Geophysical Research Abstracts
Vol. 13, EGU2011-10689, 2011
EGU General Assembly 2011

Modelling of preferential water flow trough an unsaturated expansive soils

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An approach is discussed for modeling one-dimensional preferential flow though unsaturated swelling soils. The key to the approach is the simulation of a double permeability porous medium with the shrinkage characteristic curve included into the general flow equation to account for the shrinkage exhibited under soil drying. In the model, the swelling and shrinking influences only the pore volumes and pore size distribution, and thus the hydraulic properties, of the macropores and the matrix domains. A change in microporosity due to swelling and shrinkage induces a corresponding change in macroporosity, while the total porosity, and hence the layer thickness, remain unchanged. This simplified approach allows dealing with an expansive soil as with a macroscopically rigid soil. In this sense, the more rigorous approaches using the material coordinate theory may be approximated with an easier approach dealing with the effect of volume change on water flow only by using the shrinkage curve as a non-linear variable which controls the pore space, changes the hydraulic properties and regulates water flow through both the porous domains.

Theoretical discussion and experimental evidence of the shrinkage effects on the hydrological behavior of a Vertisol are provided. A double-permeability model for a rigid soil and, alternatively, a double-permeability model accounting for the change of the pore system under shrinkage-swelling dynamics will be used, both based on Richards equation. Specifically, we will investigate whether and how well ensemble hydraulic characteristics obtained in a Monte Carlo framework, under the assumption of either rigid or swelling double permeability soil, produce effective soil water contents at three control depths, closely representing those measured in the structures soil investigated. Measured water content were obtained in this study by calculating for each time the average at a given depth z of the volumetric water contents measured over time in 12 sites in the experimental field by TDR and neutron probes. Through this comparison, we will demonstrate that neglecting changes in the pore volumes of the two domains with wetting or drying does not fit field-scale observations of soil hydrological behavior.