Numerical Modeling of Mobilization and Leaching of Natural and Water Dispersible colloids in Aggregated Volcanic Ash Soil Columns

DEEPAGODA.t.k.k CHAMINDU[1]; Ken Kawamoto[2]; Hirotaka Saito[3]; Moldrup Per[1]; Toshiko Komatsu[2]

[1] Aalborg University, Denmark; [2] Science and Engineering, Saitama Univ.; [3] Ecoregion Sci., TUAT

Subsurface migration of contaminants facilitated by soil colloids has been identified as one of the emerging soil physicochemical processes in recent years. Colloids were observed to play a key role in the translocation of potentially harmful contaminants (e.g., radionuclides, pesticides, heavy metals, pathogens etc.) into groundwater leading to groundwater contamination. Mobilization and transport (restricted by deposition) of soil colloids is the underlying process governing colloid-facilitated contaminant transport. Early contaminant transport models did not take colloid transport into account resulting in serious underestimation of groundwater pollution. Although significant progress has been achieved in simulating mobilization and transport/deposition of colloids, the present models lack accuracy and warrant further improvements. As a result, though enough evidences available to raise concerns, colloid-facilitated transport has not been paid its due attention in the present risk assessment models.

This study attempts to quantify and simulate leaching of natural volcanic ash soil colloids (NC) as well as simultaneous transport of applied water dispersible soil colloids (WDC) in aggregated volcanic ash soil columns. In this study, two saturated soil-packed columns were irrigated with artificial rainwater (ARW) at an intensity of 80mm/hr for 60 hours. Two similar columns were then irrigated at the same intensity, but a WDC colloidal suspension of 5mg/L was applied after 20 hours for a period of 20 hours. Effluent colloid concentrations were measured in each experiment. The colloid concentration curves of NC were characterized by a nearly linear breakthrough reaching a concentration peak, followed by a long-tailed breakdown. In contrast, the corresponding curves for WDC reached a plateau and exhibited a rapid breakdown afterwards.

HYDRUS-1D code was used for the simulation and estimation of colloid transport parameters. Numerical analysis revealed that, of chemical nonequlibrium models, two-site equilibrium/kinetic model with equal fractions of equilibrium and kinetic sites can better describe the leaching of NC. Release of colloids from equilibrium sites was reflected in the initial linear breakthrough curve while the receding curve with extended tailing reflected subsequent desorption from kinetic sites. The proposed conceptual mechanism presumes that water dispersible soil colloids instantaneously mobilized into interstitial pores first from the equilibrium sites giving rise to a steady breakthrough with a concentration peak and subsequently, with the depletion of equilibrium sites, a diffusion-limited kinetics controlled colloid release from intra-aggregate pore waters characterized by the long-tailed breakdown curve. Transport of applied WDC, on the other hand, seemed to follow simple first-order attachment kinetics.