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Exploring the Influence of Interfacial Processes on the Transport and Retention of PFAS in AFFF-Contaminated Soils

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Per- and Polyfluoroalkyl Substance (PFAS)-containing Aqueous Film Forming Foams (AFFFs), employed in firefighting, have been recognized as a major source of PFAS contamination across the globe. In addition to the release of PFAS-containing solutions, firefighting training and emergency response activities have also typically involved the intentional or accidental co-release of hydrocarbon fuels and chlorinated solvents (non-aqueous phase liquids (NAPLs)), creating complex contaminant mixtures. Due to their amphiphilic properties, PFAS accumulate at interfaces, and thus, the presence of air-water, soil-water, and NAPL-water interfaces within these release areas can influence both the transport and distribution of PFAS in the subsurface. This presentation provides an overview of recent collaborative research related to the development, validation, and application of mathematical models that describe the transport and retention of PFAS mixtures in complex AFFF-contaminated source areas. Modeled processes include interfacial accumulation, interfacial tension reduction and associated moisture redistribution, nonlinear sorption to the solid phase, and competitive sorption/interfacial accumulation effects. Data from interfacial tension and batch sorption measurements are used in conjunction with moisture retention curves and experimental observations from multi-phase column experiments to assess model performance. Here, a Langmuir-Szyszkowski equation is employed to model surface excess of individual PFAS, and fitted single solute parameters are employed, in an extended Langmuir isotherm framework, to predict competitive interfacial accumulation for PFAS mixtures. Experimental measurements and model simulations of PFAS transport in two-phase (NAPL-aqueous and air-aqueous) fluid systems demonstrate the influence of interfacial tension reduction and competitive adsorption phenomena on anomalous transport behavior in clean sands. The validated model provides a comprehensive tool to explore the influence of interfaces on PFAS mixture fate and transport in subsurface environments. Example applications to field-scale AFFF release scenarios illustrate the potential influence of release history, soil texture, and PFAS characteristics on the spatial distribution of contaminants within the unsaturated zone and on contaminant migration to the water table.

Participation

In-Person

References

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