# Experimental and Numerical Analysis of Colloid Transport and Strainning in Saturated Sand

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The role of colloids (particles with effective diameter is less than 10 micrometer) in facilitating the subsurface transport of contaminants has received much attention during last few decades. The growing body of literature bears strong evidences to prove beyond suspicion, the colloid facilitating transport of wide variety of contaminants including radioneuclides, pesticides, heavy metals, microorganisms etc. Colloid transport in subsurface is the underlying process governing colloid-facilitated contaminant transport. Colloid attachment and straining have been recognized as key colloid retention mechanisms in saturated porous media and hence gained much research interest. Despite extensive research, however, colloid and colloid-facilitated transport still remains poorly understood.

This study investigated attachment and straining of colloid-sized glass beads with the diameter of 1-10 micrometer and soil colloids with the diameter of less than 1 micrometer extracted from a volcanic ash soil ( Nishi Tokyo) in saturated sand (Toyoura sand) by means of a series of column experiments at different colloid concentrations and flow rates. The height and internal diameter of the sand column were 10cm and 4.91cm respectively. Bromide was also added to colloidal solution as a conservative tracer. In each column experiment, 3 pore volumes of artificial rainwater was initially applied downward at a steady flow rate, then shifted to 10 pore volumes of colloidal solution, followed by another 5 pore volumes of artificial rainwater. By measuring the colloid concentration of effluents, colloid breakthrough and breakdown curves were observed.

Glass bead colloids exhibited essentially no breakthrough in both high and low flow rates, suggesting all colloids deposited in the soil column. Since colloid attachment is unlikely due to mutual repulsion of negatively charged colloids and sand grains, we presume 100% of colloids physically strained in porous media interstices. Soil colloids, on the other hand, exhibited complete deposition at low flow rate, but only 31% deposition at high flow rate. Particle size distribution measurements of effluent colloids of the latter revealed that both smaller and larger size regions of input colloids preferentially deposited in sand column. Deposition of large soil colloids can be attributed to straining while smaller colloids are presumably attached to sand grains. Further, particle size distribution profiles of effluents at different pore volumes are similar suggesting steady filling of attachment and straining sites.

Following completion of each column experiment, sand column was disjointed in order to examine the colloid retention profile. Colloid retention profile of glass bead colloids was non monotonic with multiple deposition peaks. The highest peak occurred near the column inlet while two relatively smaller secondary peaks occurred at deeper layers. Particle size distribution measurements of deposited colloids revealed that larger size colloids were retained near the column inlet while relatively smaller size colloids were captured by deeper layers.

Assuming first-order colloid attachment, detachment and straining kinetics, HYDRUS-1 D code was used to estimate the attachment and straining parameters. In this analysis, the attachment and detachment coefficients of glass beads colloids were assumed to be zero and those of soil colloids were estimated separately from batch kinetic experiments. The results showed that deposition of both glass beads colloids and soil colloids was dominated by straining. The simulated deposition profile of glass beads well captured the observed deposition profile qualitatively, but failed to capture the secondary peaks of the observed deposition profile.

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