

Evaluation of leachate treatment methods in perspective of the character of specific compounds

Cecilia Öman

Swedish Environmental Research Institute, Box 210 60, 100 31 Stockholm

Background

A large number of hazardous compounds posing an environmental threat have previously been identified in landfill leachates (Öman 1993, Öman et al. 2000 and others). The treatment of landfill leachates may be practised at local treatment plants or at municipal treatment plants. Ahnert and Ehrig (1992) assumed that the amount of metals in the sewage from the municipal treatment plants would increase if landfill leachates were treated together with other types of discharges. This would obviously reduce the value of sewage as fertilisers in agriculture. In addition, the risk of persistent pollutants included in the leachates disturbing microbial processes and an inadequate treatment effect of landfill leachates in municipal treatment plants (not optimised for landfill leachates) was discussed by Ahnert and Ehrig (1992).

A number of operating treatment methods have previously been studied. These may be summarised as; i) biological methods, ii) physical-chemical methods, iii) methods requiring reduced technical support and, iv) combinations of these. The efficiencies of reducing organic pollutants of the methods has often been measured and evaluated using parameters describing the total amount of organic carbon. The parameters include; the biological oxygen demand (BOD), the chemical oxygen demand (COD), the total organic carbon (TOC), the dissolved organic carbon (DOC) and/or the purgeable organic carbon (POC). Parameters describing the total amount of organic carbon however do not always give the most relevant information about the actual environmental risks involved.

Purpose

The purpose of this study was to suggest a method for evaluation of the efficiency of landfill leachate treatment methods in perspective of the character of specific compounds.

Method

Identification of organic compounds in landfill leachates

A methodology for the characterisation of landfill leachates has previously been developed (Öman et al. 2000) and 15 landfill leachates have been characterised (Öman, in manuscript). The results showed that a large number of organic compounds are present in leachates including: volatile halogenated hydrocarbons, benzenes and alkylated benzenes, phenol and alkylated phenols, polycyclic aromatic compounds (PAH), phthalic compounds, chlorobenzenes, chlorophenols, phenoxyacids, chlorinated pesticides, polychlorinated biphenyls (PCB), polychlorinated dibenzo-p-dioxines (PCDD), polychlorinated dibenzofuranes (PCDF) and bromated flame retardants.

The character of specific organic compounds

Emissions of organic compounds from landfills depend on the character of the specific compounds (Öman, in press). Consequently one can assume that also the fate of organic compounds in leachate treatment systems depend on their compound character. Previous results have shown that processes which significantly affect the compounds inside landfills are sorption, dissociation, evaporation and transformation (Öman 1995). These processes could be described by the octanol/water coefficient, K_{ow} , the acid dissociation constants, pK_a , the Henry's law constants, H , and the potential of the compounds to be biologically transformed. The use of a ranking score system was suggested as a tool for interpreting the predicted fate of specific compounds caused by several simultaneous processes (Öman, in press). A good correlation could be found between the measured emissions and the theoretically evaluated fate.

It is proposed that the ranking score system previously used inside a landfill (Table 1) can also be used for leachate treatment methods. Obviously, the scoring values may need to be adjusted in perspective of the different treatment methods.

Table 1. Ranking of the characters of specific organic compounds (adjusted from Öman, in press).

Ranking	Sorption	Evaporation		Anaerobic microbial transformation *	
Score	log K _{OW}	H, Pa m ³ /mole	Description	Rate t _{1/2}	Description
0	<1	< 0.1	not volatile	> 10 years	Persistent
1	1-2	0.1-100		100 days-10 years	Medium degradability
2	2-3	100-1000		1 - 100 days	Good - medium degradability
3	>3	>1000	volatile	< 1 day	Good degradability

* The microbial transformation data may vary significantly due to different experimental conditions.

Transformation stages

One obvious concern is that the leachate character changes with time. In landfills containing organic waste, biological, chemical and physical processes proceed which affect the state of the solid waste, leachate and produced gas (Öman 1991, Öman 1998). Based on earlier literature results an idealised classification of these processes in five sequential transition stages which cover the lifetime of the landfills was made. The transformation of waste, leachate and landfill gas with time have been classified into five transition stages; the initial stage, the oxygen and nitrate reducing stage, the acid anaerobic stage, the methane forming anaerobic stage, and the humic forming stage. The descriptions given refer to only certain volumes of the waste since different parts of real landfills can exist at different stages at the same point in time. The classification of the different transition stages is based on microbial degradation of the organic material in the waste.

Results

Based on previous results the following four-step methodology was suggested for the evaluation of leachate treatment methods.

1. Identify specific organic compounds in the leachate prior to treatment. The sampling, treatment and analysis may be performed according to the previously developed method (Öman et al. 2000).
2. From the compounds present in the leachate, a suitable number of compounds are selected, in order to represent different characters according to Table 1.
3. The chosen compounds are then analysed before and after each treatment step. The results can be evaluated in relation to the total ranking scores.
4. The results are evaluated in relation to the actual transformation stage of the landfill.

References

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