MODERN LANDFILL TECHNOLOGY – LANDFILL BEHAVIOR OF MECHANICAL-BIOLOGICAL PRE-TREATED WASTE

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SUMMARY: The mechanical-biological pre-treatment of wastes has far-reaching effects on the construction and operation of landfills. The emplacement and storage behaviour of the mechanical-biological pre-treated waste (MBW) in the landfill will fundamentally different itself in many areas from the experiences which have been gained in the past with the operation of landfills for municipal solid waste (MSW). The change of the structure of the landfilled waste is decisive for a modified settlement and stability behaviour. The aftercare phase of the landfill is distinctly reduced because of the lower emissions compared to untreated wastes. MBW plants and landfill operation must be considered in conjunction as the MBW has a significant influence on the waste to be landfilled which lead to differing consequences for the landfill operation.

1. INTRODUCTION

The goal of mechanical-biological waste (MBW) treatment is the recycling of separated fractions on the one side and the biological stabilisation of the waste on the other side. With the implementation of the German Waste Storage Ordinance (Ordinance about Environmentally Compatible Storage of Waste from Human Settlements; AbfAblV) this aim was reached. By the realisation of the German Waste Storage Ordinance follows that in Germany from June 2005 on only pre-treated wastes are allowed to be dumped in landfills.

In some parts pre-treatment will fundamentally change the physical, biological and chemical properties of the material to be landfilled compared with the wastes which have been landfilled before. The behaviour of wastes during and after emplacement in the landfill is different from the behaviour which has been observed during the last 30 years by landfilling municipal solid wastes.

The composition of the mechanical-biologically pre-treated waste depends on the applied treatment concept as well as the conditioning time of treatment. In this study the waste is first automatically hackled by a cascade mill, sieved and sighted. Second, the waste is supplied to fermenter for a biological intensive treatment. After the drainage of the hydrolysis residual substance the material is rotted in a closed box for eleven days. After this the residual material is emplaced to an open subsequent decomposition for about ten weeks. The emplacement of the biologically stabilized material takes place by a crawler. In accordance to the German Ordinance about Environmentally Compatible Storage of Waste from Human Settlements; the waste

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material is highly compacted by a sheep foot roller.

Goals of the mechanical-biological pre-treatment are:

- Biological stabilization
- Homogenisation (maximum particle size < 34mm)
- Reduction of the water content
- Hygienisation
- Reduction of the gas formation potential
- Weight and volume reduction
- Increase of the deposit and mounting density.

2. MATERIAL AND PARAMETERS

2.1 Properties

The inventory characteristic of the new MBW-landfills has crucially changed compared to a conventional landfill. The landfill gas quantity and composition depend on the biological decomposition processes as well as the chemical-physical procedures within the landfill body.

2.2 Waste material

The emplaced waste materials on the MBW landfill is conform to requirements since October 2002 in accordance with appendix 2 of the AbfAblV. At present approx. 25224 Mg MBW waste (01.Dezember 2006) is emplaced. The maximum height of the deposition is about 6 m. The field mounting density is 1.35 Mg/m³. The optimal mounting water content is with a water content of 39.0% related to the anhydrous mass. The following excerpt from the solid and eluate analysis shows the most important parameters Table 1.

Table 1. Excerpt from the solid and eluate analysis as from 11. January 2005

Parameters	Units	Analysis	Limit value according to AbfAblV
AT4	mg O2/g	2,13	5,0
TOC in solid	%	14,4	< = 18,0
pH-value	-	7,41	5,5-13,0
Electric conductivity	µS/cm	2690	< 50.000
TOC in eluate	Mg/l	120	< 250

2.3 Effect of temperature and water content on the gas formation

Emplacement trials in landfill simulation reactors in the group project „mechanical-biological treatment of wastes which can be deposited“ [SOYEZ et al. 2001] show that the produced mass of gas was substantially larger at 40 degree Celsius than 18 respective 30 degree Celsius. After calculations of DACH 1998 it is to be proceeded in landfills with mechanical-biologically pre-treated wastes from temperatures between 13 degree Celsius and 16 degree Celsius at the surface. In the landfill body is to be due with temperatures between 11 and 27 degree Celsius.

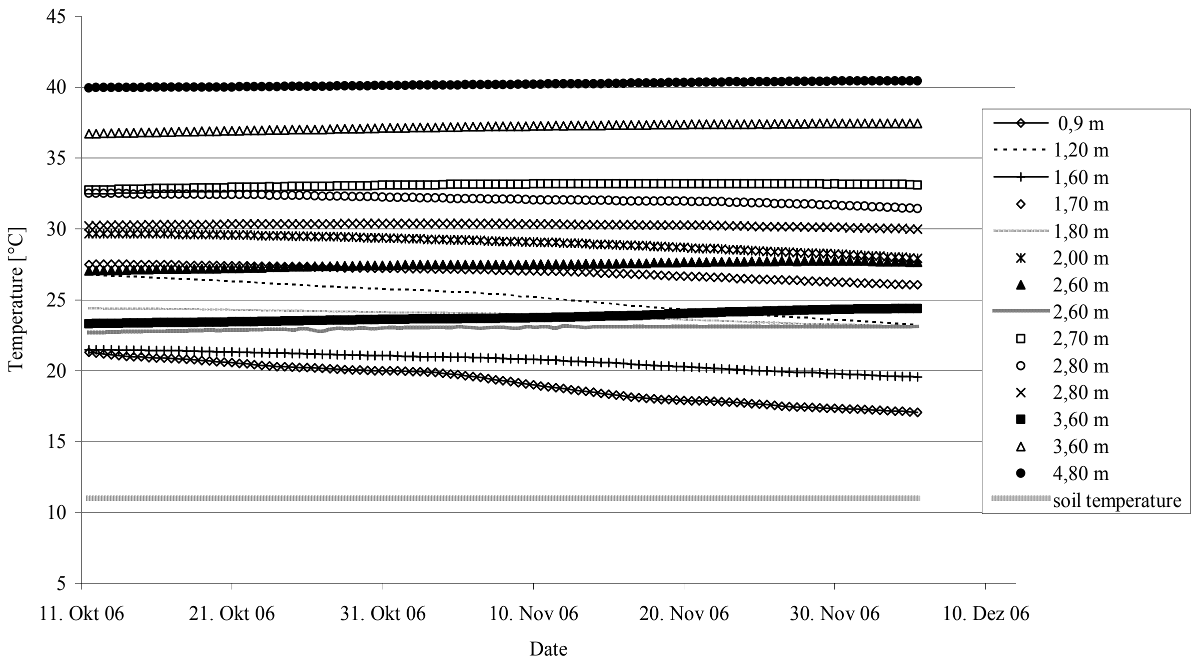

Figure 1. Temperature development in the MBW landfill body

Measurements of HENNCKE 1999 at large lysimeters suggested values under 30 degree Celsius. A damage of the surface and basis sealing systems is not to be feared at these temperatures. All prognoses referred to anaerobic conditions.

Up to date we assume from temperatures below the temperature optimum for an anaerobic biocenosis [SCHEELHAASE 2002]. First analysis at the University of Trier and the University of Applied Science Trier show higher temperatures in the landfill body (Figure 1). In a depth of 0.90 m the temperature varies between 17 and 22 degrees Celsius. However the temperature rises in a depth of 4.80 m to over 40 degrees Celsius. An absolute correlation between temperature and depth is not directly recognizable.

Water content is of crucial importance for the microbial activity in the landfill. It decides on the speed of the decomposition processes. This relationship was proven in research projects DAUBER 1993, SOYEZ 2002 and SCHEELHAASE 2002. The maximum of gas production in the research project of Soyez adjusted by a water content up to 55 to 60%.

The samples taken in the test field in Trier had a maximum water content of 82.73% related to the dry mass. On the average the analysed samples exhibited a water content of 63.28% related to the dry mass. BOCKREIS 2004 showed that the sum of the gas volumes at 40 degrees Celsius and a water content of 35 mass-% are in excess of a factor nine over the water contents of 15 mass-%. There is a clear dependence determined of the formed gas volumes on the measured variables temperature and water content. The parameters temperature and water content show good conditions in the landfill body for the microbial activity.

2.4 Composition of landfill gas

The decomposition processes in the landfill body run in different phases, which are characterized by a change of the gas composition. Figure 2 show the phase change and the different gas compositions of the respective gas phases. In the phases I-III the Landfill gas formation starts. The stable landfill gas formation developed in phase IV. During the phase V a slow decrease of the landfill gas development is to be registered. The pore volume is completely filled with

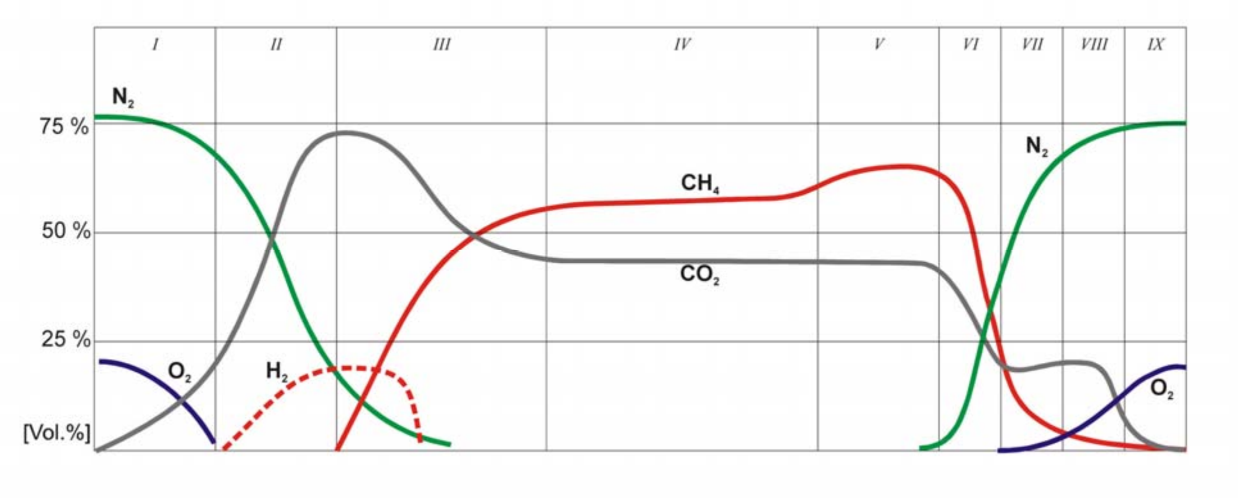

Figure 2. long term model of the landfill gas composition based on Farquhar & Rovers 1973, Franzius 1981 and Rettenberger & Mezger 1992

landfill gas. The phase VI is characterized by a constant decrease of the landfill gas development. Air can penetrate into the landfill body. The landfill body gets more and more aerobic in phase VII. Carbon dioxide is accumulated. The percentage of methane- to carbon dioxide changes. Phase VIII; the landfill body is as far as possible aerob. There is no more methane production. In the pore volume of the landfill body could be slightly increased carbon dioxide concentrations. With phase IX an inertisation took place as far as possible. The gas concentrations in the pore volume correspond to natural rock and/or soil. [RETTENBERGER 2004]

Description of the different gas phases:

I	aerobic phase	V	tong term phase	IX	air phase
II	acid phase	VI	air infiltration phase		
III	instable methane phase	VII	methane oxidation phase		
IV	stable methane phase	VIII	carbon dioxid phase		

Many research projects approve that the mechanical-biological waste treatment confirm a considerable reduction of the landfill gas production. The potential of aerosis can be reduced with biologically pre-treated wastes by approx. 90% [SCHEELHAASE 2002]. Measurements of gas potential by mechanically biologically pre-treated wastes in landfill simulation reactors showed a degassing potential of about 15 to 30 Nl/kg dry mass.

The degassing potential depends crucially on the water content, temperature, water movement, compaction and particle size. The emplacement with high compression could lead to a decrease of the free gas flow in the landfill body. With „the high“ water contents of the MBW landfills it is possible that the entire pore volume is water-satisfied. That will lead to a handicapped unresisted gas flow. Studies of STEGMANN 1987 with harbour mud show a inclusion of small gas quantities. The gas flow can in case of a highly compressed MBW landfill so strongly impair that a release of the gas omitted.

Table 2. Analysis results of the gas samples drawn from gas wells

Sample	Methane – CH_4	Carbon dioxid – CO_2	Oxygen – O_2	Nitrogen – N_2
S1-1	23,8 %	73,2 %	0,2 %	2,8 %
S1-2	21,4 %	75,4 %	0,4 %	2,8 %
S2-1	45,0 %	54,3 %	<0,1 %	0,6 %
S2-2	44,2 %	53,1 %	1,1 %	1,6 %
S3-1	39,1 %	58,0 %	1,1 %	1,7 %
S3-2	39,3 %	59,4 %	0,2 %	1,1 %
S4-1	43,3 %	56,2 %	<0,1 %	0,4 %
S4-2	42,3 %	55,4 %	0,6 %	1,8 %
S5-1	15,7 %	81,6 %	0,7 %	2,0 %
S5-2	18,5 %	80,9 %	<0,1 %	0,5 %

Test results of BOCKREIS 2004 shows that the amount of carbon dioxide in untreated waste was clearly higher than from mechanical-biologically pre-treated wastes. Our research results show different results. In these samples the carbon dioxide proportion from the mechanical biological pr-treated waste is much higher than from untreated waste. The usual percentage from methane to carbon dioxide from untreated wastes of 60:40 % turned around. In the gas well one a relationship of approx. 24:73 adjusts, while in the gas well three a relationship of approx. 40:60 adjusts.

3. PROGNOSE OF LANDFILL GAS FORMATION

3.1 Prognose

In order to be able to provide a gas prognosis, the radioactive half-life for the aerosis must be measured. By means of research projects of SCHEELHAASE 2002 compare to HEYER 1997 the radioactive half-life could be accepted with 3 to 10 years. Longer radioactive half-lives lead to a smaller aerosis. The emission period rises, whereby the gas quantities go down.

The expected gas quantity can be calculated with a landfill gas prognosis by TABASARAN 1976. The landfill gas prognosis was accomplished on the following assumption. The radioactive half-life is appropriate between 3 and 10 years, beginning of landfilling was 2002, landfilling end in 2020, 40% water content, gas potential 25Nl/kg dry mass.

Table 3. Emplaced mass

Year	Mass/Year
2003	6913 Mg
2004	8345 Mg
2005	6966 Mg
2006	3000 Mg
2007	Approx. 8000 Mg

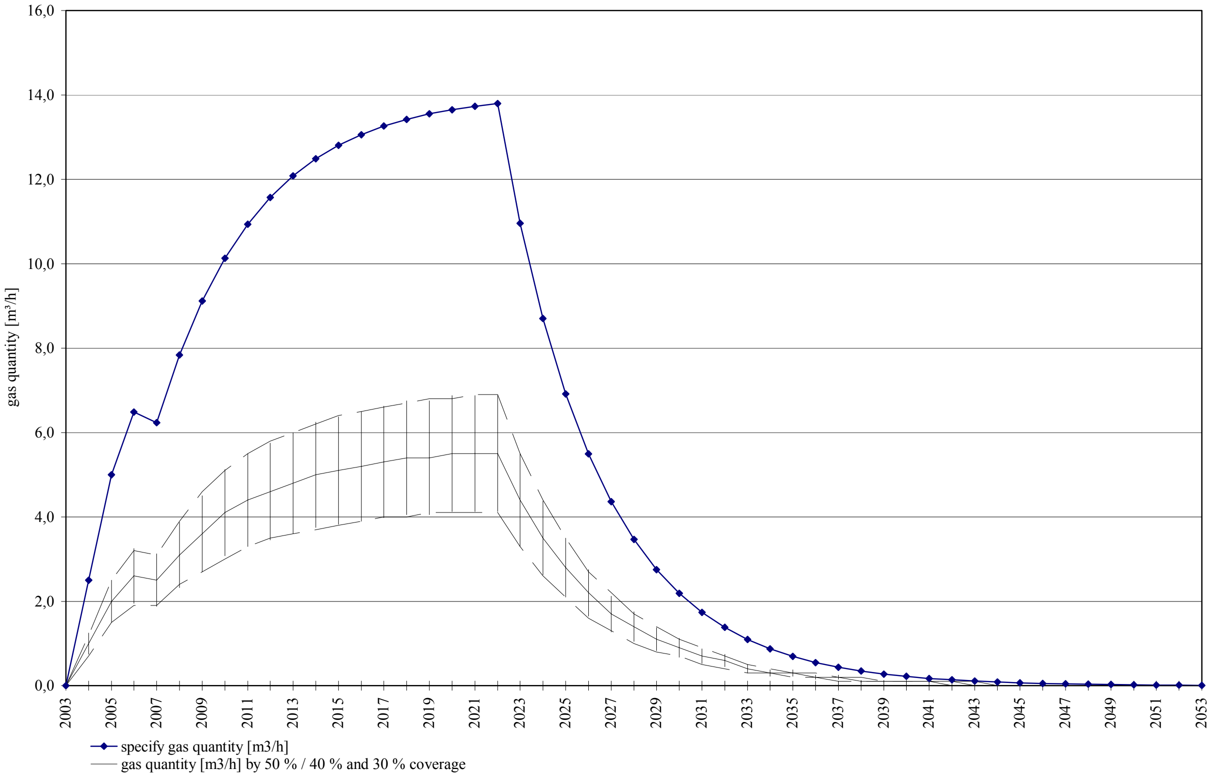

Figure 3. Prognose of gas; begin of deposition 2003, radioactive half-life three years

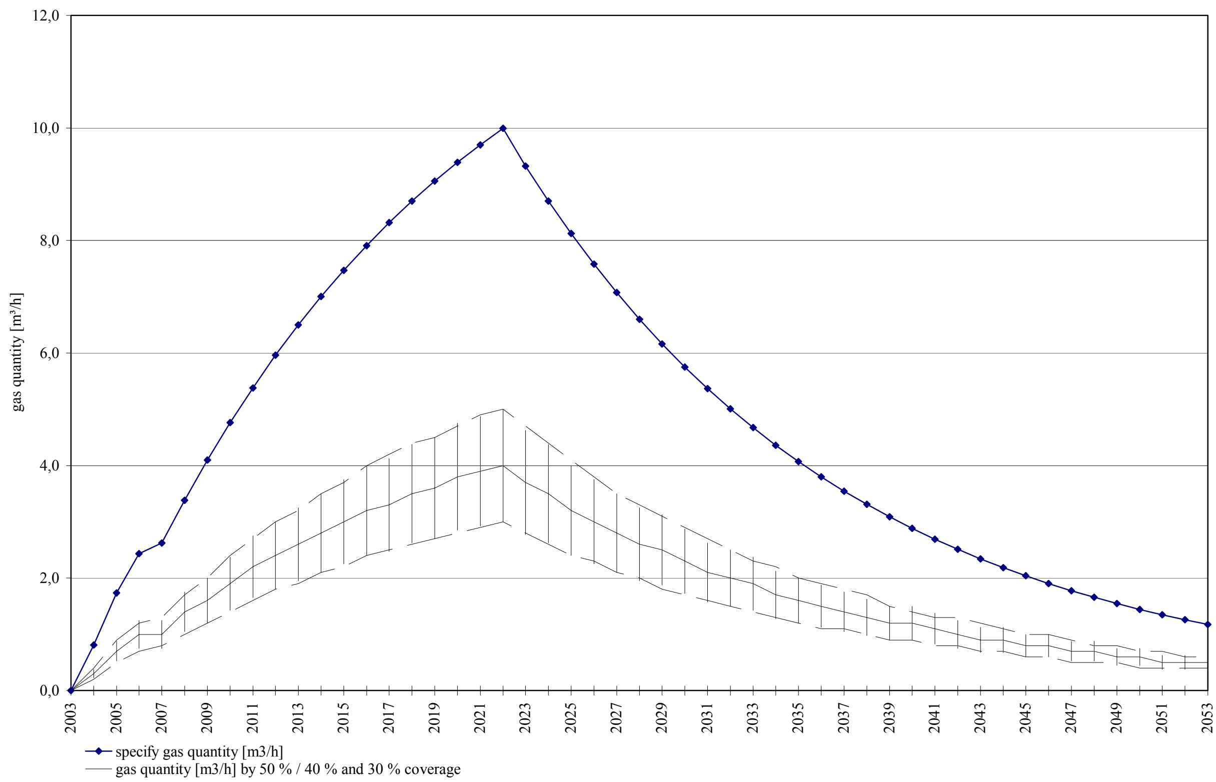

Figure 4. Prognose of gas; begin of deposition 2003, radioactive half-life ten years

In order to be able to evaluate the long-term emissions and the gas potential of MBW landfills, the breathing activity related to the dry mass is well suitable. [HÖRING 1997]

In spite of a smaller radioactive half-life of 3 years a maximum gas formation of 13.8 m³/h will follow from figure 3. The maximum aerosis for a radioactive half-life of 10 years (figure 4) is 10 m³/h. These small gas quantities cannot be captured and used any longer effectively. Therefore passive degassing measures as a methane-oxidation capping system are to be aimed. Such a measure can be converted with the help of the recultivation layer [FIGUEROA 1998].

4. RESULTS AND DISCUSSION

The results of the temperature development in the landfill body show different values from the expected values of DACH 1998 and HENNCKE 1999. The composition of the landfill gas does not correspond to the values which can be expected [SCHEELHAASE 2002] from the stable methane phase. The proportion of carbon dioxide is greater than the methane gas content.

5. CONCLUSIONS

The small quantities of the gas prognose cannot be captured any longer actively. The environmental relevant methane gas can be completely diminished by a methane-oxidation capping system. By applying a methane-oxidation capping system on a mechanical biological pre-treated waste landfill there is no longer a potential for environmental danger.

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