# MODELLING LANDFILL STABILISATION: HYDRAULIC-BIODEGRADATION PROCESSES

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## Introduction

Stabilisation of landfilled waste is dependent on a complex mix of hydraulic, biochemical and mechanical (HBM) processes. At field scale, these processes, and particularly their interdependence, are poorly understood and are usually analysed using highly empirical methods.

This abstract highlights the results of some numerical model tests of a more fundamental approach to the coupled hydraulic-biodegradation (HB) behaviour of landfilled waste. In the model, hydraulic behaviour is governed by unsaturated moisture retention and flow principles; biodegradation is controlled by biochemical and microbial entities such as the concentration of volatile fatty acid and methanogenic biomass, and coupled to the hydraulic model via the moisture regime.

## From interpretation to design

The HB model is based upon a combination of hydraulic and biodegradation phenomena that have been observed both at laboratory and field scale. Currently, model output is indicative only of qualitative performance; it should not be regarded as a fully fledged design tool. However, by revealing (to a largely sceptical audience) the interpretative potential of a more fundamental landfill model, field test programmes could be devised to obtain the type, frequency and duration of landfill data that are necessary to validate theoretical developments.

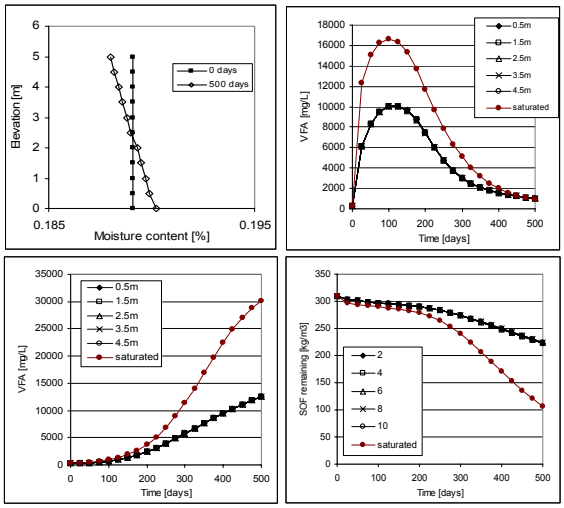
## Potential of HB landfill model

Incorporation of HB components into the landfill stabilisation model reduces the dependence upon highly empirical treatments of decomposition (typically time-dependent) used by conventional geotechnical settlement models. Moreover, implementation of the model via the finite element method, enables various influential factors and operational practices to be investigated. For example: variations in initial moisture content, moisture addition (both raw water and leachate recirculation), seeding with sewage sludge, infilling, and waste compressibility, can all be simulated.

## Trial simulations

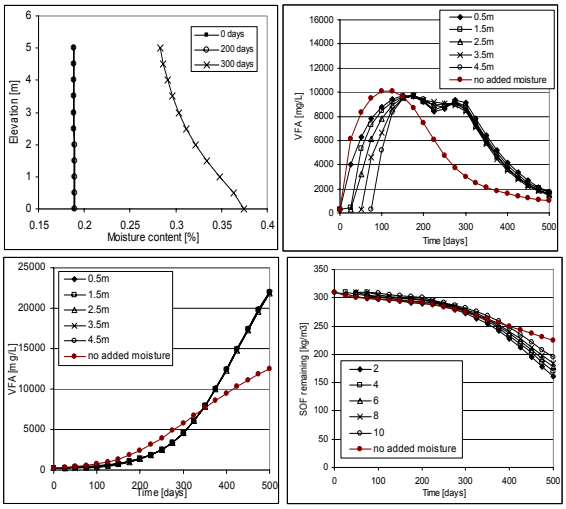
Here, the HB model is used to simulate the effect of various boundary conditions and operational practices upon an idealised waste column. The simulation runs for 500 days and is assessed using moisture content profiles and quality (i.e. volatile fatty acid (VFA) concentration and methanogenic biomass (MB)) time series; solid organic depletion data is also obtained.

**Partially saturated - uniform initial moisture content - no moisture added**




A first general observation is that the simulation reveals a system that is typical of a two stage anaerobic reactor moving from an initial acidogenic phase, when VFA concentrations are high, to a fully established methanogenic phase, as MB accumulates and VFA concentration fall. By comparison with the fully saturated state, VFA, MB and SOF depletion have all been constrained by the lower moisture content. Although the moisture profile shows a redistribution of moisture to the global hydraulic regime, it is a relatively small variation and there is virtually no difference in the evolution of the key variables with column elevation.

**Partially saturated - uniform initial moisture content - infilling (0-100 days) - leachate recirculation - 8.1mm/day from day 201**




There is a marked change of moisture content due to leachate recirculation (which assumes the infiltration has uniformly permeated the waste column). The VFA plot shows the delayed evolution of peak concentrations at selected column elevations due to infilling, and subsequent homogenisation as recirculation occurs. Peak VFA magnitudes are similar to the previous simulation although their decline is a slower process. It is interesting to observe this phenomenon in conjunction with the rate of growth of MB, which appears to show the effect of an increase in moisture content after day 201.

**Some final thoughts**

It is interesting to speculate on the joint evolution of moisture, VFA, MB and SOF in these landfill column simulations. At the very least they provide a focus for the critical assessment of landfill process analysis and, through modern engineering analysis techniques, a means of evaluating waste management options and site practice. Of course such an exercise is dependent on a realistic, but manageable, characterisation of the landfill environment.

**Reference**

McDougall JR & Pyrah IC (2001) Settlement in Landfilled Waste: Extending the geotechnical approach. Proc. Sardinia 2001, Eds Christensen, Cossu & Stegmann, CISA, Cagliari, Vol. 3, pp 481-490