

A transient numerical model for multi-component gas transport in landfill cover soils

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The landfill gas consists of methane, carbon dioxide, hydrogen sulfide, ammonia and numerous volatile organic compounds. The transport and interact between multicomponent gas in the soil cover layer of the landfills are of great importance. Based on DGM (dust-gas-model) and mass balance equation, a one-dimensional transient multi-component gas transport model in landfill cover soils was developed for the first time. The methane oxidation in the soils is considered in the model. The numerical model was solved by the finite element method based program COMSOL Multiphysics V5.0. The numerical result consists well with the laboratory soil column experiments, which was conducted to simulate four-component (CH_4 , CO_2 , O_2 and N_2) gas transport in landfill cover system. The parameter analysis shows that, ordinary diffusion plays an important role in transport process. For methane and carbon dioxide, ordinary diffusion contributes 97% of the total transport flux at the top soil. The effect of ordinary diffusion decreases with the increase of depth. The ordinary diffusion contributes 50%-60% of the flux at the bottom. The influence of advection becomes more important when the depth increases. Advection contributes 37% to the flux at the bottom of the cover soil. On the contrary, the effect of Knudsen diffusion is relatively week. It contributes 0.5%-12% to the total flux. This is due to the relatively large gas permeability of the cover soils. Advection becomes important when gas permeability increase. The effect of advection is comparable to diffusion when the gas permeability increases up to $3\text{e-}13\text{m}^2$. Methane oxidation rate is found to increases by 5 times when gas permeability increase from $3.5\text{e-}12\text{m}^2$ to $3.5\text{e-}11\text{m}^2$. The numerical solution can be used for multi-component landfill gas transport in the soils and can also be used for the design of landfill cover system with respect to gas pollution control.

Keywords: landfill, multi-component gas transport, methane oxidation, numerical model, column test