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Gas Diffusivity Fingerprints for Aggregated Soils with Different Size Fractions

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Migration and emission of climate impact gases like methane, carbon dioxide and nitrous oxide from terrestrial soils to the atmosphere can lead to significant local, regional and global environmental problems (e.g., local air pollution, regional climate shifts, and global warming). Gas transport in soils occurs predominantly by diffusion and, to a lesser degree, also by advection. Soil-gas diffusivity (Dp/Do, where Dp and Do are gas diffusion coefficients in soil and free air, respectively) and its variation with air-filled porosity governs the gas diffusion in soils at the same time providing valuable insight into the soil functional architecture (particle-pore network structure). In aggregated soils, the functional structure will to a large extent vary with the aggregate size and hence exhibit different gas diffusivity fingerprints. This study examined the variations of gas diffusivities as a function of air-filled porosity in aggregated soils sampled from three different locations in Japan; Fukushima (volcanic ash soil), Nishi-Tokyo (volcanic ash soil) and Aichi (Brown forest soil). The soils were first sieved to separate into two size fractions (0-2 mm and 2-4.76 mm) and then repacked to prepare 100-cm3 samples. The saturated samples were then drained stepwise to desired matric potentials ranging from wet (pF 1.0) to completely dry (pF 6.9) conditions using hanging water columns or pressure plate apparatus. For gas diffusivity measurements, the experimental set-up and procedure outlined by Schjonning (1985) was used. The variations of gas diffusivity with air-filled porosity showed distinct dual porosity characteristics for different soils giving useful fingerprints for each soil. The observed enhanced gas diffusivities in larger aggregate fraction can be attributed to the increased intra-aggregate porosity with more inter-connected pore networks. A previous two-region predictive model for aggregated soils reasonably described the gas diffusivities for smaller fractions but needs to be modified for the predictions in the larger aggregate fraction.

Keywords: gas diffusivity, air-filled porosity, aggregate size, structure fingerprints, predictive models