ECOLOGICAL TECHNOLOGY AND MANAGEMENT
KALMAR, SWEDEN, September 22-24, 1999

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ENVIRONMENTAL TECHNOLOGY FOR LEACHATE TREATMENT. JOINT PROJECT BETWEEN SWEDEN AND LITHUANIA

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ABSTRACT

There is a need for more efficient treatment methods for purification of leachate from municipal landfills. The leachate can contain toxic compounds that can be harmful to organisms in the surroundings. There have recently been several reports of dead fishes in lakes situated close to landfills. In a joint project named "LAQUA" between Sweden and Lithuania efforts will be taken to find suitable technology for treatment of leachate water from municipal landfills.

KEYWORDS

Treatment methods; leachate water; landfills; waste handling

INTRODUCTION

Recently there have been several reports of problems with dead fishes in Swedish lakes with landfills close by. It is assumed that the problems are caused by toxic leachate water from the landfills. The increasing interest in environmental aspects has led to development of recycling systems for paper and glass. However, since certain materials are difficult to recycle use of landfills is a waste handling system that will be unavoidable in the close future. In addition there are also a great number of closed landfills with a various mix of household waste and industrial waste. In Sweden there are about 300 active landfills, and in addition 4000 closed landfills (Swedish EPA, 1994). Leachate water together with emissions of greenhouse gases (i.e. methane and carbon dioxide) is the major environmental problems connected to landfills. The number of landfills that are of a potential environmental risk is large. With the deposited waste containing everything from municipal household refuse to environmental threatening industrial materials. Differences in the waste means that different landfills might vary from a chemical point of view (Keenan et al., 1984). The way the landfill is constructed and how much water that percolates through the landfill are other important factors for the composition of the leachate water.

https://doi.org/10.15626/Eco-Tech.1999.051

A serious problem due to leachate water from municipal landfills is the toxic effects over long-term from accumulation of organic compounds in the organism. There can also be a acute toxic effect that maybe are of less concern due the low concentrations in the leachate.

Today it is common that leachate from many of the larger landfills are co-treated with municipal waste water treatment plant. In the near future this will probably not be allowed by the authorities. This is because of increasing concern over organic compounds that are difficult for the microorganisms to degrade. This can disturb the biological processes at the municipal treatment plants. Another factor is problems with high content of heavy metals in the sludge produced.

DEGRADATION PROCESSES IN LANDFILLS

The degradation processes of a landfill pass though several phases and this influence the chemical composition of the leachate. The initial first phase is normally short and characterized by aerobic degradation of organic matter. Only small amounts of leachate is produced and the temperature increase. As the degradation continues the oxygen is consumed and the conditions become anaerobic. The anaerobic process consists of two phases, an acidogenic and a methanogenic. In the acidogenic phase first the macromolucules (e.g. polysaccarides and proteins) are hydrolyzed into smaller molecules such as sugars and amino acids. These molecules are then fermented and during the acidogenesis products as fatty acids, alkohols molecular hydrogen and carbon dioxide are produced. The high concentration of fatty acids lowers the pH and this can liberate bound heavy metals since the solubility of metals increase with a decrease in pH. The acids can also form complex with the acids and increase the mobility of the metals. In the methanogenic phase the microflora produces methan. The pH increases in he methanogenic phase. The increase in pH affects lowers the content of metals in leachate due to the decreased solubility. The organic matter is dominated by refractory compounds such as humus like substances.

CHEMICAL COMPOSITION OF LEACHATE

The chemical composition of leachate waters is very complex. Several hundred different compounds have been identified in leachate waters. The composition of leachates in terms of inorganic substances such as metals, phosphorus and ammonium is better known than the composition of organic compounds. This is because the most inorganic substances are relatively easy to analyze. Analyzing the organic substances is often complicated and time-consuming. Thus, the organic content of leachate is in general measured by analyzing such sum-parameters as chemical oxygen demand (COD), biological oxygen demand (BOD) and total organic carbon (TOC). In table 1 the content of different compounds found in leachate water from 26 landfills i Sweden. In the same table 1 the results from analyses of the leachate water from Kristianstad and Siauliai, respectively, are presented.

Table 1 Composition of leachate waters

Parameter	Lechate (median values of samples from 26 landfills[a]		Leachate water from the landfill in Kristianstad	Leachate water from the landfill in Siauliai[b]
	Median	Range		
Conductivity (mS/m)	340 (	50-1400	846	
Cl^- (mg/l)	500	50-1300	1508	4851
pH	7.1	5.2-8.7	7.2	8
BOD (mg/l)	600	90-4200	16	50
COD (mg/l)	800	180-4700	390	690
$KmnO_4$ (mg/l)	500	40-4600		
NH_4^+-N (mg/l)	23	0.2-800	271	1045
NO_3-N (mg/l)	0.6	0.06-8	0.56	
Tot-N (mg/l)	80	8.6-600	307	480
Tot-P (mg/l)	1.1	0.07-6.5	1.42	1.5
Zn (mg/l)	0.6	0.003-6.7	0.053	
Cu (mg/l)	0.05	<0.01-0.84	0.0072	0.6
Ni (mg/l)	0.05	<0.01-3.0	0.013	0.55
Cd (mg/l)	0.005	<0.0005-2.7	<0.0001	
Cr (mg/l)	0.05	<0.01-0.21	0.029	1.7
Pb (mg/l)	0.04	<0.01-0.22	0.011	0.2
Hg (mg/l)	0.0003	<0.0001-0.0033	<0.0001	
Fe (mg/l)	30	0.7-290		8.3
Mn (mg/l)	2.5	<0.05-40		

[a]Meijer, 1980
[b]Siauliai Municipality, 1999

TREATMENT METHODS

Several methods for treatment of leachate have been studied. The processes used have been biological, chemical and physical. There exists some full-scale treatment plants but the number is still very small. Some of the full-scale plants are very complicated involving different stages with combination of microbiological processes and physical and chemical processes. Many of the full-scale plants are relatively simple with only an aerated lagoon. The effects have in most cases been studied by analyzing the inorganic compounds. Welander (1998) has in her work concentrated more on the effects of biological treatment methods on refractory organic compounds. The choice of which treatment methods to use is due to the composition of the leachate water that varies from one landfill to another (RVF, 1996).

Biological methods

The biological methods can be divided into aerobic processes and anaerobic processes. Aerobic methods have an advantage over anaerobic methods in that they can operate in a wide range of temperatures and effectively reduce the content of ammonia. On the other hand, anaerobic methods can reduce the content of heavy metals by precipitation as carbonates or sulfides (Callander and Barford, 1983). The sulfides involved in this process are being formed under anaerobic conditions under reduction of sulfate. Other advantages compared to aerobic

are lower energy consumption since no aeration is needed, and less production of excess sludge. Recycling of leachate back to the landfill is a method that reduces the volume due to evaporation, and decreases the concentration of organic compounds due to anaerobic microbiological processes in the landfill.

Chemical and physical methods

Several methods using chemical and physical processes have been tested. Activated carbon has been used for adsorption of hydrophobic substances such as aromatic compounds. Precipitation is another method used for removal of phosphorus using substances such as aluminum sulfate, ferrous sulfate or lime. Precipitation processes have some effects towards organic compounds as well. Reversed osmosis is a method showing good results reducing COD and organic compounds. The main disadvantage o reversed osmosis is the yield of a concentrate that needs further treatment (RVF, 1996). Other chemical and physical methods is oxidation, ammonia stripping and evaporation.

Other methods

About 50 landfills in Sweden have some kind of leachate treatment. The dominating system among these 50 is some kind of irrigation system (e.g. energy forest). Salix is one type of energy forest that has been used (Hasselgren, 1992). In Lithuania there has been done testing of salix in a pilot plant at the Siauliau landfill (Siauliai Municipality, 1998)). One of the problems with irrigation system is how to take representative samples

THE "LAQUA"-PROJECT

The ongoing project named "LAQUA" started 1 of January 1999. It runs for three years. It is co-financed by EU-SWEDBALTCOP- Baltic Sea Co-operation Program. The Participants from Sweden are Kristianstad Municipality, Kristianstad Waste Management, Kristianstad University and small and medium sized enterprises. From Lithuania participate Siauliai, Municipality, Siauliai University and small and medium sized enterprises.

The aim of project is to find and develop ecologically and financially treatment methods for leachate from waste deposits. During the project pilot-scale treatment plants will be set up one in each country. Development of new analytical and toxic screening methods will be performed by Kristianstad University and the department of Analytical Chemistry, Lund University. Test of treatment methods involving biological treatment, chemical treatment will be performed in Sweden. Other methods such as soil-plant system and treatment with peat will be tested in Lithuania.

Further work in the project

The work in the LAQUA-project will mainly focus on the toxicity of leachate and the content of refractory organic compounds. The further work can be summarized as follows:

- Further development of a screening test for toxicity of leachate (Svensson, 1999)

- Applying analytical methods using GC-MS and LC-MS MS for finding chemical markers for different groups of refractory organic compounds.
- Testing different treatment methods in laboratory scale (pilot scale) in both Sweden and Lithuania.
- Testing treatment methods one at a time or in combination.

REFERENCES

Callander, I.J. and Barfors, J.P. (1983) Precipitation, chelation and the availability of metals as nutrients in anaerobic digestion. Meth Biotec Bioeng. 25:1947-1957.

Hasselgren, K. (1992), "Resursbevarande Lakvattenbehandling Fullskaleförsök" (Resurs saving leachate treatment method – large scale trial). FoU nr 76, Stiftelsen REFORSK (In swedish)

Keenan, J.D., Lee, S.R. and Fungaroli, A.A. (1984) Landfill leachate treament.J. Wat. Poll. Cont. Fed., 56:27-33.

Meijer, J.E. (1980) Lakvattenkaraktäristik före och efter infiltration, Royal Institute of Technology, Stockholm, Sweden. (in Swedish).

Swedish Environmental Protection Agency (1994) Lakvatten från avfallsupplag – Uppsamling och minimering. Report 4385 (in Swedish)

RVF (1996) Lokal lakvattenbehandling- en vägledning för val av behandlingsmetod lakvaten från kommunala avfallsupplag. Svenska Renhållningsverksföreningen(Swedish Waste Management Association), Report 1996:4 (in swedish)

Siauliai Municipality (1998) Landfill leachate influence to the growth of *Salix viminalis* roots and shoots. Siauliai Municipality Laboratory of Environmental Investigations.

Siauliai Municipality (1999) Content of leachate in waste deposit in city landfill of Siauliai. Presented at the Work-shop for "Project LAQUA", 28 April, 1999, University of Kristianstad, Sweden

Svensson, B.-M. (1999) The crustacean *Artemia salina* as testorganism to the detection of acute toxicity of landfill leachate. School of Engineering, Kristanstad University, Sweden(in swedish).

Welander, U. (1998) Characterization and treatment of municipal landfill leachates. PhD thesise Department of Biotechnology, Lund University.