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Transport and remobilization of multi-walled carbon nanotubes in porous media during dynamic saturation change

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Nanotechnology is one of the most important technologies in this century and it is evoking a new industrial revolution. Carbon nanotubes (CNTs) are important engineered nanoparticles with unique and beneficial properties. As a result, CNT 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 temporarily changing porous media water content has not been investigated thus far (a common scenario with rainfall/infiltration events in the vadose zone). This study investigated the mobilization of multi-walled CNTs (MCNTs) in repeated wetting and drying cycles with varying flow rates and ionic strength of the inflow solution. Imbibition-drainage-imbibition cycle experiments suggest that MCNTs mobilization increased with increase in flow rates. MCNTs mobilization occurred only with first imbibition events at low ionic strengths however less mobilization happened for higher ionic strength inflow solution in the first imbibition cycle and additional MCNTs were found in the outflow solution in second imbibition cycle, using low ionic strength solution. This observation was likely due to the attachment force between MCNTs and sand surface. Most of the MCNT mobilization occurred during liquid-gas interface movement with less chance of MCNTs to jump the energy barrier at higher ionic strength solution. As a result, less detachment of MCNTs occurred from the sand surface during drainage.