Unified Measurement System (UMS) for the Gas Dispersion Coefficient, Permeability and Diffusion Coefficient, and their Interrelations in Differently-Textured, Variably-Saturated Soil

S. Hamamoto (1), P. Moldrup (2), K. Kawamoto (1), T. Komatsu (1), and D. E. Rolston (3)

(1) Graduate School of Science and Engineering, Saitama University, Saitama, Japan(s07de004@mail.saitama-u.ac.jp), (2) Environmental Engineering Section, Dept. of Biotechnology, Chemistry and Environmental Engineering, Aalborg University, Aalborg, Denmark, (3) Dept. of Land, Air, and Water Resources, University of California, Davis, USA

The transport of gaseous compounds in soil occurs by gas diffusion, advection, and dispersion. These gas transport processes are controlled by the soil-gas diffusion coefficient ($D_p$), air permeability ($k_a$) and soil-gas dispersion coefficient ($D_H$), respectively. Among the three main gas transport parameters, the $D_H$ and how it is linked to soil types, moisture conditions and other gas transport parameters, are the least understood. In this study, a unified measurement system (UMS) that enables sequential measurement of gas transport parameters (i.e., $D_p$, $k_a$ and $D_H$) on the same soil core was developed. Using different particle size fractions of non-aggregated (Toyoura sand) and aggregated (Nishi-Tokyo loam) soils, the effects of soil structure, particle (aggregate) size and column scale (5-cm i.d. and 30-cm or 60-cm length) on the three gas transport parameters were investigated and possible links between gas transport parameters were identified. In the arterial pore region (APR) for both soils (soil-air content ($\varepsilon$) < around 0.45 m$^3$ m$^{-3}$, corresponding to the total pore volume for Narita sand and the inter-aggregate pore volume for Nishi-Tokyo loam), measured gas dispersivity ($\lambda = D_H/u_0$, $u_0$: pore-air velocity) for both soils decreased with increasing $\varepsilon$. However, for Nishi-Tokyo loam at higher $\varepsilon$, the $\lambda$ values increased again with higher $\varepsilon$, suggesting that the gas movement becomes more dispersive since intra-aggregate pores with a smaller and complicated pore structure act as additional tortuous gas pathways. In the APR for both soils, strong linear relations between the gas dispersivity ($\lambda$), the pore tortuosity-connectivity factor (X) calculated from the measured $D_p$ and the log-transformed $k_a$ were found.