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In-situ, on-site, and laboratory measurements of gas transport parameters and developments and tests of predictive model

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Understandings of gas-phase transport processes in the subsurface are important in many engineering and agricultural fields. At polluted sites by toxic, volatile organic chemicals (VOCs), the gas-phase transport should be addressed since toxic gases can migrate relatively fast and spread over large areas, causing much greater groundwater contamination and air pollution.
The transport, fate, and emissions of gases in the soil are mainly governed by gas advection and diffusion phenomena. Gas advection is driven by natural or induced pressure gradients, while gas diffusion is driven by gas concentration gradients. The air permeability (k_a) and the soil-gas diffusion coefficient (D_p) are the governing transport parameters for gas advection and diffusion, respectively.
In this study, in-situ and on-site measurements of air permeability were conducted for five different soils in Japan; two volcanic ash soils, one forest soil, one lowland soil, and one waste disposal landfill site. In addition, soil-gas diffusion coefficient as well as air permeability were measured in a laboratory by using undisturbed 100cm^3cores sampled from each site. The effects of soil structure and soil texture on gas advection characteristics (i.e., air permeability) were investigated and predictive models for gas transport parameters were developed and tested based on the measured $k_a$and $D_p$data.
For the forest and lowland soils, measured in-situ air permeability ($k_{a,in-situ}$) values were higher than air permeability measured in a laboratory ($k_{a,lab}$). This may attribute to the enhanced gas advection through soil macropores such as plant roots or cracks which more strongly influenced $k_{a,in-situ}$due to larger representative soil volume. On the other hand, $k_{a,in-situ}$values agreed well with the $k_{a,lab}$values for volcanic ash soils at the deep layer where the massive and homogeneous soil structure were observed. At the landfill site, the $k_{a,in-situ}$values were lower than $k_{a,lab}$. This is probably due to the restricted air flow by the highly compacted subsurface layer in the cover soil.
Simple power-law models for $k_a$and $D_p$as a function of soil-air content were developed by modifying existing predictive models with reference-point soil-air content, $k_a$and D_p. The developed models performed well against measured $k_a$and $D_p$data.

Keywords: gas movement, gas diffusion coefficient, air permeability