

INTEGRATION OF LAB-SCALE TESTING AND PILOT SCALE MONITORING OF A STABILISED WASTE LANDFILL TO REACH SUSTAINABLE LANDFILL

R.P.J.J. Rietra*, H.A. van der Sloot*, A. van Zomeren*, R. Bleijerveld **

* *ECN, Clean Fossil Fuels, P.O. Box 1, 1755 ZG Petten, The Netherlands*

** *VBM, Loswalweg 48,3199 LG, Rotterdam, The Netherlands*

Revisions		
A		
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Made by: R.P.J.J. Rietra	Approved:	ECN-Clean Fossil Fuels
Checked by: Joris Dijkstra	Issued:	

This paper will be submitted for presentation during the 8th International Waste Management and Landfill Symposium to be held from October 1 to 5, 2001, at S. Margherita di Pula (Cagliari) Sardinia, Italy.

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R.P.J.J. RIETRA*, H.A. VAN DER SLOOT*, A. VAN ZOMEREN*, R. BLEIJERVELD **

* *ECN, Clean Fossil Fuels, P.O. Box 1, 1755 ZG Petten, The Netherlands*

** *VBM, Loswalweg 48,3199 LG, Rotterdam, The Netherlands*

SUMMARY: Hazardous waste is stabilised/solidified to reduce the potential for environmental pollution. This paper described the integration of lab-scale testing at different scales, and pilot scale monitoring of stabilised waste in order to reach sustainable landfill conditions.

1. INTRODUCTION

For the treatment of hazardous waste to reduce the environmental impact stabilisation/solidification is applied. Stabilisation/solidification aims at changing the process of release from percolation dominated to a diffusion surface-dissolution dominated regime. Stabilisation/solidification can be operated in various ways, in which recipe development and control of a stable and durable end-product is a main objective. Durable in the framework of stabilisation should be read as a product with minimal deterioration under the considered disposal scenario conditions. In the framework of a national research project on sustainable landfill (Mathlener, 1999), an integrated study is carried out at a landfill site of stabilised waste. In this work laboratory leaching tests are carried out in parallel with laboratory scale simulations of field exposure conditions and actual measurements at a large-scale demonstration of different disposal conditions for stabilised waste.

One of the main objectives of the work is to take up-front measures to reduce potential long-term liabilities and thus to reduce the need for extensive aftercare funds. Key aspects to be addressed are:

- (1) the degree to which carbonation of the predominantly alkaline products leads to beneficial (surface sealing) or detrimental (surface cracking) effects,
- (2) the extent to which alkaline leachate generated can be neutralised by exposure to the atmosphere and thus by natural causes as opposed to treatment with agents,
- (3) a further aspect relates to the hydrodynamic situation in the landfill for stabilised waste.

Very mild infiltration may, due to the hydraulic conductivity of the material, lead to “percolation/permeation” of water rather than only a superficial (surface area related) contact (Francois, 1999). Clearly, a significant difference exists between the two release mechanisms. Management measures are discussed to ensure optimal water management and landfill stability.

The results of laboratory leaching tests carried out in developing recipes and used in the process of quality control are used to evaluate the long term release of contaminants from the stabilised waste landfill, in which also geochemical modelling is applied. These results are also assessed in terms of the required level of aftercare.

2. MATERIALS AND METHODS

2.1 Laboratory leaching tests

Information from laboratory leaching tests was used in the recipe development. The pH dependence leaching test (CEN TC) was used to assess the release parameters and the tank leach test (NEN 3745) was used to assess the level of release. For relative quick assessments an adaptation of the tank leach test is used (compliance leaching test for monolithic materials; CEN TC 292 WG2). This quick procedure was especially useful for quality control.

2.2 Laboratory tracer experiments to assess diffusion in unsaturated conditions

In the laboratory leaching tests the diffusion can be quantified for completely water saturated circumstances. The effect of lower water saturation's on the leaching is assessed by determining the diffusion of Na^{22} -tracer from spiked material to unspiked material.

2.3 Laboratory scale simulations of field exposure conditions

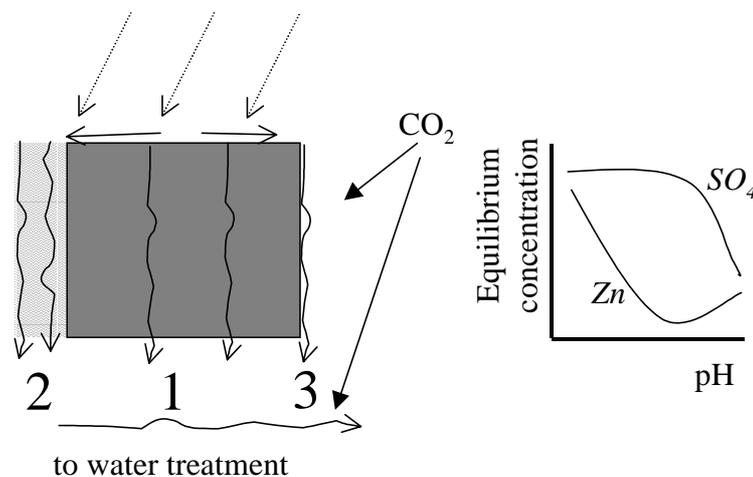


Figure. 1. Effect of pH on different types of percolate: 1. partly saturated pore water, 2. quick percolation along the geotextile, limited contact, 3. run-off. Neutralisation of percolate by CO_2 especially after release and on the route to the water treatment. Schematic representation of the effect of pH on the solubility of sulphate and zink.

The laboratory leaching test enable the assessment of the emission under standardised conditions. In field conditions the emission is different due to other physical conditions (wet/dry) and due to other chemical conditions (CO_2). To test the effect of these different effects in controlled-laboratory conditions a set-up has been developed as shown schematically in Fig. 2. The set-up enable the measurement of the emission from stabilised/solidified material in

fluctuating wet and dry conditions, and under the influence of air, CO₂-free (N₂) or CO₂-enriched air.

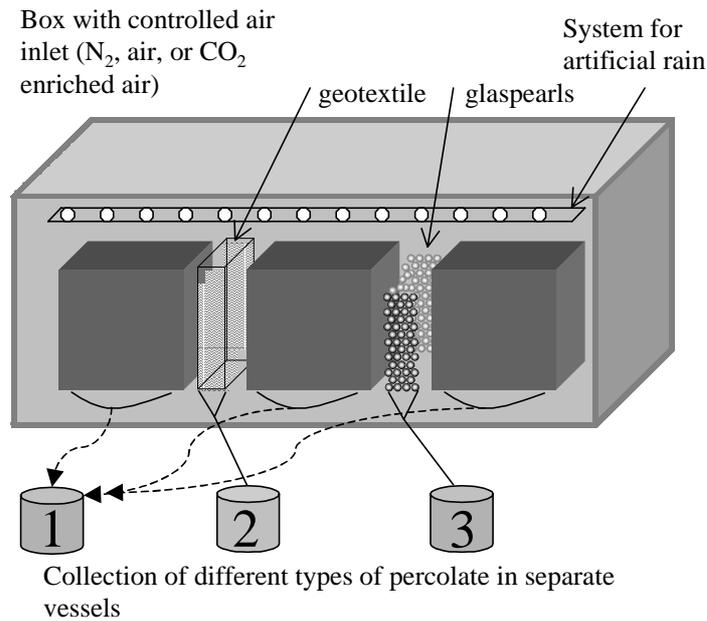


Figure 2. Set-up for testing monolithic materials under various conditions (size of the monoliths: 15 x 20 x30 cm, length of the box 80 cm). Collection of different types of percolate as explained in the text.

2.4 Pilot-scale test

At the site of VBM (Maasvlakte, The Netherlands) a pilot study of stabilised waste is being developed. A cross section of the pilot scale landfill is schematically shown in Fig. 3. The pilot landfill is divided in four sections in which the solidified/immobilised waste is landfilled (here called blocks) and treated in different manners (1 to 3, see Fig. 3). Facilities are being made that enable sampling of the different types of percolate from the sections. For each section three types of percolate are discerned: porewater, percolate and run-off, as will be explained further below. In the experiment porewater is the displaced water which flows through the blocks. The porewater is sampled by having a plastic foil on a slight slope in the sand directly beneath the blocks. The porewater drains via a tube to a vessel where precautions are available to prevent CO₂ poisoning from the air. In the experiment we mean by percolate the water that preferentially flows through the spaces between the blocks. The spaces between the blocks are filled with geotextile. In the experiment we mean by run-off, the water that does not impregnate into the blocks and that flows across the surface of the blocks. The run-off water is sampled from each section via a gutter at the edges below the blocks.

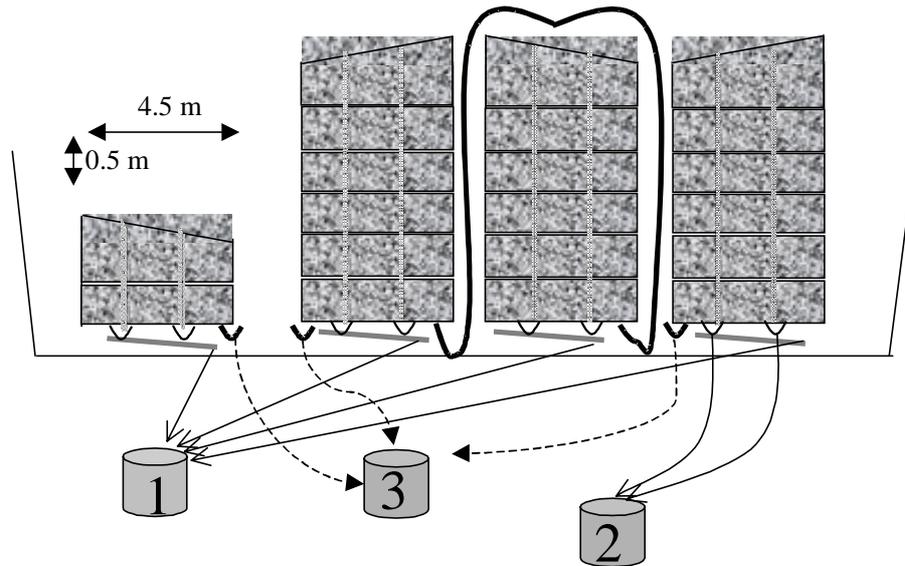


Figure 3. Set-up for pilot scale landfill of stabilised/solidified hazardous waste (size of the monoliths app. 4.5 m with geotextile at each 1.5 m, length of the pilot cell is app. 40 m). 1. porewater that has percolated through the solidified waste 2. percolate that has flowed through the geotextile 3. run-off.

The waste is stabilised in situ in layers of approximately 0.5 m and in the pilot it is separated at intervals of 1.5 m by geotextile foil. The space filled by geotextile foil is part of the sustainable concept for stabilised/solidified material to create preferential flow channels for water instead of extremely large stabilised blocks. This minimises the amount of water that reaches saturation when it percolates through the stabilised waste.

2.5 Modelling

A series of approximations have been formulated previously to assess the impact of stabilised/solidified material on the environment (De Wilde and Aalbers, 1999). This model has been used as a basis to define limits for monolithic materials to be landfilled. The results from the pilot scale landfill are used to test the model assumptions and to improve the prediction of the emission from stabilised/solidified material in the field on the basis of basic leaching tests.

3. RESULTS AND DISCUSSION

3.1 Laboratory tests

Results from tank leaching tests (64 days) and pH dependency tests serve as reference for a certain recipe of stabilised/solidified hazardous waste (see figure 4). The tank test with a short duration and with only limited analysis is used to assess the quality of individual recipes in comparison to the more extended reference tank test which is performed only for a limited amount of recipes, and serves as a tool to control the input in the landfill (Van der Sloot, 1999).

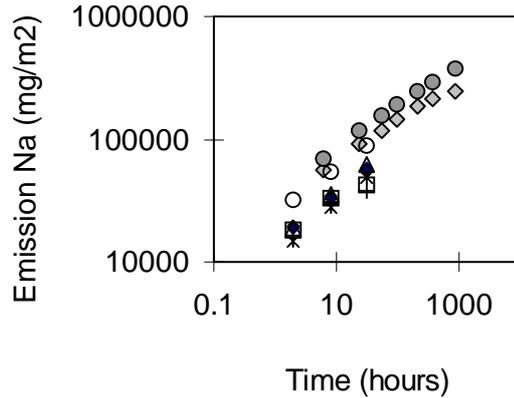


Figure 4. Results from reference diffusion tests and short tests to assess and control the quality of the input in the landfill.

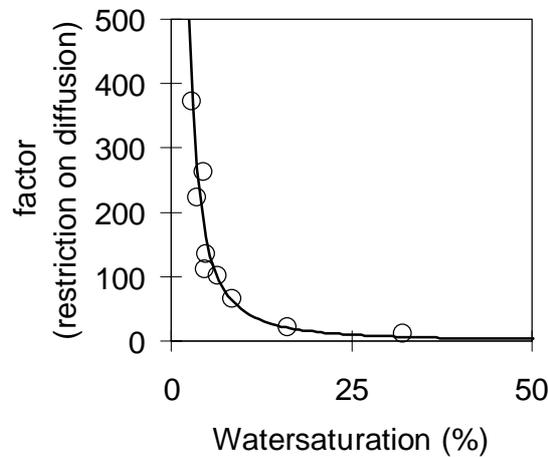


Figure 5. Relation between water saturation for a finally grained matrix and the restriction on diffusion. The results show that under relative dry situation the transport by diffusion is much less compared to water saturated situation.

In Figure 5 the effect is shown of unsaturated circumstances on the transport by diffusion of Na. The experiments were performed for a finally grained material. For a coarse grained material the relation the factor at similar water saturation will be even higher.

3.2 Preliminary results of laboratory scale simulations of field exposure conditions

The preliminary results indicate that in the used laboratory set-up some of the main factors that determine the environmental impact of treated hazardous waste can be quantified. In Figure 6 the emission is shown that has been determined, also showing the contribution of different of percolation and pore water. It shows the potential effect of sealing the solidified material as the contribution of salt in pore water to the total release is high (50%).

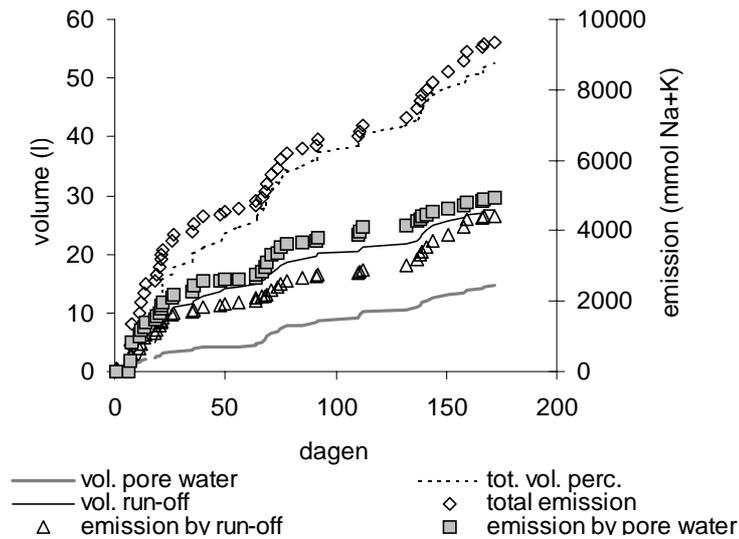


Figure 6. Results from lab-scale experiment (emission of Na+K). During the experiment rain has been simulate for short periods between long periods without rain. The total amount of percolate after the test period is similar to 660 mm within 150 days (without evaporation) which is app. 4 times as high a percolation in field conditions.

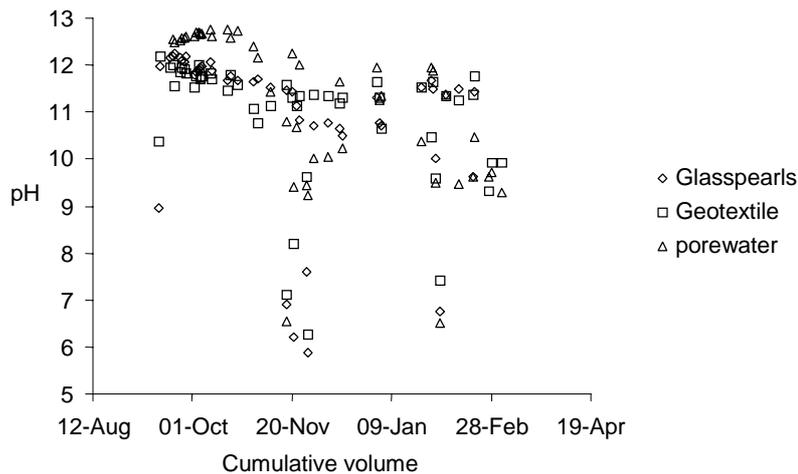
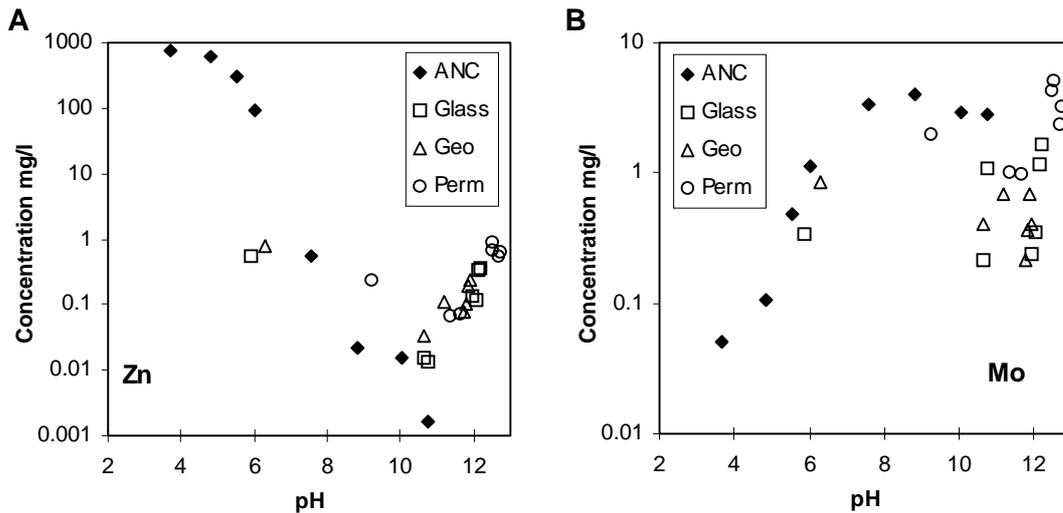


Figure 7. Variation of pH of the percolate. During the experimental period the pH of the percolate is determined by the alkaline binder and CO₂ from the air, during periods with a slow percolation the pH is high while during the periods with a high percolation the pH is determined by the CO₂. During the experiment increased CO₂ levels were applied to speed up the carbonation process.



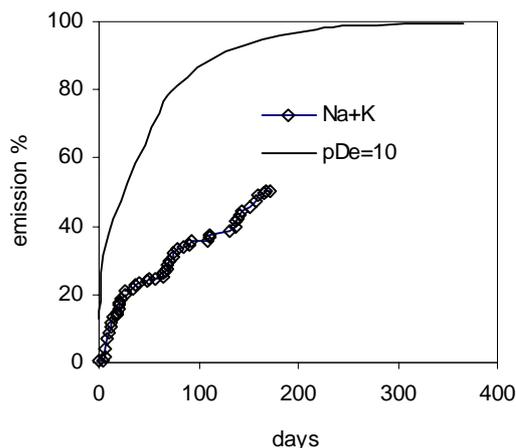


Figure 9. Emission of the sum of Na and K on the basis of EC measurements in the lab-scale experiment (25 °C). The lines drawn give the maximum emission as a function of time (=material in a bath of water) and are extrapolated using a 3D diffusion model from laboratory diffusion tests. The experimental data have been assessed in relative wet conditions (app. 4 time's higher percolation relative to field conditions). It is therefore expected that the emission in field conditions is much lower.

4. CONCLUSIONS

The aim of the concept of sustainable landfilling by solidifying waste is to reduce direct infiltration into the waste and reduce the emission to diffusion. In this manner hazardous waste becomes potentially non-hazardous waste. Preliminary results have been obtained of leaching tests (field, compliance and characterisation tests), lab-scale simulations for field exposure conditions. Together with results from monitoring at the pilot landfill an integration is possible of all the results that can give quantitative information on the influence, and potential influence of different options for treatment of waste and of managing a stabilised waste landfill.

The preliminary results indicate that a low emission from monolithic materials in field conditions, as aimed at, can be simulated in the lab-scale simulation experiment. A low emission of salts is obtained by the partial water saturation of the solidified material and the limited contact with the waste by preferent flow of water through large pores. Percolation of water through the matrix has a large contribution to the emission of salt and potentially this can be decreased by sealing the topside of the solidified material. Chemical equilibria control a range of chemical components and this can be influenced by air (effect of CO₂ on pH).

ACKNOWLEDGEMENTS

The project is financed by VBM as part of the Sustainable Landfill project supported by VVAV.

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