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Can we model solute transfer in heterogeneous soils with MIM model?

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The fate of pollutants in the vadose zone must be understood, in particular, underneath infiltration basins for an optimum management of these plants. Stormwaters carry pollutants (heavy metals, organics, emerging pollutant like nanoparticles, etc.) and thus constitute a risk for groundwater and soil quality. Most infiltration basins are settled over highly permeable soils that exhibit a strong lithological heterogeneity. The impact of such lithological heterogeneity on flow and solute transfer has already been questioned. Previous studies have already proved that lithological heterogeneity was prone to the establishment of preferential flows. In more details, the concomitance of several materials with contrasting hydraulic properties induces funneled flow at the interfaces between less permeable and more permeable lithofacies. Solutes are then carried by water fluxes quickly along preferential flow pathways and have restricted access to zones far from these pathways. It can clearly be imagined that such pattern could be modeled by a MIM model postulating water fraction into two fractions, one mobile and the other immobile, with solute transport by convection and dispersion in mobile water fraction and solute diffusion at the interface between mobile and immobile water fractions. The application of MIM approach to the case of solute transport in strongly heterogeneous soils may be quite advantageous: simplification of the problem, fewer parameters, ease of modeling, numerical computation, gain in computation time, etc. However, such consistency has never been investigated in details. In this paper, we focus on the possibility to model solute transport in a strongly heterogeneous deposit using MIM model. The deposit has been the subject of intensive campaigns of characterization of its lithology and the hydraulic and hydrodispersive properties of its lithofacies. Numerical computations were performed for a section of deposit 13.5 m wide and 2.5 m deep. Numerical results clearly showed the establishment of preferential flows with funneling mostly under unsaturated conditions. Solute elution at 2.5 m depth was characterized and discussed as a function of solute reactivity. Solutes breakthrough curves show clear evidence of MIM like pattern. In this paper, we clearly demonstrate that MIM model accurately reproduces solute elution at 2.5m depths but also at different depths. MIM approach accuracy is ensured provided that related parameters are optimized as a function of depth, hydric and hydraulic conditions and the contrast in hydraulic parameters of the lithofacies that constitute the deposit.