Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

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

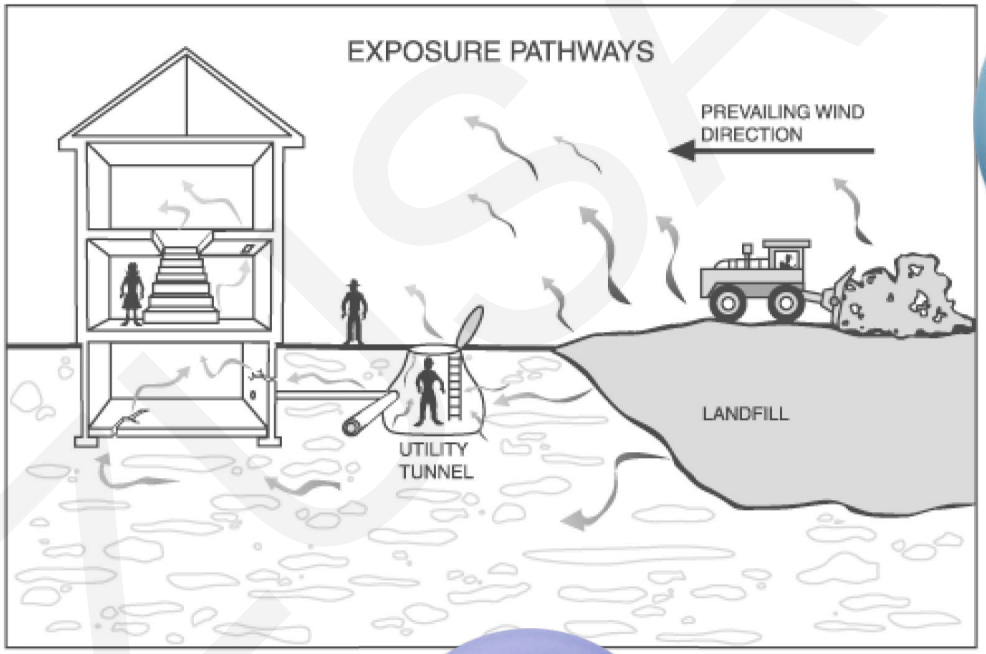
Cite this as: Chi GUAN, Hai-jian XIE, Zhan-hong QIU, Yun-min CHEN, Pei-xiong CHEN, 2016. One-dimensional coupled model for landfill gas and water transport in layered unsaturated soil cover systems. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 17(8):667-676. http://dx.doi.org/10.1631/jzus.A1500073

JZUSA

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

Introduction

Unsaturated landfill cover



Coupled model study

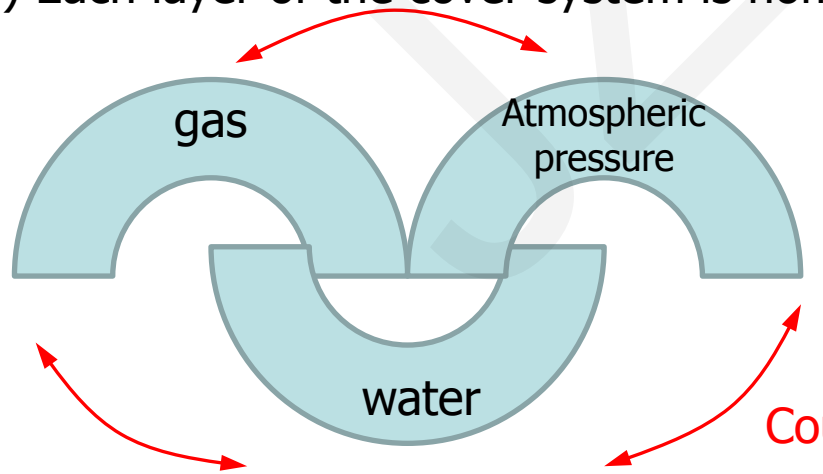
atmospheric pressure

Gas and water migration

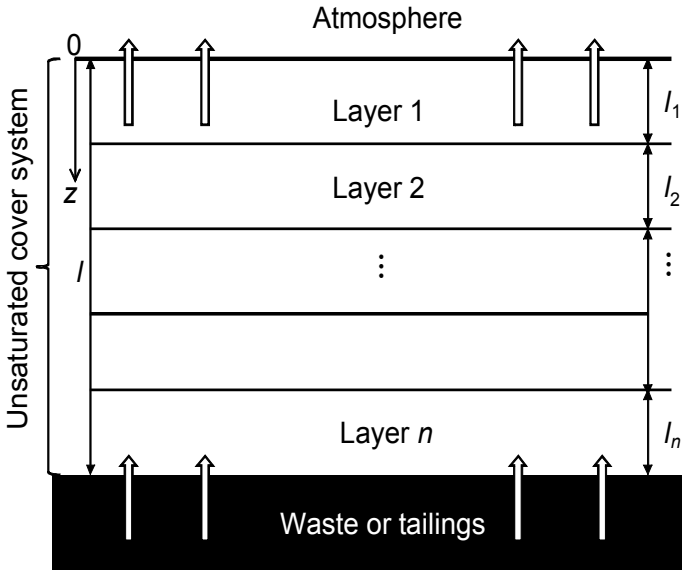
Mathematical model

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.



Couple effects

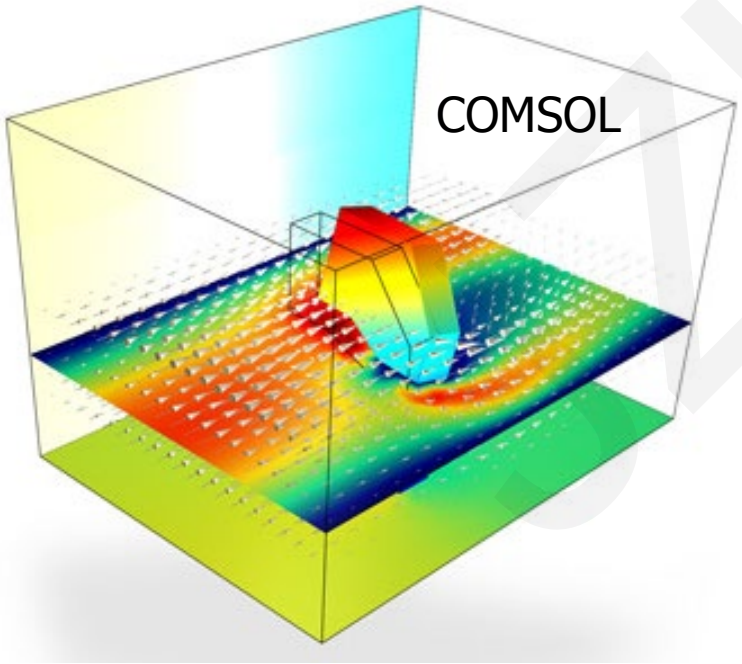


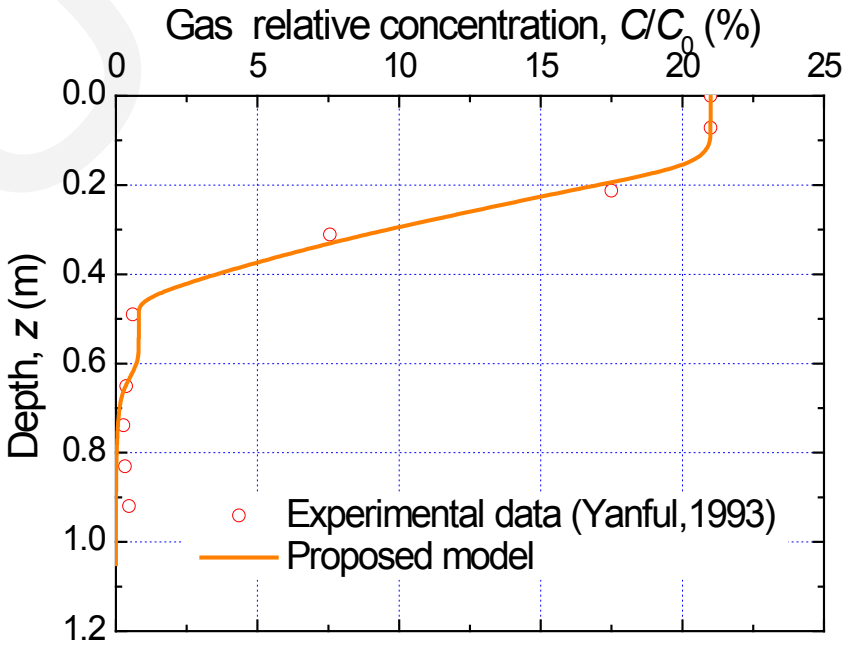
Governing Equations

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

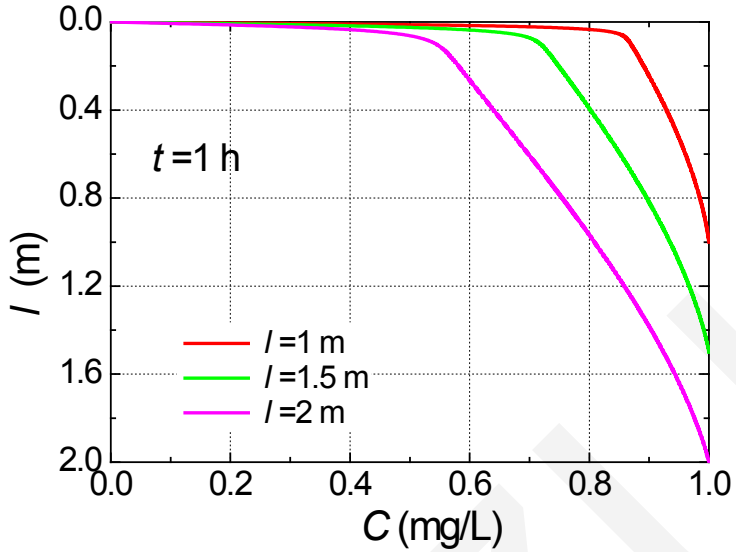
convection-diffusion transport of gas: $$\theta_{\mathrm{g},i}\frac{\partial C_i}{\partial t} = D_{\mathrm{e},i}\frac{\partial^2 C_i}{\partial z^2} - \frac{\partial (v_{\mathrm{g},i} C_i)}{\partial z} + M_i,$$

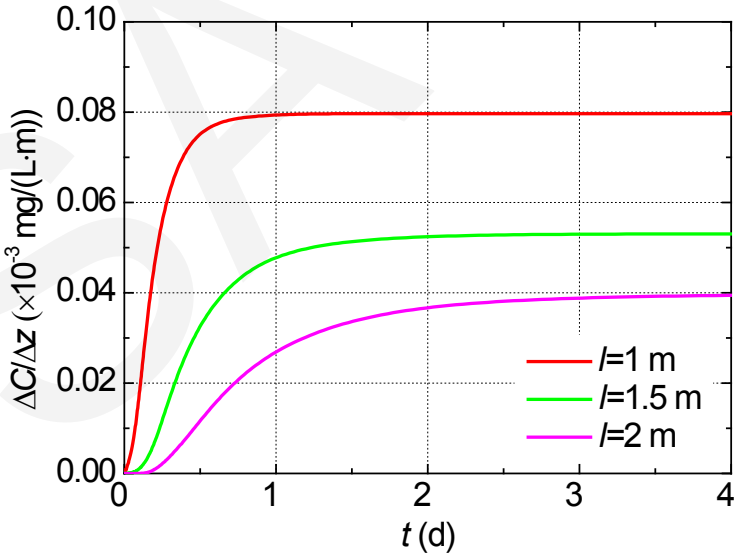
Coupled effect of pressure: $$v_{\mathrm{g},i} = -\frac{k_{\mathrm{g},i}}{\mu_{\mathrm{g},i}}\frac{\partial p_i}{\partial z}, \qquad P = P_0 + A \times 369\sin\left[\frac{\pi \times (669 + t)}{175027}\right],$$

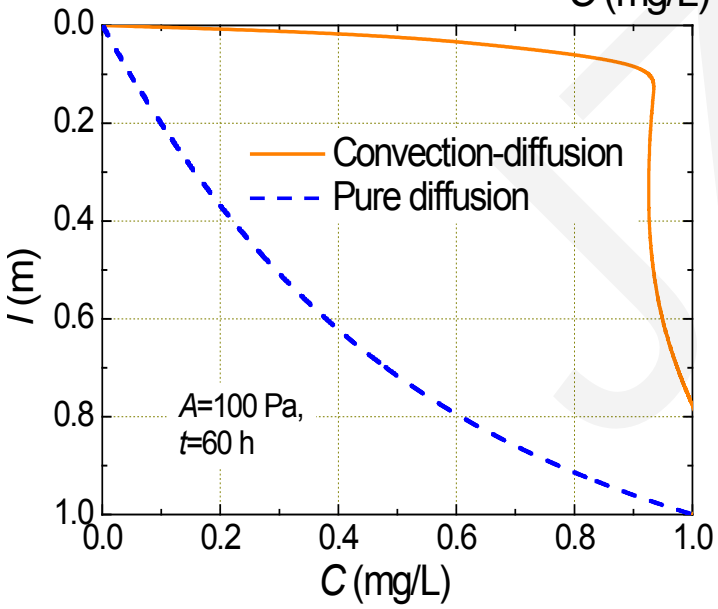


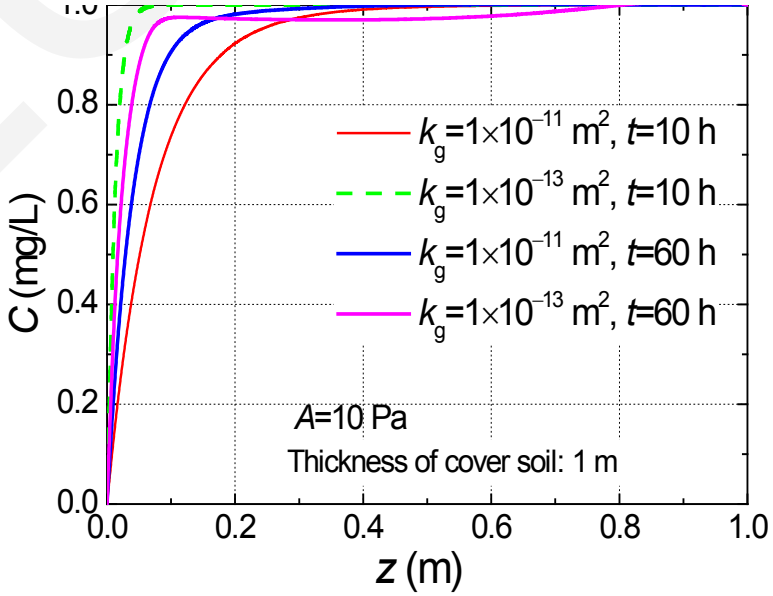


Results and Discussion: Case studies









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., <10 h) 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.