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Influence of graphene oxide nanoparticles on the co-transport of biocolloids in saturated porous media

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Graphene oxide (GO) is a material with rapid production growth and wide range of applications, consequently engineered GO nanoparticles (NPs) may enter subsurface formations, where biocolloids (e.g. viruses and bacteria) of human origin are in abundance. This study examines the effect of GO NPs on the inactivation, attachment, transport and co-transport of three biocolloids in saturated porous media. The common bacteria Escherichia coli, Enterococcus faecalis and Staphylococcus aureus of human origin were used as model biocolloids. A series of dynamic batch experiments of biocolloid inactivation by GO NPs were conducted at constant room temperature (22°C), in the presence and absence of quartz sand. Moreover, flowthrough experiments were performed in 30-cm long laboratory columns packed with coarse quartz sand in order to determine the effect of GO NPs on biocolloid transport, cotransport and retention in water saturated porous media. Both experiments, batch and flowthrough, were conducted under the same aqueous chemistry conditions (pH=7, Is=2 mM).
The biocolloid inactivation experimental data were satisfactorily fitted with a pseudo-first order equation with a time dependent rate coefficient. The experimental data indicated that the inactivation rates, for all three bacteria examined, increased in the presence of quartz sand. S. aureus exhibited the highest inactivation rates. Certainly, the presence of quartz sand was shown to enhanced the antibacterial properties of the nanoparticles under batch conditions.
The biocolloid cotransport results indicated that the mass recovery values for all biocolloids, calculated based on total biocolloid concentration in the effluent, were reduced compared to those in the absence of GO NPs. Among the examined bacteria, the E. coli and E. faecalis strains were shown to be more vulnerable to GO nanoparticles, while the antimicrobial effect of GO suspension against S. aureus was lower for the given dose and contact time. Temporal moments of the breakthrough concentrations suggested that the presence of GO significantly influenced biocolloid transport, cotransport and irreversible deposition onto quartz sand. Finally, the extended DLVO (XDLVO) theory was used to quantify the various interaction energy profiles based on electrokinetic and hydrodynamic measurements.