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# Modeling the Co-transport of Viruses and Colloids in Unsaturated Porous Media

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Viruses are of major concern in groundwater because of their high infectivity, small size and persistence. Virus transport in groundwater is found to be significantly affected by colloids, which are abundant in both organic and inorganic forms and have a large surface area. Indeed, virus retention in porous media has been observed to increase in the presence of clay colloids due to the co-deposition of colloids with attached viruses. In unsaturated conditions, colloid (and virus) deposition have been observed to increase as the degree of saturation decreases due to the presence of the air-water interface and enhanced adsorption to the solid-water interface.
In this study, we have developed a one-dimensional mathematical model to simulate the co-transport of viruses and colloids in porous media under variably saturated conditions. We use linear reversible kinetic model to describe virus attachment to colloids and soil grains. The governing coupled partial differential equations are solved numerically using alternating operator split approach. The colloid transport is decoupled from the virus transport and solved first. We have used our model to simulate two sets of published column experimental studies in literature on the co-transport of viruses and clay colloids under saturated conditions. We have found that the model fits the observed virus breakthrough curves well. The increased virus removal in the co-transport experiments is found due to: 1) the virus attachment to mobile and immobile colloids and 2) the increased attachment of clay colloids to the grain surface in the presence of viruses. The increased deposition of clay colloids in the co-transport experiments may be because of the decrease of the surface charge of the grains by the attached viruses; making the surface more favourable for colloid attachment. A sensitivity analysis of the model to various parameters under unsaturated conditions will be performed so as to understand the relative importance of various model parameters on the co-transport of viruses and colloids in porous media.