EGU22-2062
https://doi.org/10.5194/egusphere-egu22-2062
EGU General Assembly 2022
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Comparison of bacteriophage MS2, norovirus, rotavirus and adenovirus transport and attenuation in alluvial aquifer media

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Contamination of potable groundwater by human enteric viruses pose serious health risks. Our knowledge about virus subsurface transport relies largely on using bacteriophages as surrogates. Relatively few studies have compared enteric viruses, especially norovirus, with phage surrogates regarding their transport behaviour. Given that bacteriophages and enteric viruses have dissimilar physiochemical properties, differences in their behaviour and interactions in subsurface media and groundwater are possible.

Laboratory column studies were conducted to examine the attenuation and transport of norovirus and MS2 bacteriophage in alluvial sand (d_{10}=0.25 mm), and rotavirus, adenovirus and MS2 in alluvial gravel (d_{10}=2 mm) in 2 mM NaCl (pH 6.6–6.9) at pore velocities of 4.6–5.4 m/day. The experimental data were evaluated using colloid filtration theory and HYDRUS-1D two-site attachment-detachment modelling.

The $\log_{10}$ reduction values, mass recoveries, attachment efficiencies and irreversible deposition rate constants indicated that compared with MS2, norovirus removal was lower in the alluvial sand and the removal of rotavirus and adenovirus was markedly greater in the alluvial gravel. Modelling suggested virus attachment was reversible, and that the rates of virus detachment were faster than the rates of virus attachment, which favoured free virus transport. Hence, continual virus transport through subsurface media poses health risks if viruses are not inactivated, and virus remobilisation could cause contamination events. Thus, virus transport predictions in subsurface media should incorporate virus attachment reversibility.

Some of these observations align with other studies' findings, but viruses behave very differently in different systems; hence, disparate relationships in other systems have been described, especially in the presence of multivalent cations and organic matter. Our understanding of enteric virus mobility and removal is limited, and data based on bacteriophages may not represent enteric virus behaviour accurately. Thus, further research is needed into enteric virus transport, especially that of norovirus, in different subsurface media under a variety of experimental conditions.