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Dual-domain mass transfer effects on tracer breakthrough curves from packed and intact soil columns

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Structured soils often contain highly-permeable preferential pathways, such as macropores, fissures or inter-aggregate conduits, through which water and solute move at significantly higher velocities than through the surrounding soil matrix, leading to local nonequilibrium conditions reflected in soil water potential and concentration differences between the preferential pathways and soil matrix blocks. Interdomain water and mass transfer is a key process in the description of water flow and solute transport in structured soils. The transfer term parameters depend on the geometry of the soil matrix (shape and size) and the properties at the interface between the domains. To quantify the mass transfer, breakthrough curves obtained from the controlled inflow-outflow laboratory experiment were analyzed by one-dimensional dual-continuum model. Several replicates of breakthrough curves of conservative bromide tracer were determined on the homogeneous packed sand column and on undisturbed soil column of heterogeneous soil with preferential pathways. Breakthrough curves observed on the sand column were characterized by Gaussian-type shapes, while the heterogeneous soil column showed a rapid appearance of the tracer in leachate and prolonged tailing. Inverse modeling indicated a significant influence of the interface between the soil matrix and preferential flow domains on the prediction of the tracer concentration in the effluent. This interface influence could be simulated and quantified in terms of the first-order mass exchange parameters of the water and solute mass transfer terms in the dual-continuum model.

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