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Transport and deposition of red-yellow soil colloids in saturated sand columns

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Colloids act as a carrier for facilitating transport of strongly adsorbing contaminants in the subsurface and result in soil and groundwater contamination. Understanding colloid mobilization and deposition in subsurface is essential for predicting colloid facilitated transport of contaminants and developing remedial strategies. Although great progress has been made in the study of colloid transport and deposition in porous media, our understandings on natural colloid transport and deposition mechanisms in the subsurface is still limited since most of the previous studies have focused on model colloids (latex microsphere, silica) and model porous media and very little attention has been given to natural soil colloid transport and retention. This study investigated transport behavior of water dispersible colloids (WDC) extracted from Red-yellow soil (RYS) of Okinawa, Japan. WDC solution containing colloids with diameter less than 1 micrometer was applied at water-saturated flow conditions through 10cm column packed with 0.42-0.85mm size fraction of Narita sand and 0.1-0.5mm Toyoura sand at different colloid concentrations, flow rates and pH conditions. 0.001M NaBr was used as a conservative tracer and the pH was adjusted using 0.1M HCl. Mechanisms of colloid transport and retention were studied by analyzing colloid effluent concentration breakthrough and breakdown curves, deposition profile, and particle size distribution. Assuming first-order colloid attachment, detachment and straining kinetics, HYDRUS -1 D was used for the simulation and estimation of transport parameters.
The results of this study showed that there was less significant effect of porous media since almost all WDC leached out through both Toyoura sand and Narita sand at high flow rate and natural pH condition, however at low pH condition, Toyoura sand retained more colloids than Narita sand. The breakthrough and breakdown curves of effluent WDC also showed that low flow rate (10 times higher residence time) caused more reversible entrapment of WDC compared to high flow rate condition. Effects of low solution pH resulted in stronger colloid retainment in the porous media. The solution concentration of WDC had minimum effects on transport and deposition. The spatial distribution of the column experiments revealed that it followed clean-bed filtration theory and resulted in exponential depositional profile. The particle size distribution of effluent WDC at natural pH condition for both sands indicated no change in the size and distribution but particles with larger diameter were observed in the effluent at low pH condition in Narita sand. However, the change was less significant indicating both smaller and larger size fractions of input colloids preferentially deposited in sand column. The numerical analysis showed that both one-site and two -site model fitted the breakthrough curve well; however, the simulated deposition profile of natural soil colloids was overestimated by both models, thus unable to capture the deposition profile well.

Keywords: Water dispersible colloids, deposition profile, breakthrough curves, particle size distribution