Geophysical Research Abstracts
Vol. 16, EGU2014-3213, 2014
EGU General Assembly 2014

Mimicking Retention and Transport of Rotavirus and Adenovirus in Sand Media Using DNA-labeled, Protein-coated Silica Nanoparticles

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Rotavirus (RoV) and adenovirus (AdV) are important viral pathogens for the risk analysis of drinking water. Despite this, little is known about their retention and transport behaviors in porous media (e.g. sand filtered used for water treatment and groundwater aquifers due to a lack of representative surrogates. In this study, we developed RoV and AdV surrogates by covalently coating 70-nm sized silica nanoparticles with specific proteins and a DNA marker for sensitive detection. Filtration experiments using beach sand columns demonstrated the similarity of the surrogates' concentrations, attachment, and filtration efficiencies to the target viruses. The surrogates showed the same magnitude of concentration reduction as the viruses. Conversely, MS2 phage (a traditional virus model) over predicted concentrations of AdV and RoV by 1- and 2-orders of magnitude, respectively. The surrogates remained stable in size, surface charge and DNA concentration for at least one year. They can be easily and rapidly detected at concentrations down to one particle per PCR reaction and are readily detectable in natural waters and even in effluent. With up-scaling validation in pilot trials, the surrogates can be a useful cost-effective new tool for studying virus retention and transport in porous media, e.g. for assessing filter efficiency in water and wastewater treatment, tracking virus migration in groundwater after effluent land disposal, and establishing safe setback distances for groundwater protection.