LANDFILL CONCEPT FOR MECHANICAL-BIOLOGICALLY TREATED RESIDUAL WASTE

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SUMMARY: In Germany from the year 2005 landfills may receive only pretreated municipal solid waste (MSW). Besides thermal treatment (MSW-incineration) also mechanical-biological treatment (MBP) (aerobically and/or anaerobically) is allowed where strict regulations have to be met. The MBP-treated MSW of the high calorific value fraction a completely different quality than raw MSW. The pretreated waste can be more compared with soil than with MSW. As a consequence the waste landfilling operation as well as the landfill design has to be rethought and new concepts have to be developed. It is important to investigate these new landfill concepts once they are in operation. In this paper the material properaties are presented and a new MBP landfill concept is developed.

1 INTRODUCTION

Due to the passing of the Directive for Waste Landfilling (Abfall Ablagerungsverordnung) (AbfAblV) (Anonymous, 2000) the landfilling of mechanical-biologically treated residual waste (MBP-residual waste) is now legally regulated in Germany. This procedure will be applied especially where landfill volume according to the Technical Regulation Municipal Solid Waste (TASi) (Bergs et. al. 1993) still is available. Due to the new directive (AbfAblV) also the combined landfilling of thermally and mechanical-biologically treated wastes is now possible.

Only few experiences about construction and operation of landfills receiving MBP-waste are available (Kühle-Weidemeier et. al., 2001), however, the current landfill concepts do not seem to be material adapted according to the author. In the following a landfill concept for mechanical-biologically treated wastes is introduced. It will have to be further developed in co-operation with the landfill owners and adapted to the specific situation. MBP-waste is

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called the remaining fraction after separation from the hight calorific value material (Leikam and Stegmann, 1997).

Operation accompanying investigations are of crucial importance in this context in order to collect practical experiences with this new landfill type and to accomplish further improvements. However, it has to be taken into account that the following proposals do not always comply with legal regulations in Germany.

2 LANDFILLING CHARACTERICTICS OF MBP-WASTE

Due to mechanical-biological pretreatment of the waste the landfilling characteristics and the emission behaviour are significant different from non treated MSW:

- Due to the separation of the fraction rich in calorific value it has low contents in structural material
- The emissions potential of the deposited waste is reduced by appr. 90 % (Leikam and Stegmann, 1997). The gas formation potential is low. According to current knowledge an active gas extraction will not be necessary; however, the residual amounts of gas need to be biologically oxidised before leaving the landfill.
- The MBP material can be landfilled with high density ($\gamma \pm 1{,}5 t/m^3$ wet weight) so that the permeability is low ($kf \pm 10^{-8}$ m/s). As a result there will be low leachate production and a high build-up of surface water.
- The stability of the landfill can be affected by the placement water contents of the waste material and the landfill operation. If for instance the pore gas pressure or/and the pore water pressure is too high landfill stability may be reduced.

Basic target is to keep the landfill aftercare as short as possible so that the landfill will become self-regulatory. A minimum monitoring programme will be necessary also at that stage.

3 REQUESTS FOR A MBP - LANDFILL

3.1 Control of surface water and leachate

As mentioned before due to low permeability of the placed MBP waste the rainwater will infiltrate only to a very low extent and then very slowly. Therefore, the surface water has to be collected and diverted. If possible it should not get in touch with the waste in order to prevent contamination. The Directive for Waste Landfilling (Anonymous 2000) stipulates among other things the following measures: "The MBP-waste placement should be carried out on a restricted area with a slope of < 10 % and as far as possible only in dry weather. Non-operated areas should be covered temporarily."

Due to present experience the following procedure for the minimization of leachate production from a MBP-landfill seems to be appropriate:

- In order to achieve low permeability the waste should be highly compacted in thin layers, i.e. by means of compactor/roller (Maak, 2001) where the operation area should be kept small.
- The placement areas should be covered f. e. with plastic membranes after business hours (see also Stegmann, 1993). In a similar way the areas that are not in operation and not yet recultivated should be intermittently covered.

The planning and operation of a surface water collection system is necessary, whereas 100 % of the precipitation has to be expected as surface run-off. The plastic membranes used for temporary cover should be reused as far as possible after resuming operation of those areas. The dirt underneath the plastic membranes has to be minimised:

- Installation of an alternative surface cover/linersystem consisting of a ≥ 1,5 m soil layer with a high water storing capacity and a capillary barrier which has to be installed with a slope of > 8°. (see Figure 1). It is necessary to collect the surface water as well as water from the capillary barrier and to divert them from the landfill body. This water has to be collected in ditches outside the landfill or if need be temporarily stored in ponds and its quality has to be controlled.

Low amounts of leachate will still be observed (around 2 – 10% of the yearly precipitation rate). The leachate is collected at the base and diverted through the drainage system from the landfill body according to the prescribed combination liner by the TASI (Bergs et al. 1993). The leachate quality will have concentrations approximately according to leachate from MSW-landfills in the methanogenic stage with significant lower concentrations in anorganic nitrogen (about 90 % reduction).

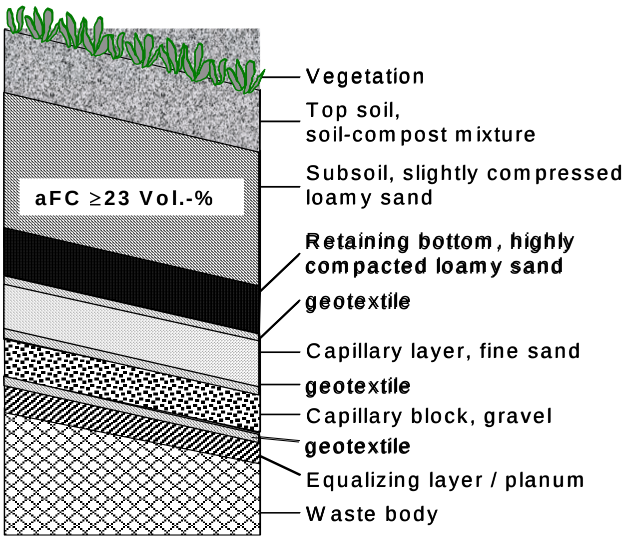

Figure 1 - Structure of the alternative surface sealing, (aFC ⇒ available field capacity)

The water should be treated if possible together with the municipal wastewater in sewage treatment plants or it has to be treated separately. Due to a low content in biological degradable substances of the water, activated carbon absorption and membrane separation processes are suitable for a treatment of those little amounts of leachate in order to achieve the German target values for the discharge of treated leachate. (Anonymous, 1996).

Aerobic conditions should be ensured within the landfill body permanently by means of suitable constructional and operational measures. Should anaerobic conditions restore, a rise in leachate concentrations and methane formation however low has to be expected.

3.2 Control of residual gas, press water and aerob conditions in the MBP-landfill

Over decades still very low gas formation rates are to be expected. The total remaining residual gas potential is about 30 – 40 m^3/ t dry matter MBP- waste.

An active gas extraction is not recommended because of the low amounts of gas production and the low gas permeability of the landfilled MBP-waste. The formed residual gas needs to be able to escape from the landfill body so that the build-up of gas pore pressure is prevented. Experiences gained in the context of the construction and operation of a deposit filled with dredged material from the harbour in Hamburg can be used. Dredged material is a very fine-grained material which also has little kf-values. For the reduction of possible gas and pore water pressure the installation of about 30 cm horizontal sand drainage layers every 1.5 m was proposed (Dührkop, 1984).

A similar procedure could be implemented for the construction and operation of a MBP-landfill. Every 1.5 – 2.0 m intermediate horizontal layers made of porous material should be installed for which coarse-grained bottom ashes from MSW incineration plants could be used. A slope is also necessary for those layers, so that leachate can be collected and drained.

Which achievements will be obtained? Possible press water can escape through the pores and can then be collected and diverted by means of the intermediate layers. The same can be said for gas which is formed within the deposited MBP-material. It is expected that due to the reduction of gas and pore water pressure a reduction of the stability of the landfill body is prevented. Furthermore, the stability of the entire landfill body is augmented due to a significantly higher friction angle of the installed bottom ash components in comparison to the MBP-material. This concept has to be secured resp. modified by means of soil-mechanical examinations. By means of suitable constructional and operational measures the aforementioned intermediate layers should enable also a passiv aeration. Thus semi aerobic conditions in the landfill can be expected. This means that with increasing distance from the intermediate layers anaerobic conditions may occur within the MBP-material for quite a while. The still produced low amounts of gas could be decomposed within these natural aerated intermediate layers. This still needs to be confirmed by suitable investigations. The small amounts of residual gas could also be decomposed within the alternative surface sealing/cover (see Figure 1).

4 NEW CONCEPT FOR A MBP LANDFILL

In order to reach the aforementioned targets a new landfill concept has to be implemented. Such a proposition will be discussed in the following. However, this publication cannot go into more detail. Decisions for developments and implementations have to be made site-specifically and situation-specifically. A concept of a landfill for mechanical-biologically treated wastes is shown in Figure 2.

The landfill consists of a combination bottom liner with drainage layer according to TASi. (Bergs et. al. 1993). The landfill has to be constructed on a geologically suitable subsoil. The treated waste is placed highly compacted in thin layers. Appr. every 1.5 m a 20 – 30 cm strong aeration, stabilisation and drainage layer made from coarse-grained MSW bottom ashes is installed. Mainly completely burnt out, sieved (and if need be washed) bottom ashes with predefined grain sizes should be used. These layers have to be installed with a sufficient cross and rectangular slope. Drainage by the intermediate layers is carried out by means of vertical coarse-grained bottom ash layers into the base drainage where the leachate is escaping. The passive aeration is carried out by open pipes which connect the intermediate layers with the outer air (see Figure 2).

This concept of a landfill for mechanical-biologically treated wastes is an approach for a low in monitoring sustainable landfill. Many securing measures exist: geological barrier, lining according to TASi, placement of mechanical-biologically treated residual waste with a low emission potential, intermediate layers and surface liner. Except for the plastic liner at the

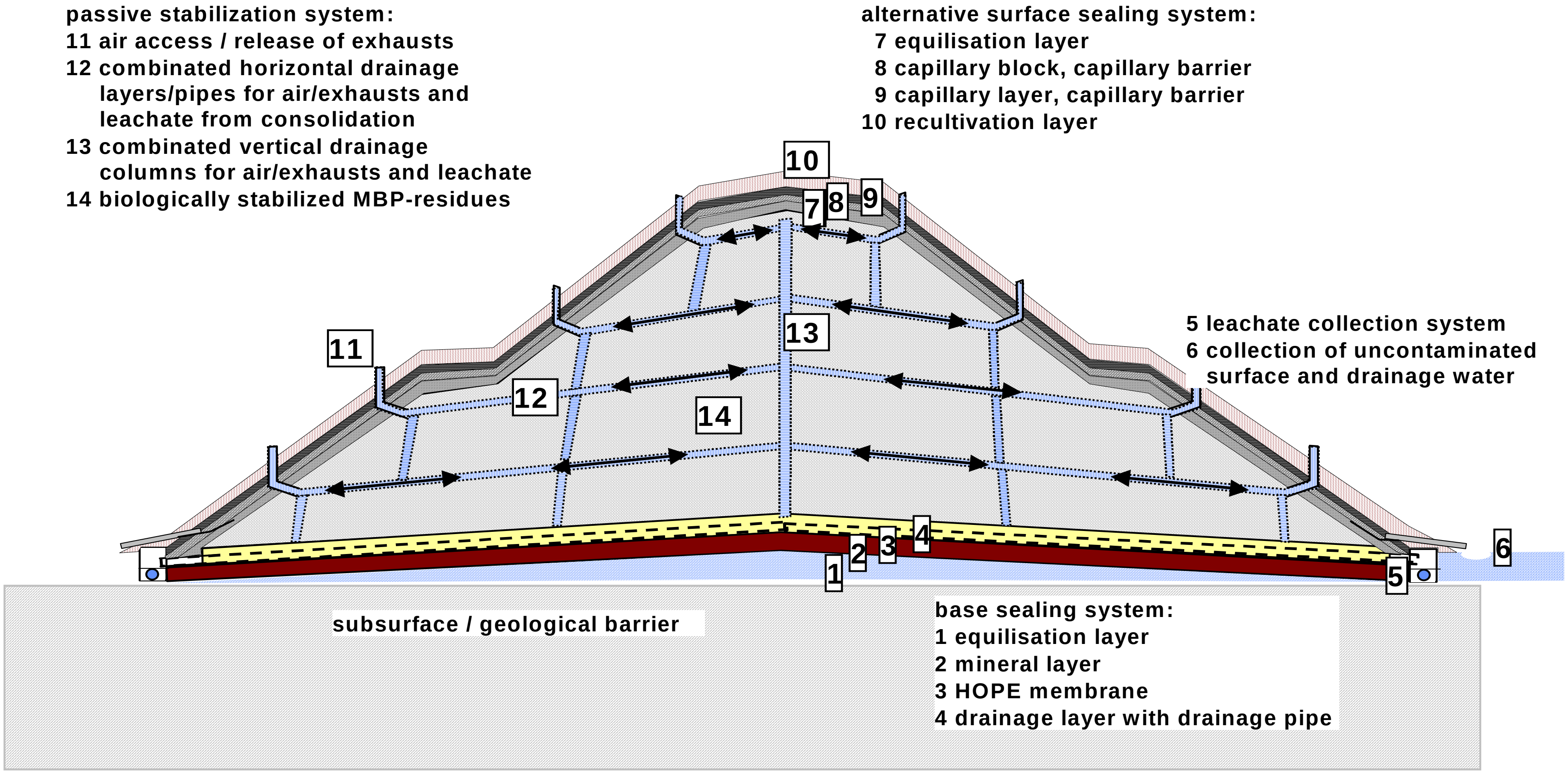

Figure 2 - Concept of a landfill for MBP-residues

base only natural and long-lasting materials are used. Hardly any settlements are to be expected due to the pretreatment and the highly compacted placement of the waste.

5 OPERATION ASPECTS

The placement of MBP-wastes requires a suitable water content which should be at 95% proctor density on the dry part of the proctor curve. This has the purpose to prevent the formation of load-induced pore water excess pressures.

The new concept aims to prevent leachate procuction already during the operation phase. Because of this the waste should be placed – as stipulated in the AbfAblV (Anonymous, 2000) – on areas as small as possible, (approx. 5 % of the deposition area with a slope of < 10 %).

The author proposes to cover the operation areas every day with mobile plastic membranes. The same is applicable for momentarily unused areas. On the event of medium to strong rainfall operation has to be stopped or resumed underneath a movable cover/tent because the MBP-wastes need to be placed at a defined water content.

As mentioned before the collected water on the plastic sheets has to be diverted from the landfill site as quick as possible by means of suitable measures preferable without being contaminated by the waste. Furthermore, the plastic membranes have to be protected against drifts. A possible solution would be to put weight on them by means of used tyres and/or waterfilled pipes. The drainage water has to be collected in reservoirs at the landfill base through ditches.The water can be discharged into natural surface waters if the water quality allows it.

According to Maak, 2001 compactors and rollers proved to be worthwhile for the compaction of MBP-wastes. Maak, 2001 measured a relatively high surface water discharge on the rolled surfaces. The water, however, is being contaminated by the waste and treatment becomes necessary.

6 BALE LANDFILLS

The author has made a proposal for the construction and operation of bale landfills (Stegmann, 1993). This type of landfill is especially suitable for mechanical-biologically treated wastes. The following operational advantages and realisation possibilities can be pointed out:

- Due to the considerable pressure necessary for baling water is pressed out and no elevated load-induced pressure on the bales is to be expected. As a result there are no pore water pressures to be expected when the bales are landfilled
- Bales with relatively even edges and high density can be produced due to the adjustment of an optimum water content and the high rate of fine-grained material. This enables exact placement of the bales.
- The baling process could be integrated in the same building where the mechanical biological treatment takes place.
- The placement of the bales could be carried out also during moderate rainfall if the stored bales would be immediately covered with plastic membranes.
- The space in between the bales could be used for passive aeration which allows at the same time preferential flow residual biogas and probably biologically oxidation of the methane.
- Intermediate layers made of coarse-grained material are probably not necessary

- The landfill equalising layer on the final bale surface on which the surface sealing/cover is placed should be made of a appr. 0.5 – 1.0 m layer of MBP-material put in place in thin layers.

Due to the sometimes not easy placement of the MBP-material and the operational limitations due to rainy weather conditions the operation of bale MBP-landfill is easier. With regard to the residual emissions there should be no significant differences in thin-layer operation (f. e. disposal) to the MBP-bale landfills. The elevated costs of the bale production could be compensated for by savings in the areas of operation, installation of intermediate layers and no or considerable reduction of the MBP-waste interim roofed storage area to bridge bad weather conditions.

7 CONCLUSIONS

A concept for construction and operation of MBP-landfill which takes into consideration the special characteristics of the landfilled material is introduced. Leachate and gas emissions will be reduced and the stability has to be ensured. The aftercare phase should be as short as possible in order to attain the self-regulatory state of the landfill within one generation.

The concept of an MBP-landfill with intermediate layers made of porous MSW bottom ashes allows for the reduction of possible gas and water pore excess pressures as well as for passive aeration and probably residual methane oxidation. The surface cover should-as opposed to the German regulation TASi-be carried out by an alternative surface sealing/coversystem consisting of a capillary barrier and a soil layer with a high water storage capacity and vegetation.

Proposals with regard to construction and operation of MBP-landfills were among others also made by Kühle-Weidemeier et al. (2001) and Scheelhaase (2001). Experiences with aerobic resp. semi-aerobic deposits are made in Japan. However, the placed wastes cannot be compared with MBP-waste but the experience gained in Japan can still be used (Hanashima, 1999).

As an alternative to the above explained MBP-landfill the author introduces the basic concept of an MBP-bale-landfill deposit. Such a deposit type is likely to show advantages.

Construction and operation of MBP-landfills has to be optimised according to current experiences. The here introduced proposals have to be further developed in the frame of definite plans. The functioning of intermediate layers for the reduction of pore water and pore gas excess pressures has to be confirmed on the basis of soil mechanical investigations.

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