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LEACHATE TREATMENT AT LANDFILL SITE

The Spillepeng experience

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ABSTRACT

The major environmental problem with landfilling of waste is the production of leachate. The amount of the leachate depends on precipitation, run-off and groundwater impact, whereas the concentration of dissolved solutes in the leachate depends on the waste landfilled.

The appropriate treatment of landfill leachate must be investigated for each plant. In principle, the ultimate environmentally critical factors are the resulting concentrations and the availability of contaminants in an aquifer, a surface water system or a wastewater treatment plant into which the leachate is discharged.

With emphasis on the Swedish waste handling company SYSAV:s landfill Spillepeng, north of Malmö, some examples of leachate treatment systems on-site from some Swedish landfills are given in the text as well as strategies on how to fulfil environmental demands on a cost-effective basis. Biological, chemical and physical treatment methods are exemplified.

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LANDFILL LEACHATE PRODUCTION

Landfilling of excess material is still the most used method of handling waste. Landfills are most commonly categorised on the basis of the *type of waste* accepted for disposal: municipal solid waste landfills (MSW); hazardous waste landfills; industrial waste landfills etc. Different countries have different landfilling regulations. Some EU-member states insist upon complete encapsulation for all hazardous wastes while others allow co-disposal of certain types of hazardous wastes with MSW if the site has an active leachate management.

The major environmental problem with landfilling of waste is how to handle and discharge the generated leachate. The quantity of the leachate depends on precipitation, run-off and groundwater impact, whereas the composition of the leachate depends on the waste landfilled. Other factors that influence the leachate production are water production and consumption resulting from biochemical processes, retention and temporal delay of leachate discharge, initial moisture content of waste, effect of compaction and impermeable barriers. The waste and the leachate change composition with time, both as a result of depletion of various components and of changes in the chemical environment (e.g. redox-potential, pH, concentration of sulphides, ionic strength).

To date managers of landfill sites generally have to conduct an annual water balance in which the parameters precipitation, potential evaporation and leachate amount are considered. But even in humid climates longer periods without rainfall occur, thus reducing the exhaustible water store of the waste surface. In this case, the potential evaporation values exceed the available soil water resources and do not reflect the real evaporation from the landfill surface. The steepness of slopes and high rainfall intensities must bring about considerable runoff quantities, especially when sections of the landfill area are intermediately covered with little or non-permeable layers. This factor is omitted from open landfills and seldom considered for landfills with final cover.

With the use of water balance calculations, the leachate volumes at new and existing landfills can be modelled, predicted and interpreted. Water balance equations are usually satisfactory in order to design the size of disposal facilities. The importance and costs of leachate treatment are such that regular (i.e. annual) re-evaluation of water balances is informativ and hence beneficial. A number of inputs and outputs to the water balance equation may be considered but the most contributing factors are the effective rainfall (rainfall surplus or precipitation excess) and the leachate removed for disposal. The resulting volumes of leachate are reduced by absorption by the wastes, particularly during the operational phase and the run-off and lateral drainage from completed areas with low-permeability top cover.

To minimise infiltration from the precipitation, many landfillls are covered by a low permeability top cover. The presence of moisture and leaching is however generally necessary to reach final storage quality and to minimise leachate production. Dry conditions in a landfill may prolong the period of active leachate management. Leachate recirculation is practised at a significant proportion of landfills in many countries (e.g. 30% of MSW in Denmark). It can be done for the purpose of increasing the flushing rate of solutes from the waste, but it is mainly done to promote more uniform biochemical degradation rates of organic waste and, certainly, as a method to store leachate seasonally.

LANDFILL LEACHATE CATEGORIES

The generated leachate can be treated in many different ways. The most common form of active leachate management in Europe is abstraction and discharge to sewer, usually without pre-treatment. The greatest use of this route is for MSW landfills.

The leachate from the landfill categories existing in Europe has broadly been divided into 5 main types (see Hjelmer et al., 1995):

1. Hazardous waste leachate: Leachate with highly variable concentrations of a wide range of components. Extremely high concentration of e.g. salts, halogenated organics, and trace elements can be seen.
2. Municipal solid waste (MSW) leachate: Leachate with an initial high load of organic matter (COD in the range of 20,000 mg/l and BOD/ COD ratio > 0.5) reduced to a low organic load (COD in the range of 2,000 mg/l and a BOD/COD ratio < 0.25) within a period of 2-10 years. High content of nitrogen (> 1000 mg/l of which more than 90% is Ammonia-N) is expected for more than 50-100 years.
3. Non-hazardous low organic waste leachate: Leachate with a relatively low content of organic matter (COD does not exceed 4,000 mg/l and it has a typical BOD/ COD ratio of < 0.2) and a low content of nitrogen (typically total-N is in the range of 200 mg N/l, but can be in the range of 500 mg N/l). Relatively low levels of trace elements concentrations are observed. This leachate is representative of landfills for mixed non-hazardous industrial and commercial waste.
4. Inorganic waste leachate: Leachate with relatively high initial concentrations of salts (sulphates + chlorides in the range of 15,000 mg/l), a low content of organic matter (typically COD < 1,000 mg/l) and low content of nitrogen (total-N < 100 mg/l). Trace elements concentrations are often negligible. This type or leachate is representative of landfills for inorganic waste (e.g. incineration slag).
5. Inert waste leachate: Leachate with low strength of any component. This type of leachate is representative of inert waste landfills.

The environmental impact of leachate is governed by several important factors, such as the mass flux of contaminants transported out of the landfill with the leachate, the hydrogeological setting and the degree of protection it provides and the background quality and sensitivity of the receiving groundwater or surface water. This means that proper investigations prior a landfill siting, during the construction and management and after the closure is of great importance in order to minimise environmental disturbances.

LANDFILL LEACHATE TREATMENT OPTIONS

There is no rule of thumb stating the correct treatment of landfill leachate nor giving safe predictions of the impact of particular types of leachate. It is not appropriate to recommend a fixed choice of landfill design strategy as the most appropriate for different types of waste. Instead, this must be investigated for each plant. In principle, the environmentally critical factors are the resulting concentrations and the availability of contaminants in an aquifer, a surface water system or a wastewater treatment plant into which the leachate is discharged.

The most widespread active leachate management strategy is to contain and collect the leachate. The major components in such a system is to line the landfill with mineral and/or geotextil liners, drain and collect the leachate in a well developed drainage system, recirculate the leachate and possibly treat it at site prior discharging.

Several contaminants in the leachate may pose a risk to the environment or to a wastewater treatment plant when discharged. Several EU member states already have guidelines or regulations concerning the discharge of potential pollutants, expressed in terms of limit values for leachate composition.

LEACHATE AT THE LANDFILL SPILLEPENG

At SYSAV:s landfill Spillepeng, north of Malmö, Sweden, three different stages, named the old stage, stage I and stage II, with different leachate collection systems has developed during the years of landfilling. A fourth stage is planned at present.

The old stage has a leachate system that is drained via two pumping stations (named P4 and P4b) to municipal wastewater treatment plant Sjölundaverket.

Stage I and stage II is landfilled in pre-sorted cells according to the properties of the landfilled waste: inert coarse material, biologically degradable material and ash- and special material. The leachate can be collected separately from the cells for inert, coarse material (via pumping station P1), from the cells for biologically degradable material (pumping station P2 and P6) and finally from the cells for ash- and special material (pumping station P3 and P7). The latter pumping station is equipped with a finer leachate collection system, which allows SYSAV to treat leachate from five different cells separately.

The only leachate treatment method which, so far, has been enjoined the Spillepeng landfill by the National board of environmental concessions is to lead the leachate to the municipal wastewater treatment plant.

This treatment has been questioned in Sweden during the last years since the wastewater sludge contains valuable soil nutritients (ex.gr. N, P and K) which should be recycled to forest and farming land, whereas the leachate is suspected to contaminate the sludge. During the following 10 years, leachate may gradually be excluded from MWTP and leachate may be treated on site or at site to a great extent.

Depending on type of contaminant in the leachate, different treatment steps may be useful:

Wetland treatment and infiltration of leachate have been introduced at some plants of which Måsalycke in Simrishamn and Skedala in Halmstad have been operating for quite some time. Both plants are at present giving results fulfilling the demands from the environmental authorities, with high reduction in phosphorous and at least 30% reduction in total nitrogen.

Leachate with a high content of BOD can be treated biologically in aerated lagoons or in SBR-reactors. If possible, the leachate can be recirculated to the landfill, which is especially effective when landfill gas is extracted. Micro- and macronutritients can be utilised in wetlands or irrigated forests. If peat is present, the natural adsorption capacity in peat can be used for metal reduction.

A natural evaporation which takes advantage of the potential evaporation during May to September may reduce the leachate with as much as 50-100 mm monthly.

A test with recirculation and aeration of leachate from P4, the old stage at Spillepeng, has been performed since June 1994. A reduction of 25-30% of the COD, as well as reductions in nitrogen and phosphorous has been observed. Due to recirculation of leachate, a higher moisture content in the waste is expected, resulting in a higher landfill gas production and a faster leaching process.

Two different landfills in southern Sweden use sequential batch reactors (SBR-system) for reducing BOD/COD and especially ammonia-nitrogen and phosphorous in the leachate. The landfills are Varberg and Hyllstofta. If the SBR is monitored correctly, it has a high efficiency in reducing BOD (>95%), N (>80%) and P (>90%).

The nitrification and denitrification must proceed at temperatures above 13°C. In order to maintain high denitrification rates, easily degradable organics must be added to the leachate. In Hyllstofta, some 4,2 kg ethanol expressed as COD is dosed to the leachate per kg nitrogen to be denitrificated. The process generates sludge, approximately 3,5 kg sludge/m3 leachate treated.

If SBR would be implemented at Spillepeng, the leachate rich in organics from the biocells could be treated. A treated leachate with <100 mg/l BOD, <400 mg/l COD and <20 mg/l total-N can be anticipated. The overall metal content in the leachate from the biocells can be expected to reduced with 40-60%, due to that metals are chelated by microbes to a great extent.

With the use of chemical precipitation, COD and BOD can be reduced with 50-80% and phosphorous and metals with as much as 95%. The precipitation produces a sludge with a low dry matter-level, which must be upgraded and thickened further. An advantage is that the size of the precipitation step can be kept small, but a disadvantage is that the coagulant chemicals must be dosed continuously.

Tests are at present made on the leachate from the cell for special waste, P7. The leachate is pre-treated with a chemical precipitation prior discharging to the wastewater treatment plant. The precipitation causes >95% of the heavy metals, particularly lead, to precipitate as sludge. The sludge is sedimented, while the treated leachate is decanted off the sedimentation tank. All sludge is collected and transported to SAKAB in Kumla, the Swedish company for hazardous waste.

Specific adsorption via activated carbon, ion exchange and different membrane separation methods can be used for the reduction of metals and low-molecular weight organics.

In her licentiate thesis (1995), Kristina Linde presented a number of reverse osmosis and nanofiltration experiments with leachate from Spillepeng. The high chloride content in the leachate caused a high osmotic pressure and a low treatment capacity with membranes; the permeate quality was generally sufficient and NF had a higher capacity than RO. No membrane treatment system is in production at Spillepeng, but further trials are to be made.

The leachate from the special waste cells may be further treated in a membrane system where not monovalent ions are retained, hence more than half of the total osmotic pressure can be omitted.

The appropriate treatment of landfill leachate must be investigated for each plant. Leachate studies need to be done. Properly designed leachate treatment systems together with measures to reduce the total leachate production will be the solution to some of the leachate treatment challenges at landfills. The optimal choice is a system that is both environmentally sound and cost-effective.

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