Parameter Estimation of Hysteretic Soil Hydraulic Functions of an Andisol using the Multistep Outflow-inflow Experiments

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Japanese volcanic ash soils, Andisols, have unique physical properties. For example, the water retention curve of an Andisol generally has a dual-porosity shape resulting from separate macropore (inter-aggregate) and micropore (intra-aggregate) contributions, and a very high saturated water content (often as high as $0.85 \text{ cm}^3/\text{cm}^3$) because of the inherent nature of soil aggregation in these soils. Since capillary retention is dominant in inter-aggregate pores, hysteresis in water retention curves may occur between drying and wetting processes. This study presents inverse estimation of hysteretic soil hydraulic functions of Andisol using the multistep outflow-inflow experiments.

An Andisol from an upland field at the National Institute of Vegetable and Tea Science in Mie, Japan was passed through 2 mm sieve. The soil was packed with a bulk density of 0.75 g/cm3 in .a 5-cm-long, 5-cm-diameter acrylic column having a porous plate at the bottom. The bottom boundary pressure ranging from 0 to -85 cm was controlled for drainage and wetting from the bottom. A tensiometer was installed horizontally at 2.5 cm depth. Cumulative water outflow-inflow was monitored based on the weight of the soil column.

Soil hydraulic functions described with a bimodal van Genuchten (VG) introduced by Durner (1994) were separately estimated for drainage and wetting. We assumed hysteresis only appears in the first part of the VG function. When ?1 values for the first VG are different between drying (alpha$_1$^{d}) and wetting (alpha$_1$ ^{w}), however, hysteretic unsaturated hydraulic conductivity in terms of water contents appears in lower water contents. Hence we defined an independent alpha$_1$ ^{k} for the unified unsaturated conductivity in terms of water contents. Initial values for the bimodal VG were determined based on the observed water retention curve. Parameters alpha1, n1, w2, Ks and l were optimized for the objective functions of pressure readings, cumulative water flux at the bottom, and the average water contents of the soil column using HYDRUS1D. The modified hydraulic conductivity of bimodal VG was found to successfully describe hysteretic soil water retention and unsaturated hydraulic conductivity in term of pressure head, whereas the estimated unsaturated hydraulic conductivity is non-hysteric in terms of water content.

Keywords: Andisol, Hysterisis, Water retention curve, Unsaturated hydraulic conductivity, Inverse analysis