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Variably-charged soil colloids: characterization and transport in saturated sand columns

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Characterization of natural colloids and knowledge of their transport and deposition behavior in the subsurface and at extreme environmental conditions is required to effectively manage and remediate soil and groundwater pollution caused by colloid associated contaminant transport. In the present study, suspended soil-colloids with diameter less than 1 micrometer, extracted from a volcanic ash-soil (VAS colloids) from Nishi-Tokyo, Japan and a red-yellow soil (RYS colloids) from Okinawa, Japan were characterized in terms of their surface charge and stability and their transport and deposition in saturated sand columns was investigated. The extracted soil colloids, characterized as variably-charged colloids, were applied to 10-cm long saturated sand columns repacked with either Narita sand (mean dia. = 0.64 mm) or Toyoura sand (mean dia. = 0.21 mm) at different flow rates and pH conditions. NaBr (0.01M) was used as conservative tracer and pH was adjusted using 0.01M HCl. Colloid transport and deposition were studied by analyzing colloid effluent concentration breakthrough curves and deposition profiles. Based on zeta potential measurement, VAS colloids were characterized as pH-dependent surface charge dominant colloids whereas, RYS colloids were categorized as less pH-dependent or permanent surface charge dominant colloids. The results of column studies indicated that higher deposition was observed for decreasing flow rate, decreasing pH and for soil-colloids dominated by pH-dependent surface charge (VAS colloids). At natural pH and high flow rate, higher elution and less deposition was observed for RYS colloids as compared to VAS colloids and the deposition of both colloids was mainly due to attachment. At low pH, the deposition was mainly controlled by depth-dependent straining for VAS colloids in both Narita and Toyoura sands, and for RYS colloids in Toyoura sand. Due to pH-dependent surface charge characteristics of VAS colloids, charge neutralization of colloids occurred and hence the deposition was enhanced leading to ripening with decreasing pH. The transport and deposition of variably-charged colloid was highly influenced by the surface charge characteristics of colloids coupled with solution chemistry and receiving medium surface properties.

Keywords: Variably-charged colloids, zeta potential, colloid transport, deposition profile