Aeration of old landfills as an innovative method of process enhancement and remediation


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1 The emission behavior of landfills and old deposits and the in situ aeration

Due to the biological and chemical-physical processes in landfills, leachate- and landfill gas emissions are produced. These emissions have to be controlled, recorded and treated in a way that they are reduced to environmentally acceptable impacts afterwards.

In the first years and – if need be – decades after the end of a landfill completion, the produced landfill gas can be collected and utilized by means of an active gas collecting system. With a increasing deposition duration the gas production decreases in the advanced methane phase in a way that an economic utilization of landfill gas is no more possible. Nonetheless, a controlled collection and disposal of the remaining gas quantities is to be carried on with respect to environmental protection and the avoidance of dangers. The same goes for the many old deposits which - to a large extent - do not have a controlled gas collection and treatment.

As far as sanitary landfills are concerned, a collection and a treatment of the leachate is necessary over many decades probably. As to old deposits which very often do neither have a bottom sealing nor a leachate collection, there is a permanent risk of a leachate outflow into the underground and thus into the ground water so that securing- or remediation measures could become necessary.

With this background the question arises of how to exert a positive influence on the emission behavior of waste depositions with regard to a cost-saving concerning after-care, securing and controlling.
With a new remediation method - the complete aerobization of the waste body with a low energy demand – an economical possibility for the accelerated stabilization shall be realized on the large scale. The method has been developed in the laboratory of the Waste Management Department of the TU Hamburg-Harburg and was examined in a large-scale preliminary test on a North German old deposit in autumn 1998 with regard to its applicability. The technical practicability of the in situ aeration could be successfully proved in a short-time test and first positive effects on the emission behavior could be stated.

2 General objectives of the in situ aeration and economical potential concerning landfill aftercare

As a considerable decrease of the hazardous potential due to the significant reduction of the emissions is effected by the aerobic stabilization of waste depositions, the following cost-saving potentials can be stated:

- a surface covering brought in line with the landfill body poor in emission can be applied
- lower operation costs concerning the leachate purification or ground water remediation
- lower costs for the maintenance of the surface covering system
- shortening of the aftercare phase by several decades and earlier recultivation

The costs for the aeration measure are compared to the cost-saving potential and it can be stated that on the medium-term and on the long-term a large amount of money can be saved. Thus a repair of a surface sealing which only conserves the emission potential of a waste deposition can be dropped on the long-term for example.

3 Investigations on a laboratory scale regarding the in situ stabilization of waste deriving from old deposits

To show the fundamental effects of the aeration on the emission behavior of deposited waste, results of extensive laboratory investigations shall be presented in the following. Within the frame of the BMBF-joint research project "Landfill Body" a higher amount of laboratory tests (in “landfill simulation reactors” LSR) concerning the accelerated in situ stabilization has already been carried out – apart from investigations into the long-term behavior of waste deposits under predominantly anaerobic conditions – which were aiming at a shortening of the landfill aftercare phase and at a reduction of the aftercare costs.
3.1 The effect of aeration processes on the leachate emissions

The tests on the lab scale concerning the aerobic stabilization of solids from old disposal deposits show that due to the aeration biodegradable organic components are converted faster and that especially the nitrogen concentrations in the leachate, that are shown in Figure 1, can be significantly reduced. It is – above all – the parameter nitrogen which under anaerobic conditions determines costs and duration of the after-care of a landfill.

![Graph: Extrapolation of the TKN-leachate concentrations under strictly anaerobic milieu conditions and the course of the TKN – content in the LSR leachate with aerobic stabilization (Heyer and Stegmann, 1997)](image)

Figure 1 Extrapolation of the TKN-leachate concentrations under strictly anaerobic milieu conditions and the course of the TKN – content in the LSR leachate with aerobic stabilization (Heyer and Stegmann, 1997)

3.2 Effects of aeration processes on the biodegradation processes and on the gas path

Apart from the positive effects on the leachate impact the carbon conversion during the aeration phases is increased in a considerable way.

In Figure 2 where the maximum carbon discharges under aerobic and anaerobic conditions are presented it becomes obvious that the carbon conversion has been multiplied several times by aeration. For the comparison, the carbon charge was extrapolated from the landfill gas production under anaerobic conditions.
4 FUNDAMENTAL CONCEPT OF AERATION

The fundamental principle of the aeration and of the exhausts collection is shown in Figure 3. In dependency on the boundary conditions of a landfill or of the old deposit – especially when there is no bottom sealing - it can be useful resp. necessary not only to stabilize the landfill body to stop the source of the emissions but also to add air to the underground. To realize that a certain portion of air can be introduced into the unsaturated soil zone below the old deposition. In this soil zone biological processes can be stimulated so that a kind of filter layer is realized between landfill body and ground water conductor.

When blowing in compressed air, pollutant-free compressed air can be injected into the landfill body and into the unsaturated soil zone by aeration wells and by additional aeration lances. The exhausts can be collected and treated via the gas collecting system. For the exhaust air treatment biofilters or – if need be – activated carbon filters or autocatalytic methods can be applied.
5 Preliminary tests with regard to the in situ aeration on a north german old deposit

While the influence of the aeration on the emission behavior of waste depositions was shown by means of the laboratory tests, the technical practicability of aeration shall be closely examined on the basis of preliminary tests on a North German old deposit. To give an answer to the question whether a complete aeration for an accelerated stabilization of the old deposit "K" is technically practicable, extensive preliminary tests were carried out in autumn 1998.

5.1 Details concerning the old deposit "K"

The old deposit "K" was originally used as a sandbox. On a surface of 3.2 ha sand to a depth of max. 3 m below the surface was quarried. Table 1 gives a perspective of the old deposit which can be considered to be typical in many respects for a large amount of old deposits.
Table 1. - General details concerning the old deposit "K"

| Operation: | middle of the sixties to 1973: uncontrolled deposition 1973 – October 1987: operation as interim landfill |
| deposited kinds of waste: | Household waste, bulky refuse, household comparable waste, rubble |
| total area: | about 3.2 ha |
| height: | about 8 - 10 m |
| volume: | about 220,000 m³ |
| excavation in the soil: | about 2 - 3 m |
| bottom sealing: | no |
| degasification installation: | no |
| surface sealing/covering: | provisional: sections were covered by topsoil and sewed; a final covering was not installed up till now |

Because of leachate outflows in 1987, a risk assessment has been carried out in 1988. A high hazardous potential due to the old deposit was stated and the following reasons were given:

- ground water-, build-up water- and soil contaminations
- missing interlayer and sealing
- the pollutant potential above the ground water conductor and
- the pollutant discharge via the ground water conductor, i.a. into surface water

5.2 Preliminary tests into the accelerated aerobic stabilization of the old deposit

The objective of the preliminary tests was to examine whether the specific situation of the landfill body allows the technical practicability of an accelerated aerobic stabilization. To assess this, different investigations were carried out like:

- Aeration- and exhaustion tests on the old deposit with different volumetric rates of flow to facilitate the determination of the air flow-low pressure-ratios by means of measurements of the low pressure resp. overpressure and of exhaust air-/landfill gas compositions in the landfill body. Examination of the air diffusion behavior in the landfill body, of different operation modes and of the corresponding energy demand.

To determine the compression ratios and the air movements in the landfill body during the exhaustion and particularly during aeration, 16 gas gauges (GG) were installed at different distances (from 5 to 60 m) and directions from an aeration well (AW). The arrangement of the gas observation gauges and of the aeration well is shown in Figure 4.
5.3 Results of the aeration- and exhaustion tests on the old deposit

The aeration and exhaustion tests on the old deposit show that overpressure resp. low pressure fields can be induced in dependency on the exhausted/supplied air quantity and on the permeability of the underground. With the chosen technical process an even aerobization of the landfill underground could be achieved. It could be seen then that after a few minutes of aeration the pressures reached a quasistationary status. Figure 5 describes the pressure distribution in dependency on the gas gauge distances from the aeration well. Even in a distance of 60 m an influence on the gas balance could be discerned in spite of the low overpressures at the aeration well.
The aeration has been carried out discontinuously in a daily operation of several hours. The measurements of the gas composition during the aeration- and exhaustion tests clearly show that a switch-over of the gas balance to aerobic conditions is possible. Figure 6 shows - as expected - that the decrease of the methane contents is stronger than the decrease of the carbon dioxide contents in the aeration phase. The gas gauge 6 was situated in a distance of approx. 25 m from the aeration well. The change of the ratio in favor of the carbon dioxide content can be put down to a beginning methane oxidation as well as to the carbon dioxide production due to a conversion of the supplied oxygen. Furthermore, first effects on the leachate of the landfill body could be ascertained – such
as a change of the pH value and of the redox conditions. For a complete in situ aeration of the whole landfill body the aeration rates were chosen in a way that the explosion range was passed as fast as possible.

5.4 Further aspects of the technical conversion

When carrying out the aerobic in situ stabilization it has to be taken into consideration - with regard to safety aspects – that the peripheral zones between treatment area and surrounding underground or landfill body are protected by suction lances so that no landfill gas can escape in an uncontrolled way from the treatment area. As methane with concentrations between 5 an 15 vol.-% forms an explosive mixture together with atmospheric oxygen, this has to be taken into account with regard to the technical conversion. To increase the effect of the aerobic in situ stabilization a moistening of landfill areas which are too dry is necessary. The increase of the water content can be carried out by means of the aeration process.

As the in situ stabilization should be carried out over longer periods (about 1 to 1,5 years) the energy requirement of the aeration aggregates has to be taken into consideration as an important cost factor. Figure 7 shows a variant of how the aeration installations on the old deposit "K" could be arranged.

![Figure 7 Aeration installations for the in situ stabilization of the whole old deposit "K"](image-url)
6 Summary of the results of the preliminary tests and the significance for practice

The main results of the preliminary tests can be summed up as follows:

- On the whole, the old deposit "K" which can be considered to be typical for many old deposits and old sites with regard to the landfill behavior and to the boundary conditions is in the advanced stable methane phase as far as the degree of stabilization is concerned.
- Exhaustion- and aeration prove show that the landfill body shows a good gas permeability so that even with low overpressures an even aerobization of the landfill body can be achieved.
- Small economical gas wells allow aeration rates of at least some 100 m$^3$/h. Existing gas collection installations can be integrated in the aeration concept.
- First operation modes regarding the passive aeration confirm the possibility for an aeration with a low energy requirement in the advanced course of remediation.
- The unsaturated soil zone below the landfill body could also be reached by the aeration.

On the whole, the preliminary tests were very successful and they confirm the fundamental assumption that this method is practical in real life.

Compared to conventional processes concerning the securing of landfills and old deposits and the aftercare, significant costs shall be economized by the in situ stabilization. With the large amounts of landfills and old deposits in Europe and elsewhere where there is still need for action, a considerable cost-reduction potential can be stated without having to accept losses regarding environmental protection.

Even if the concept of aeration is simple, the technical conversion on landfills and old deposits is a demanding task. Thus preliminary tests for a backed-up location-specific conceptioning and planning of the aeration measures and of the following surface covering is necessary.

REFERENCES