2008 USDA-CSREES National Water Conference
Sparks, NV

Trapping of Colloids in Soils by Straining

Elena Rodriguez and Steven L. Bryant

Abstract Text:

Modeling the retention of colloidal particles in soils provides a better understanding of the danger of water contamination from viruses, bacteria or contaminants adsorbed on the colloids. Colloids transported by fluid remain in the soil when they arrive at constrictions in pore space too small to admit them. Pore throats have been typically considered the place where colloids are trapped. However, column experiments offer clear evidence of trapping of colloids smaller than the smallest pore throat in the column.

We explain this observation in terms of straining, a geometric mechanism independent of physicochemical factors. We hypothesize that colloids can be trapped in gaps between pairs of grains besides throats between three grains. Computer generated dense random packs of mono-dispersed spheres are used as a model soils. Its geometric analysis reveals that the occurrence of right sized gaps is enough to trap a significant number of colloids. A geometric analysis of gaps in the model soils, combined with a new methodology to compute flow rates in gaps, was input to an existent straining theory to study the dependence of straining rate on colloid size.

Different hypotheses were considered in order to obtain a scaling exponent between straining rate and colloid size. Classical theories assume the probability of trapping proportional to the flow rate through the constriction. For gaps we consider the possibility that the particle can rebound and be swept through a wider part of the constriction. Thus we assume the retention probability proportional to the flow rate through the gap and inversely proportional to the kinetic energy of the carrier fluid. We also consider the limiting case of trapping probability depending only on the geometry of the gap. These assumptions bracket the scaling behavior reported in experiments, explaining a long-standing set of observations for which previous theories could not account.

Impact Statement: