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

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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 (ε) $<$ 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 ε. However, for Nishi-Tokyo loam at higher ε, the λ values increased again with higher ε, 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 (λ), the pore tortuosity-connectivity factor (X) calculated from the measured D_p and the log-transformed k_a were found.