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Colloidal particle transport in unsaturated porous media: Influence of flow velocity and ionic strength on colloidal particle retention

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Recently, anthropogenic colloidal particles are increasingly present into the environment. They can carry contaminants or constitute themselves a risk for the environment. Several factors can influence the fate of colloidal particles in soils. This work presents the investigation of effects of flow velocity and ionic strength on colloidal particles retention in unsaturated porous media. Experiments were carried out in laboratory column (D = 10 cm, L = 30 cm) with compacted mixture sand-gravel from a fluvioglacial basin of Lyon, France. Fluorescents nanoparticles (D = 50 to 60 nm) of silica doped with fluorescent organic molecules (fluorescein) have been used to simulate colloid particle transport. A solution of a non-reactive tracer, Br-, was used to determine the water flow behavior. Three different unsaturated water flow velocities (i.e. V = 0.025, 0.064 and 0.127 cm/min) and five ionic strengths (i.e. IS = 1, 5, 50, 100 and 200 mM at pH=8.5) have been tested for the case of a pulse injection of a colloidal particle solution at a concentration of 2 mg/L. Breakthrough curves are modeled by the non-equilibrium transfer model MIM (mobile and immobile water fraction), taking into account a sink term to reflect the colloidal particles adsorption. Results show that, when the flow velocity increases, the colloidal particle retention decreases. The decrease in flow velocity allows a better homogenization of the flow. In addition, colloidal entrapment is favored by the fact that their pore velocity is reduced. The retention of colloidal particle is function of ionic strength as well. Indeed, when the ionic strength increases, the retention increases. However for ionic strength higher than 50 mM, the retention decreases suggesting that there is a threshold value for the ionic strength with respect to the retention of colloidal particles. The retention profiles at the end of experiments indicate that the colloidal particles are retained at the inlet of the columns. Experimental and simulation results can be used to understand the mechanisms that are responsible for the transfer of colloidal particles in the environment and then to improve remediation techniques for contaminated soils.

Keys words: colloidal particles, flow velocity, ionic strength, unsaturated soil