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Dual-permeability model for water flow and solute transport in shrinking soils

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A dual-permeability approach was extended to describe preferential water flow and solute transport in shrinking soils. In the approach, the soil is treated as a dual-permeability bulk porous medium consisting of dynamic interacting matrix and fractures pore domains. Water flow and solute transport in both the domains are described by the Richards' equation and advection-dispersion equation, respectively. In the model the contributions of the two regions to water flow and solute transport is changed dynamically according to the shrinkage characteristic exhibited under soil drying. Aggregate deformation during wetting/drying cycles is assumed to change only the relative proportions of voids in the fractures and in the aggregates, while the total volume of pores (and thus the layer thickness) remains unchanged. Thus, the partial contributions of the fracture and aggregate domains, are now a function of the water content (or the pressure head h), while their sum, the bulk porosity, is assumed to be constant. Any change in the aggregate contribution to total porosity is directly converted
into a proportional change in the fracture porosity. This means that bulk volume change during shrinkage is mainly determined by change in crack volume rather than by change
in layer thickness. This simplified approach allows dealing with an expansive soil as with a macroscopically rigid soil.
The model was already tested by investigating whether and how well hydraulic characteristics obtained under the assumption of "dynamic" dual-permeability hydraulic parameterizations, or, alternatively, assuming the rigidity of the porous medium, reproduced measured soil water contents in a shrinking soil. Here we will discuss theoretical implications of the model in terms of relative importance of the parameters involved. The relative importance will be evaluated for different flow and transport processes and for different initial and top boundary conditions.

Key words: Preferential flow and transport, Double permeability models, Shrinkage characteristics