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Mobilization of Multi-walled Carbon Nanotubes in Partially Saturated Porous Media

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Carbon nanotubes (CNTs) are important engineered nanoparticles with unique and beneficial properties. As a result CNTs has been used in a wide range of commercial products including electronics, optical devices and drug delivery leading to their disposal in the natural environment. Literature studies have investigated the mobility of CNTs in saturated porous media under differing physical and chemical conditions. However CNT transport in unsaturated porous media has not been investigated thus far. This study investigated the transport of Multi Walled CNTs (MWCNTs) at different water contents and flow rates, a common situation in the event of infiltration/rainfall in the upper layer of the unsaturated subsurface. We have used a column packed with silica sand, at different water contents by applying a suction at the base of the column, and sprinkled the MWCNTs solution at different flow rates at the top of the column. Experiments suggest that MWCNTs deposition was independent of the change in water content (until 21% of total pore space) of the porous media for chosen applied suction if the flow rates are higher (0.5 m/day). There was a significant amount of MWCNTs filtration occurred at low flow rates (0.1 m/day) and no filtration occurred at high flow rates (4 m/day) at any porous media saturation. In transient flow conditions, all the deposited nanotubes at low flow rates were re-mobilized after application of high flow rates. All these findings indicated that the nanotubes were possibly deposited in the immobile zone created in the relatively smaller pores during low flow conditions and straining did not significantly affect the nanotubes filtration.