Modelling of the source term for a predominantly inorganic waste landfill using data obtained from laboratory-scale testing, lysimeter studies and pilot scale monitoring.

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Introduction

In landfilling of waste, still a lot of emphasis is placed on isolation. Several isolation technologies, however, are generally not guaranteed for longer than 50 years. The leachate quality of landfills, in particular modern large-scale landfills, is not expected to be harmless beyond that time scale. Therefore, more emphasis has been placed on processes within the landfill in recent years as the mutual interaction of individual wastes determines the long-term quality of the leachate. This understanding is needed for setting proper criteria on wastes to be landfilled. Although current waste acceptance is based on a judgement of the individual wastes delivered for disposal, the quality of individual wastes disposed in a site are not of major relevance, but rather how these wastes mutually interact leading to concentrations in leachate from an entire cell or landfill site as a function of time. The latter is important from the operator's perspective in relation to the necessary aftercare. The key question being: is leachate treatment required in the long-term? And if the answer is yes, what level of leachate treatment would be required, or can measures in waste acceptance and waste treatment be taken prior to landfilling to eliminate the need for leachate treatment after closure?

Goals

Identification of factors controlling leachate quality in mixed waste based on individual waste characterization and waste waste interaction studies. Evaluation of changes in leachate quality with time as a result of interaction and degradation by applying analysis and testing at different scales (laboratory, lysimeter and pilot scale). Modelling the behaviour of mixed waste for prediction of long-term leachate quality. Evaluation of the feasibility of waste segregation by compatibility in separate compartments.

Experimental

In the framework of a Dutch national research project on sustainable landfill, laboratory experiments (percolation test – PrEN 14405, pH dependence test – PrEN 14429), lysimeter studies (1-1,5 m^3) and a 12,000 m^3 pilot demonstration project (filling started April 2000 and completed November 2001) are carried out in conjunction with chemical speciation modelling and release modelling. The waste input to the pilot cell is controlled by more stringent acceptance criteria than currently required by regulation. Samples were taken from all waste streams deposited in the cell for the laboratory testing and for filling three lysimeters with a representative waste mixture.

The studies at field, lysimeter and laboratory scale represent different time scales through the liquid to solid ratio, to which the waste is exposed. By carrying out a pH dependence leaching test on the waste mixture, information on chemical speciation can be derived through geochemical modelling. The role of dissolved organic carbon (DOC) on metal mobilisation is addressed by applying the NICA-Donnan model in ECOSAT (geochemical speciation code). The relative importance of reducing conditions versus DOC mobilisation is addressed.

The time-dependent source term for the predominantly inorganic waste landfill is modelled to provide a prediction of long-term leachate quality. This information can be used as input for contaminant transport modelling in the unsaturated and saturated zone to assess local impact, which forms the basis for management decisions on acceptance of waste and treatment of waste prior to disposal.

Results

From a wide range of parameters analysed in the laboratory, lysimeter and filed scale experiments DOC and Zn are given in figure 1. The left figure shows the pH dependent leaching of the individual wastes, the full representative waste mix, the basic mix representing about 70 % of the total waste mix and the full waste mix with additions of shredder waste and sewage sludge to see the effect of an increased organic matter content. Note that the individual wastes cover a 3 - 5 order of magnitude spread in leached amount (L/S=10). The second figure gives the release (in mg/kg) for the different test scales as a function of L/S (liquid to solid ratio in l/kg) showing the consistency of the data from the different levels of experimenting. The third graph shows the corresponding leachate quality as a function of L/S, which can be related to a time scale using the net infiltration, the height and the density of the waste. Note that the variation in the data to be used for prediction of leachate quality is reduced to an order of magnitude or less. The three graphs are complementary and are used to superimpose speciation/transport modelling. This combined data set then forms the basis to describe the source term for the landfill.

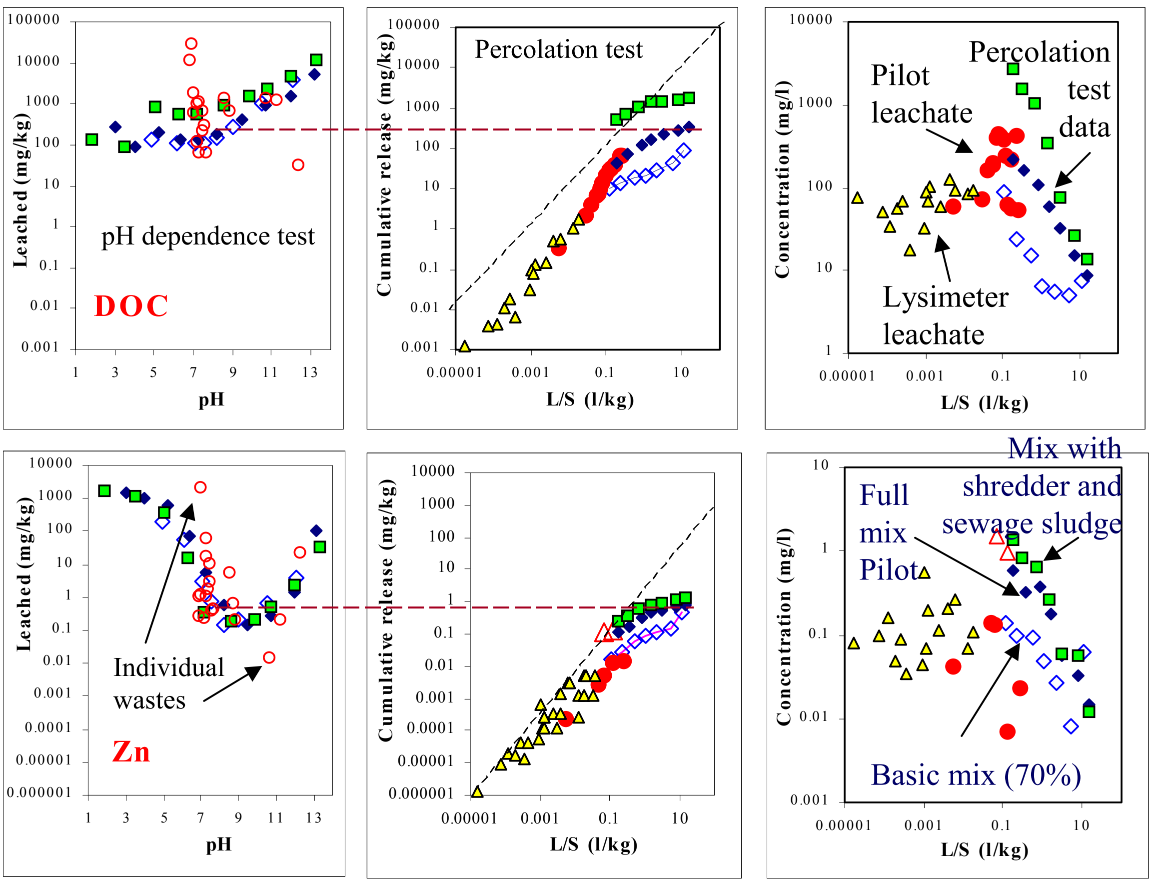

Figure 1. Relationships between pH dependence and percolation test (laboratory) for a mixture of wastes disposed in a 12,000 m3 pilot cell with leachate data from 1.5 m3 lysimeters and the full scale pilot.

Conclusion

The mutual consistency of the data at different scales (not only for DOC and Zn , but for many other parameters) as well as the consistency between the different forms of data representation covering different aspects of the same basic question form a very promising approach to tackle the issue of assessing long-term leachate quality and the means to control it by a new waste acceptance policy. The tolerance of the system to accept a wide variety of wastes is good. Key controlling factors for this predominantly inorganic waste disposal are controls on the individual waste DOC level, mobile inorganic (e.g. Cl, sulfate) and water-soluble organic contaminant (e.g.BTEX, phenols) levels.