Co-transport of Microplastics and a surrogate for Human Enteric Viruses in a saturated column packed with Quartz Sand

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Abstract

Groundwater can be contaminated with infective human enteric viruses from various sources, such as wastewater treatment plant discharge, landfills, septic tanks, agricultural practices, and artificial groundwater recharge. Anthropogenic pollutants, such as microplastics, may exhibit an affinity to transport biocolloids (bacteria, viruses) further and reduce their degradation rates in the natural environment. Human enteric viruses (poliovirus, hepatitis A, rotavirus, and adenovirus) can adsorb to the abiotic surface of microplastics and are simultaneously present in wastewater discharge. These newly formed clumps of pathogens and microplastics could penetrate deeper into soils as vectors for preferential flow and threaten groundwater systems, triggering a higher risk for drinking water and possibly followed by a disease outbreak. The mechanisms behind the adsorption of human enteric viruses on microplastic surfaces and their potential role in prolonging virus survival and promoting environmental transport remain unclear. This study aims to explore the possibility of co-transport of microplastics and human enteric viruses in saturated porous media, using PRD1 bacteriophage as a surrogate. PRD1 bacteriophages have been widely used as surrogates of rotavirus because they share many fundamental properties and features.

Column experiments were performed using quartz sand (soil grain size: 0.60 - 1.30 mm) as a porous media in a 30 cm long and 7 cm diameter column. The column experiments were conducted by maintaining Darcy velocity of 2.65 m/day. Three different influent solution scenarios were considered in the experiments: PRD1 mixed with microplastics, PRD1 alone, and microplastics alone. The enumeration of PRD1 in the effluent solution was performed using quantitative polymerase chain reaction (qPCR) as well as the culture

method, in order to differentiate between infective and inactive virus transport. Microplastics were quantified using Solid-Phase Cytometry (SPC). Results were analyzed by calculating the collision and sticking efficiencies of the microplastics and PRD1 using the classical colloid filtration theory and Hydrus 1D modeling tool.

There was no evidence of interference or inhibition of microplastics on the performance of qPCR and DNA extraction in the methodological setup. Additionally, the efficacy of qPCR and DNA extraction methods did not yield significantly different results across any of the influent solution conditions. Preliminary results suggest that the presence of microplastics enhanced the transport of PRD1, which led to reduced attachment of PRD1 in the porous media. The concentration of infective phages showed a delayed sharp increase, indicating that there may be a sorption mechanism that delays their breakthrough. It is possible that a portion of the active phages possess a higher sticking efficiency and that population heterogeneity contributes to this phenomenon. A comprehensive understanding of the processes that govern virus transport with globally distributed microplastics is crucial for protecting public health.

Keywords

polystyrene microplastics, PRD1 bacteriophages, saturated porous media, groundwater contamination, public health

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Presented at

ISEB-ISSM 2023

Preference: Oral Presentation

Session: Impacts from Anthropogenic Activities (Pathogens and pathogen transport)

Conflicts of interest

The authors have declared that no competing interests exist.