Two-dimensional Modelling of Landfill Gas Migration with a Spreadsheet Add-on

Yao-Tsung Chen and Mark W. Milke*, *Department of Civil and Natural Resources Engineering, University of Canterbury, NEW ZEALAND*

Abstract

The proper assessment of landfill gas migration is important and difficult; unfortunately, there are few software tools available for quick, simple analyses. In many cases, the combined effect of the lack of data and the multiple control options results in the need to consider numerous possible scenarios. As a result, large, complex modelling programs are usually an inappropriate tool. This work updates a spreadsheet-based program (**LfG**) that uses a finite-difference method for a two-dimensional, steady-state analysis. The model allows the user to control gas generation, site heterogeneities, cover or liner use, and the use of trenches or wells. The program is a file written for Microsoft Excel© (Excel for Windows 98™ and later versions) using Visual Basic commands.

A number of researchers have previously developed computer programs to model landfill gas migration. Most models are developed based on the assumption that models developed for groundwater flow can be applied to soil gas, while recognising the limitations that this assumption creates (Massmann, 1989). It assumes that gas transport is affected by neither buoyancy effects (Seely, *et al.*, 1994) nor compressibility effects (Massmann, 1989). The method used in this work is based on the finite-difference approximation of Freeze and Witherspoon (1966). The analysis used is analogous to the 'flow net' analysis familiar to many hydraulic and geotechnical engineers and scientists. Because it is a steady-state model, the user would need to re-run the program under different conditions to evaluate the effect of atmospheric pressure changes, gas production rate changes, or soil moisture changes on gas migration.

The user interface for the program is built around a series of Excel sheets. The user either chooses a gas generation rate or one is estimated based on waste composition and the duration of active decomposition. The user then divides up the cross-section into a series of cells, setting the lengths and thicknesses for each cell. The user specifies the ground surface elevation, the landfill cross-sectional size, and the locations of any covers/liners, trenches, or vents/wells by changing the type of cell used. The user then specifies gas conductivities for the cells composed of soil and the covers/liners. The user can specify heterogeneties in the subsurface gas conductivity. The program solves iteratively for the gas pressures throughout the subsurface. The program iterates towards a solution by changing the landfill pressure until the rate of gas flow out of the landfill equals the desired landfill gas pressure.

A sample simulation is conducted for the cross section of a landfill that is 40 meters wide, 6 meters deep, and buried by 0.5 meters of soil. All soil around the landfill is homogeneous with a gaseous conductivity of 0.08 m/day. Gas production is taken as 1.8 m^3 gas/day/m length. A uniform landfill pressure of 0.51 meters of air provides the desired gas flow rate out

* Corresponding Author: Mark W. Milke, Department of Civil and Natural Resources Engineering, University of Canterbury, Private Bag 4800, Christchurch, New Zealand, mark.milke@canterbury.ac.nz, Tel: 64-3-3642-248.

of the landfill. In this case, most landfill gas is flowing through the soil into the atmosphere. This base case is demonstrated in the Figure as "no cover".

Consider that an improved cover material is desired at the site in order to limit leachate formation, and you have been asked to consider the possible implications for gas migration. To evaluate this, the gaseous conductivity of the cells above the landfill can be changed to a less permeable 0.0008 meters/day. In this case, the landfill gas has more resistance, and so greater pressure in the landfill would develop. This additional pressure would force more flow of gas outside of the liner. This case is demonstrated in the Figure as "with cover". The placement of cover would imply more gas flow laterally off-site, perhaps creating additional problems. The user could continue the analysis by examining the effect of trenches or vents for the gas along its perimeter.

The **LfG** model has been developed to assist practitioners in landfill gas assessments; however, it has severe limitations that should be highlighted.
The finite-difference method used works well except when thin layers with highly variable gas conductivity are used. In particular, the model would poorly model gas migration through thin geo-membrane liners.

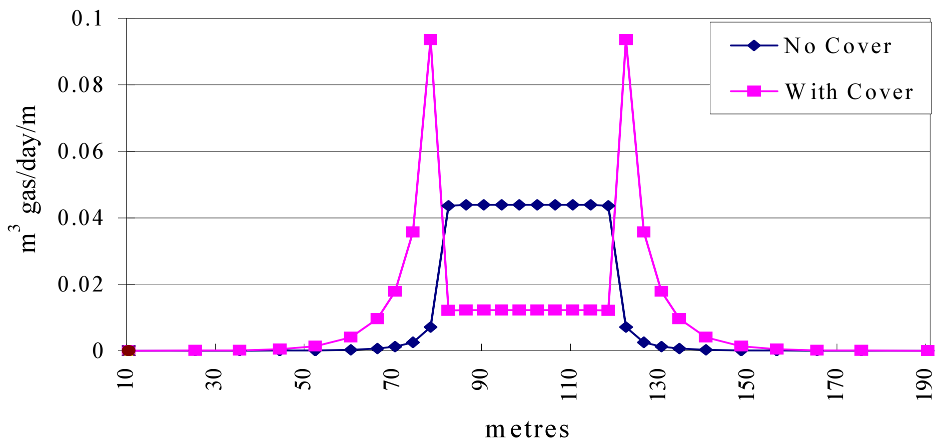

Figure. Simulated gas flow rates (m^3 of gas/day/meter of landfill length) out of the land surface for the base case (no cover) and for a simulated, less permeable cover.

References

Freeze R A and Witherspoon P A (1966) Theoretical analysis of regional groundwater flow: 1. Analytical and numerical solutions to the mathematical model. *Water Resources Research*, **2**, 641-656.

Massmann J W (1989) Applying groundwater flow models in vapor extraction system design. *J. Environmental Engineering*, **115**, 129-149.

Seely G E, Falta R W, and Hunt J R (1994) Buoyant advection of gases in unsaturated soil. *J. Environmental Engineering*, **120**, 1230-1247.