

One-dimensional coupled model for landfill gas and water transport in layered unsaturated soil cover systems

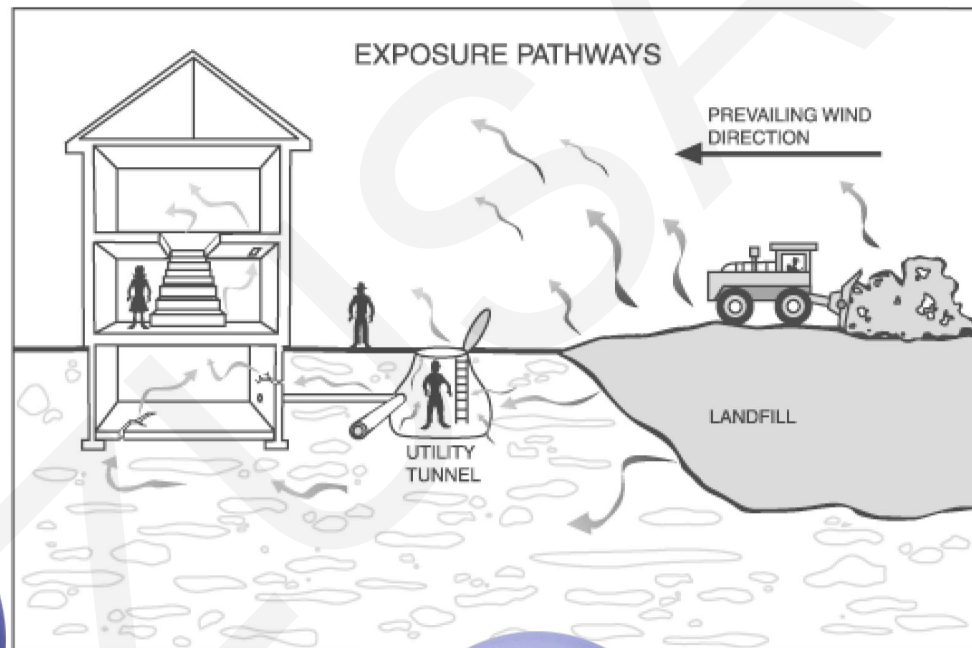
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Key words: Landfill gas, Cover systems, Unsaturated soils, Gas-water transport, Coupled model

Introduction

Unsaturated
landfill cover

Coupled
model
study



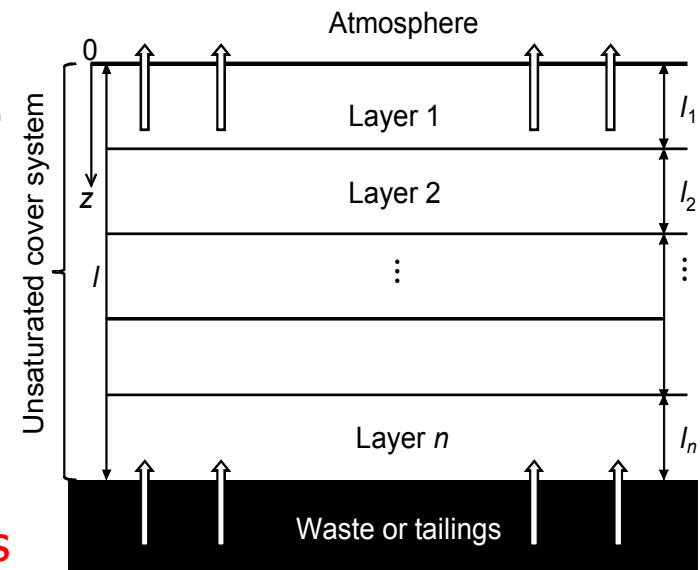
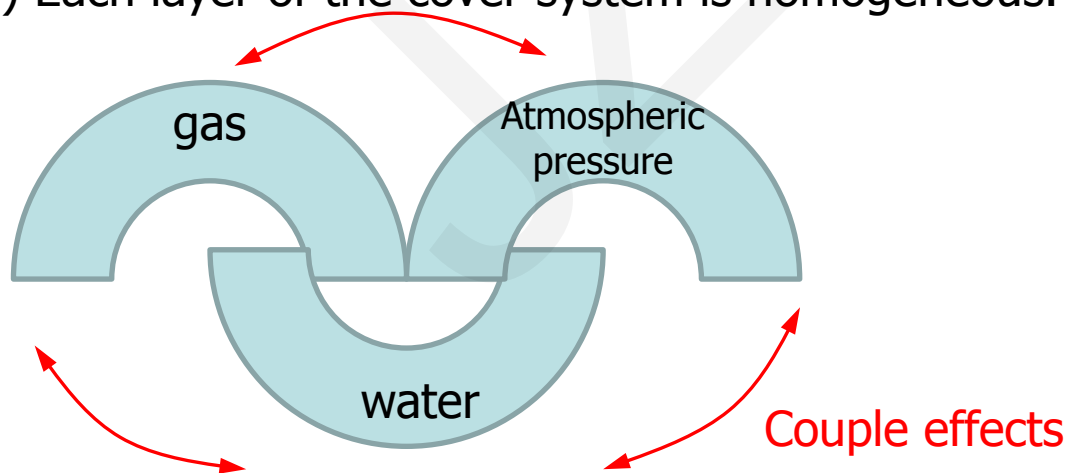
atmospheric
pressure

Gas and
water
migration

Mathematical model

Basic assumptions:

- (1) Gas transport is a 1D problem;
- (2) Gas diffusion can be described by Fick's second law;
- (3) gas adsorption and are not considered;
- (4) gas dissolution volatilization are ignored;
- (5) Gas flow is assumed to be isothermal, incompressible and driven by barometric pressure fluctuations;
- (6) Each layer of the cover system is homogeneous.

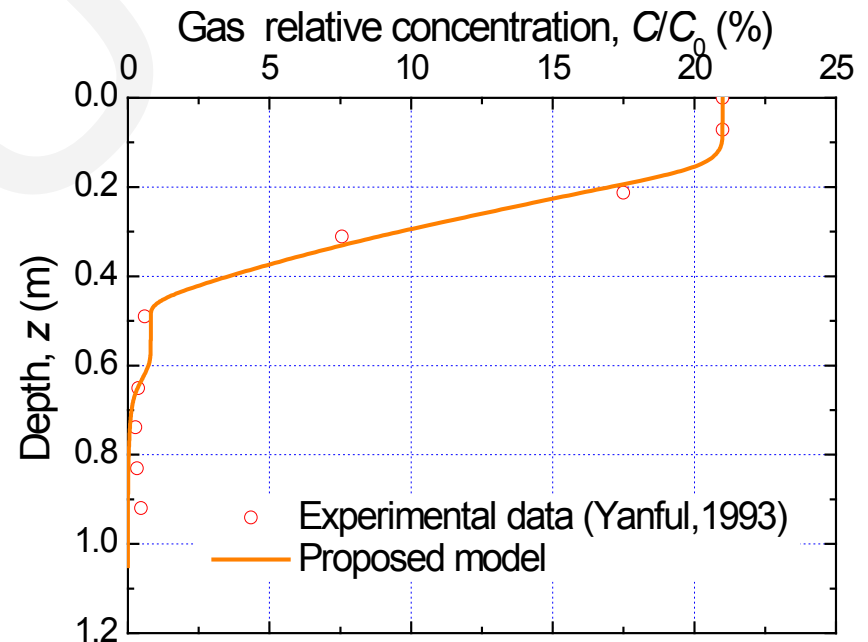
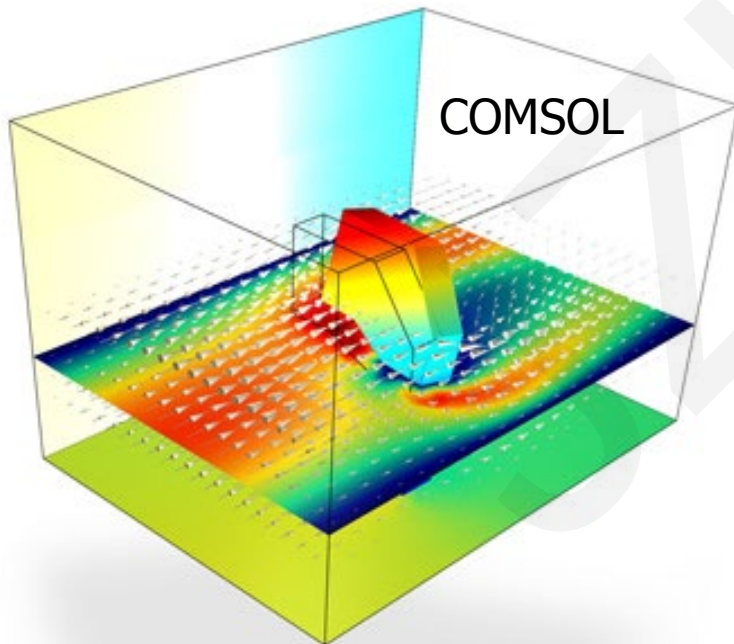


Governing Equations

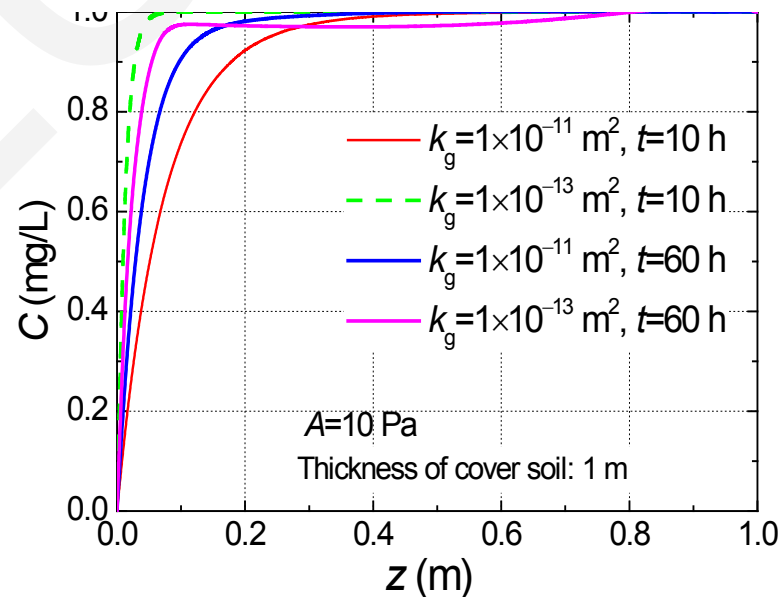
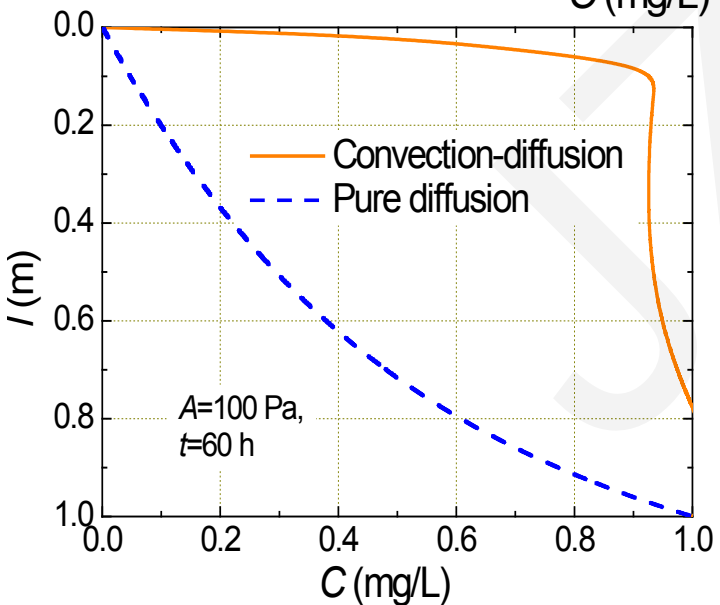
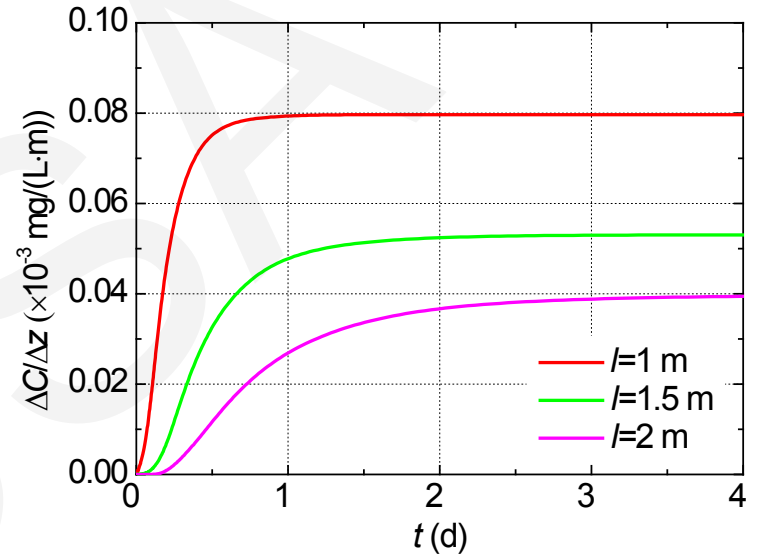
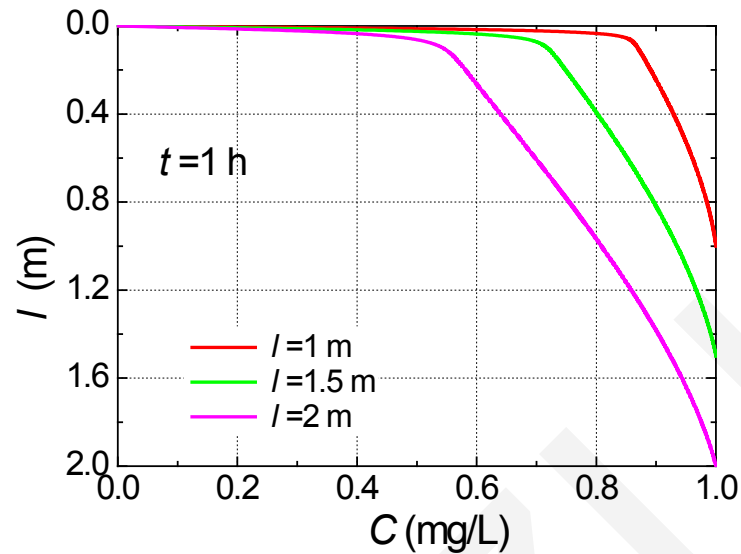
water content migration:
$$\frac{\partial \theta_i}{\partial t} = D_{m,i}(\theta) \frac{\partial^2 \theta_i}{\partial z^2} - \alpha_i D_{m,i}(\theta) \frac{\partial \theta_i}{\partial z},$$

convection-diffusion transport of gas:
$$\theta_{g,i} \frac{\partial C_i}{\partial t} = D_{e,i} \frac{\partial^2 C_i}{\partial z^2} - \frac{\partial (v_{g,i} C_i)}{\partial z} + M_i,$$

Coupled effect of pressure:
$$v_{g,i} = -\frac{k_{g,i}}{\mu_{g,i}} \frac{\partial p_i}{\partial z}, \quad P = P_0 + A \times 369 \sin \left[\frac{\pi \times (669 + t)}{175027} \right],$$



Results and Discussion: Case studies



Conclusions

- ✓ The difference in soil gas concentration can reach up to 31% when the thickness of the landfill cover increases from 1 m to 2 m.

- ✓ Effect of atmospheric pressure on the performance assessment of landfill cover systems should be considered when pressure fluctuations are large.

- ✓ The influence of gas permeability coefficients on gas migration is more significant in the initial stages of landfill gas migration (e.g., <math><10\text{ h}</math>) for the same gas permeability coefficient .

- ✓ The gas concentration increases by only 3% when gas permeability doubles for a relatively long period of gas migration under the given conditions.

