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Hysteretic Behavior in Gas Transport Parameters in Porous Media Using Unified Measurement System with Suction Control
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Gas movement of a porous media is controlled by pore structure characteristics of that medium. Pore geometric parameters including pore size distribution, total and air-filled porosities, pore tortuosity and connectivity strongly influence gas transport parameters (air permeability, ka, gas diffusion coefficient, Dp) in porous media. In this study, the gas transport parameters were measured for varying textured porous media under repeated drying and wetting cycles using a newly-developed measurement system, and the hysteretic behaviors of these gas transport parameters were investigated.

A unified measurement system with suction control (UMS_SC) was developed for measuring soil water characteristics curve (SWCC) and gas transport parameters sequentially under drying and wetting cycles. It consisted of a porous plate, diffusion chamber, sample ring (15 cm in inner diameter and 12 cm in height), tensiometer, soil moisture sensor, oxygen electrodes and air pressure gauges. Soil water characteristics curves and gas transport parameters for differently textured materials including fine sand, granulated molten slag (MS), and a mixture material of MS and volcanic ash soil were measured under repeated drying and wetting cycles. The measurement for each porous material was initiated from a full saturation and suction head was increased /decreased in steps in the drainage/wetting cycles. Moreover, independent measurements of Dp and ka were carried out for repacked samples using a cylindrical mold (15 cm in inner diameter and 12 cm in height) in order to obtain the Dp and ka values at a full dry condition.

The performance of the newly-developed UMS_SC was well for the applied suction head less than 50 cm of water with corresponding saturation of roughly 0.3-0.5. The gas transport parameters were well measured at each suction head level under repeated drying and wetting cycles, and the measured gas transport parameters including the independent measurements were verified by literature data as well as predicted values by existing models. For each material, the measured Dp values were mainly controlled by the air-filled porosities, indicating that the effects of drying and wetting paths on the gas diffusion coefficients were insignificant. On the other hand, considerable hysteretic behavior was observed in measured ka values for each material, and the ka values under the wetting processes were larger than those under the drying processes at the same air-filled porosities. This suggests that preferential pathways for gas advection could be easily created under wetting cycles. The results further show that entrapped air (air filled porosity below which no gas diffusion or air flow occurs) has no significant effect on drying and wetting processes for the used porous media.