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Fate and Transport of Cryptosporidium parvum in Soils, Streambeds, and Aquifer Sediments

The transmission of Cryptosporidium parvum, a leading cause of waterborne disease, from its mammalian source (wildlife, cattle, animal feeding operations, waste water treatment plants) through the watershed to drinking water sources involves both, surface and subsurface pathways. In surface waters, the transport of the oocysts may be mediated by interactions with suspended sediments and by subsurface filtration and removal in streambed sediments. On hillslope soils, substantial oocyst transport occurs in macropores. We show that the presence of macropores, travel distance, flow velocity, ionic strength, pH, and grain surface properties substantially effect the removal and remobilization of oocysts in the subsurface environment. Classic colloid filtration theory is a reasonable tool for predicting the magnitude of breakthrough. The collision efficiency, a key parameter of the classic filtration model, is shown to strongly depend on aqueous geochemical conditions. Significant tailing observed in the breakthrough of C. parvum oocyst through sand columns (or, equivalently, through streambed sediments) is better explained with a newly developed Continuous Time Random Walk (CTRW) approach. The CTRW is generalized transport modeling framework, which includes the classic advection-dispersion equation (ADE), the fractional ADE, and the multi-rate mass transfer model as special cases. Within this conceptual framework, it is possible to distinguish between the contributions of pore- scale geometrical (physical) disorder and of pore-scale physico-chemical heterogeneities (e.g., of the filtration, sorption, desorption processes) to the transport of C. parvum oocysts.

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