 m and minus 1.6 m was only partially successful because of water flowing from the side into the well and stored on the first layer of foam. In this case the foam reacted with water and expanded too fast and too much. Important is the result, that the leakage even in this well could be closed.

Table 17.1 Gas concentrations measured in different depths;gas well V 3/2 on 11.04.2014 (3)

Well Depth: 17,30 m below POK; Waterlevel below POK: none; Well above membrane liner: 1,20 m

	Depth [m b. POK]	CH4 [Vol.-%]	CO2 [Vol.-%]	O2 [Vol.-%]	Temp. [°C]	CH4/CO2
0	0,0	18,7	9,62	13,0	12,9	1,94
1	-1,0	19,2	8,40	12,4	14,1	2,29
2	-2,0	47,1	20,21	2,2	15,7	2,33
3	-3,0	42,9	18,14	3,9	17,6	2,36
4	-4,0	53,4	22,34	0,4	19,4	2,39
5	-5,0	57,1	23,78	0,6	21,7	2,40
6	-6,0	57,7	25,61	0,5	24,3	2,25
7	-7,0	56,3	26,25	0,0	25,1	2,14
8	-8,0	56,5	27,46	0,0	25,2	2,06
9	-9,0	55,5	27,60	0,0	25,7	2,01
10	-10,0	56,3	27,31	0,0	25,9	2,06
11	-11,0	55,0	27,31	0,0	26,5	2,01
12	-12,0	52,6	26,92	0,0	27,7	1,95
13	-13,0	52,3	27,07	0,0	27,9	1,93
14	-14,0	52,1	26,61	0,0	28,0	1,96
15	-15,0	52,3	26,93	0,0	28,1	1,94
16	-16,0					
Control Measurement 7 m:		55,0	27,21	0,0	26,3	2,02

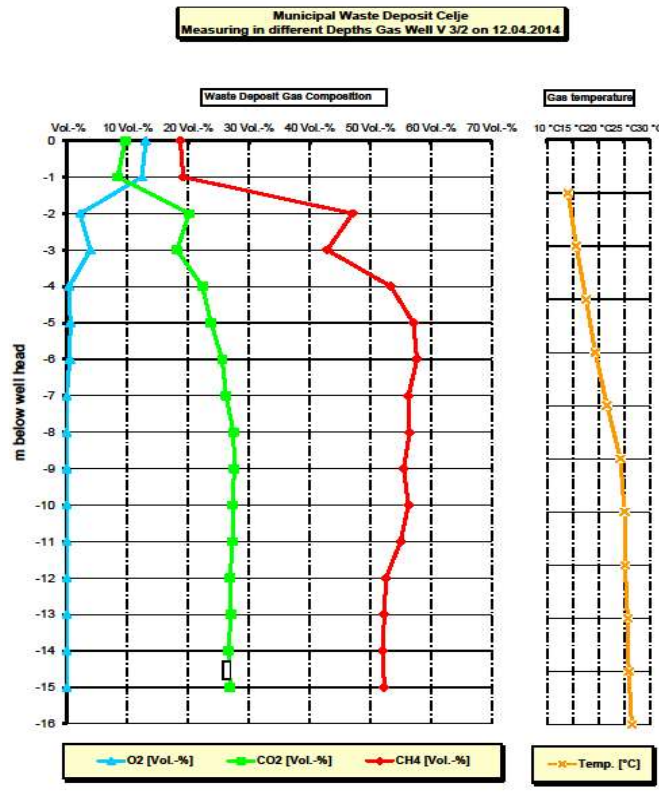

Fig. 17.9 Gas concentrations in well V 3/2, Gas concentration analysed meter wise in a gas wellunder suction (3)

17.5 RESULTS OF RESTORATION

In all of landfill Celje restored gas wells the leakage to the surface could be reduced. In gas well 3/1 the leakage tothe surface is still existing but it is smaller than before. The well is installed quite near to an open slope;ambient air can migrate into the gas well. The other three gas wells show oxygen concentrations below 1 vol. -%. The leakage to the surface around the gas wells is nearly closed. The effect of the suction islimited only to the waste and doesn´t reach the surface of landfill anymore.

17.6 CONCLUSION

It could be shown, that leaking gas wells could be restored. Instead of drilling new wells, the sealing of leakages with PU foam is a fast and effective method. So it is possible to develop a gas well with a strongly reducedchance to achieve an increasing leakage to the surface with an increasing oxygenconcentration in thesucked landfill gas.

17.7 INTRODUCTIONTOREACTIVATION OF GAS PRODUCTION

In the last century nearly every village in Germany, but not only in Germany, had have their own municipal waste deposit. There was no soil or groundwater protection or a system to suck any gas. With the first "LAGA Merkblatt" from September 1979 began the system with a new type of landfills. This type consists about a base with low permeability, a water and a gas drainage system as well as a surface covering. Concentration on a few great landfills began and a lot of old landfills were abandoned. These old landfills were covered with soil and most of them still exist in this form in the landscape. Unfortunately these landfills still show chemical reactions. They still produce waste water and landfill gas. So they still contaminate the groundwater and their gas productionstill destroysthe vegetation on their surface. Methane and CO_2 still pollute the atmosphere. But most authorities don't accept this problem because these landfills are closed for more than 30 years and therefore they should be inert.

17.8 FIRST STEP TO URBAN MINING"

The former municipal waste deposit Bluecherstrasse is situated in the city of Bochum-Wattenscheid between small companies, houses and fields (Fig. 17.10). The area of the landfill is 130000 m² and the maximum height is about 35 m above ground level. The dump has been mainly filled in the years 1959 to 1983, and then closed. On the surface trees are growing and on the first sight it looks like a normal wood and not like an abandoned waste deposit.

But the trees are only growing until their roots enter layers with toxic gas concentrations. Therefor elder trees on this landfill are dying. This is a first sign that there is still reactive material inside this landfill and that there is still a production of landfill gas in the depth.

Fig. 17.10 a+b Location of municipal waste deposit "Bluecherstrasse" in Bochum, Germany

In February 2013 the company CellerBrunnenbau started to drill the research hole into the old landfill (Fig. 17.11).

Fig. 17.11 Start of the research drill hole on the abandoned landfill

The location of this hole was in the NW of the deposit on top of the hill. The diameter of the hole was 324 mm and the depth 24 m. Each meter a (disturbed) sample was taken (Fig. 12.12).

In this drill hole a gas well was installed. The inner pipe was filtered from the bottom (24 m below ground) to 5 m below ground and has a diameter of 100 mm. In the filter length the hole was filled with gravel, the rest was filled with a suspension of special cement which is also used for geothermal purposes. There was burnable gas inside the landfill which flew out with a rate of 18 m^3 per hour (Fig. 17.13).

Fig. 17.12 a+b Taking samples from the research drilling

Fig.17.13 a+b Filling the drill hole with cement suspension and the flame rom the landfill gas on top of the pipe

To run the sucking test a container with test equipment was installed (Fig. 17.14).

Fig.17.14 a+b Preparing the area for the container with the test equipment and the container with guests from Italy

17.9 RESULTS OF LABORATORY TESTS ON SAMPLES AND OF SUCKING TEST

To get an idea about the amount of organic material in this landfill, the ignition loss from the samples of the drill hole were taken (Tab. 17.2). In a landfill which should be free of organic material after 30 years an average of more than 15% of ignition loss were found.

Table 17.2 Results of ignition losses

Sample no.	Depth [m]	Dried material [g]	Ignitionloss [%]
1	6-7	24,69	16,30
2	7-8	17,69	9,395
3	8-9	18,685	9,65
4	9-10	9,02	34,80
5	10-11	25,695	26,455
6	11-12	14,27	30,655
7	12-13	38,62	13,90
8	13-14	23,17	10,16
9	14-15	30,90	6,76
10	15-16	20,385	11,825
11	16-17	20,805	11,78
12	17-18	53,13	4,085
13	18-19	13,86	20,315
14	19-20	19,855	4,995
15	20-21	21,075	10,70
16	21-22	16,245	19,945
17	22-23	52,01	11,58
18	23-24	16,21	22,37
19	24-25	22,27	38,075
>19	>25	33,355	2,07
			Average 15,791

Figure 17.3 shows in the beginning (Bereich 1) a very high concentration of Methane up to 80 Vol. -%. This gas was produced in the years before. Oversucking the well leads to decrease of methane concentration down to 20vol. -% (Bereich 2). In a longer sucking period (Bereich 3) methane concentration was stable at about 15 vol. -%. This is the production of methane inside a cold landfill (about 15°C). An increasing production of methane is expected with increasing temperatures from 35 up to 40°C.

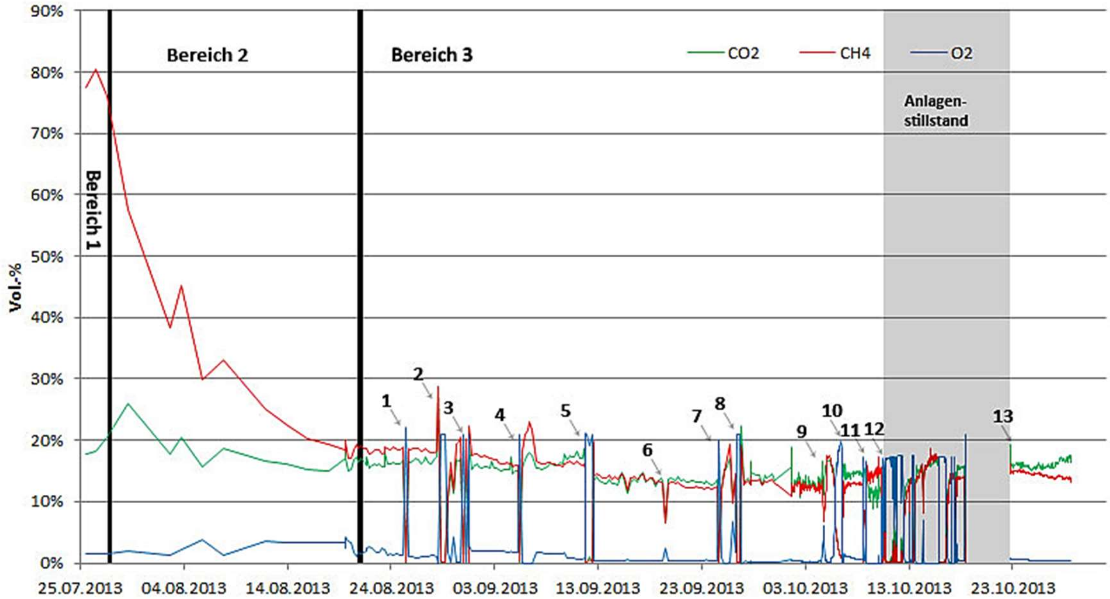

Fig.17.3 Result of sucking test

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PIERWSZY KROK W STRONĘ GÓRNICTWA MIEJSKIEGO. ODNOWA STUDNI ODGAZOWANIA W SKŁADOWISKACH ODPADÓW KOMUNALNYCH. REAKTYWACJA PRODUKCJI GAZU

Streszczenie: W artykule przedstawiono dwa tematy dotyczące studni odgazowania:na składowiskach odpadów komunalnych, które nie dostarczały odpowiedniego dla wykorzystania gazu oraz opuszczonych składowiskach odpadów komunalnych, zamkniętych w latach 80. XX w. Oba rodzaje składowisk stanowią zagrożenie dla środowiska – są źródłem zanieczyszczeń atmosfery, a problemem w obu przypadkach jest brak środków finansowych na przeciwdziałanie tym zagrożeniom. Celem badań zespołu THGA było znalezienie niskonakładowych rozwiązań umożliwiających ograniczenie zanieczyszczeń wokół wspomnianych składowisk odpadów komunalnych.

Słowa kluczowe: opuszczone składowiska odpadów komunalnych, studnie odgazowania, koncentracja gazu

FIRST STEP TO URBAN MINING. RESTORATION OF GAS WELLS IN MUNICIPAL WASTE DEPOSITS AND REACTIVATION OF GAS PRODUCTION

Abstract: There are two themescombined: first, there are gas wells in municipal waste deposits with leakages which don't deliver usable gas anymore and second, there are abandoned municipal waste deposits closed in the 1980's with any sealing neither at bottom nor on top. Both, abandoned municipal waste deposits and waste deposits with leakages in their gas wells, are sources of air pollution and common to both is the lack of money to stop this pollution. The aim of research team of THGA is to find cheap solutions to stop the contamination around municipal waste deposits.
Gas wells in municipal waste deposits normally are filtered from the bottom to the top over their full length. In the top layers the organic waste reacts with oxygen and these parts are inertised in a short time. This will result in leakages between the surface and the well. From that time the well will suck air from the surface but no more gas from deeper layers. Power plants cannot work anymore because of the bad quality of the gas. In a laboratory test the restoration of such wells with a special kind of foam was tested and improved. Later in several wells of Celje municipal waste deposit (Celje, Slovenia) leakages were located in sucking tests. The filter lengths with leakages were foamed and after this restoration gas of higher quality was sucked.
In the last century nearly every village in Germany, but not only there, had have their own municipal waste deposit. There was no soil or groundwater protection or a system to suck any gas. By the first "LAGA Merkblatt – Die geordnete Ablagerung von Abfällen" (a regulation about waste deposits in Germany) from September 1979 a system with a new type of landfills started. This type contains a base of low permeability, water and gas drainage system, as well as surface covering. Concentration on a few great landfills began and a lot of old landfills were abandoned. These old landfills were covered with soil and most of them still exist in this form in the landscape. Unfortunately these landfills still show chemical reactions. They still produce waste water and landfill gas. So they are contaminating the groundwater and their gas production still destroysthe vegetation on their surface. Methane and carbon dioxide are polluting the atmosphere. But most authorities don't accept this problem because these landfills have been closed for more than 30 years, and therefore the landfills are expected to be inert.

Key words: old municipal waste deposit, gas wells, gas concentration

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