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Water and Colloids Transfer in the Heterogeneous Unsatured Zone: Experimentation and Modeling

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Recently, many studies have been conducted in the laboratory to understand the mechanisms of transport and deposition of colloids in heterogeneous unsaturated soils. In this paper, we study the influence of the soil textural heterogeneity on colloids transfer. Two columns (D=10cm, L=29cm) with different textured compacted soils where carried out to simulate the observed textural heterogeneity underneath an urban rainwater infiltration basin. The first material is sand (0-2mm in diam.) and the second a bimodal mixture of 50% sand and 50% gravel (4-11mm in diam.). Fluorescents nanoparticles of silica doped with fluorescent organic molecules (i.e. with fluorescein) have been used as a tracer for particles transport. The aerodynamic diameter of these nanoparticles is between 50 and 60 nm (Nano-H, Saint-Quentin-Fallavier, France). A solution of a non-reactive tracer, Br- (Co=10-2M and ionic strength I1=0.005M) was used to determine the solute behavior. For each soil column, we present two unsaturated flow tests carried out with a nanoparticles solution (Co=0.196mg/L) and with a solution of both nanoparticles and bromide at the same concentrations but having a double ionic strength (I2=0.01M). Particles and solute transport was modeled using Hydrus1D assuming physical non-equilibrium between mobile and immobile phases, a convection-dispersion model on the mobile phase with first-order solute exchange between the mobile-immobile phases and a first order kinetics for colloidal retention. The main results show how much the physical heterogeneity of the porous medium is important in the deposition mechanisms of colloids; the colloid trapping being more important in the bimodal soil. The estimated parameters for the solute tracer don't fit with those for particles elution curves, which confirm that the flow pattern of both colloids and solute are different. Modeled concentration of retained colloids is more important in the immobile phase. Thereby an important ionic strength induces stronger trapping colloids. The use of the fluorescent nanoparticles as a colloid tracer can improve our knowledge of the transfer of colloids in the heterogeneous unsaturated zone.