A Sustainable Alternative to Excavation of PFAS Source Areas

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Background/Objectives. Per- and polyfluoroalkyl substances (PFAS) include persistent, bioaccumulative, and mobile fluorinated compounds that potentially present a risk to human health and the environment. The prolonged application of aqueous film-forming foams (AFFF) containing PFAS at firefighting training areas (FTAs) has resulted in long-term sources of PFAS leaching into soil and groundwater. The leachability risk of PFAS from resultant soil source zones to groundwater can be mitigated by reducing their mobility in the subsurface via fixation. A treatability test program was designed to explore the in situ soil stabilization (ISS) of PFAS in FTA source zones using commercially-available adsorption media (i.e., “fixants”). ISS presents a potential PFAS source zone management alternative that eliminates ex situ management of PFAS wastes while protecting groundwater from future leaching. ISS consists of the use of heavy-construction equipment, augers, and/or cutting tools to mix soil, water, and fixants in place in the vadose and saturated zones. ISS can be a highly-effective method for accessing source mass because it homogenizes soil, reduces geological anisotropy, and provides immediate access to soluble PFAS stored in low-permeable strata. The ISS reduces leachability through stabilization with the fixants and minimizes vertical infiltration and lateral hydraulic conductivity by homogenizing preferential pathways with low-permeability strata. Laboratory tests were conducted with four objectives: 1) establish basic adsorption performance of selected fixants for PFAS; 2) test performance as a function of pH; 3) compare performance with and without Portland cement; and 4) obtain leachability data to demonstrate potential long-term stability of in situ treatment.

Approach/Activities. Bulk soil and groundwater samples were collected from an airport site in Australia known to be impacted with PFAS from AFFF use. Three commercially-available fixants were selected for the test program based on their potential for adsorption of anionic PFAS: aluminum hydroxide (AlOH)/carbon blend (AHCB), pyrolyzed cellulose (PC), and modified clay (MC). The program consisted of batch contact tests of impacted soil and groundwater mixed in a liquid/solid ratio of 2:1. The batches were mixed on a linear mixing table for 18 hours. Control and duplicate batches were run and pH was monitored at points along the process. After mixing, samples were separated and filtrate samples were analyzed for a PFAS suite of 28 compounds using LC/MS/MS method at an accredited commercial lab in Australia. Larger batch contacts were run with soil and groundwater to simulate in situ soil mixing. Leachability tests were then conducted on treated batches with and without Portland cement.

Results/Lessons Learned. All three reagents tested demonstrated effective adsorption of PFAS and have potential for stabilization of PFAS. MC demonstrated the best removal of perfluorinated sulfonates, which were the main contaminants. The result at the lowest dose of 5 percent on a weight basis (% wt) represents better than 99.9% reduction in dissolved-phase concentration. The AHCB demonstrated the best overall removal of perfluorinated carboxylate (PFCAs) compounds, particularly for short-chain PFCAs. Adsorption capacities measured for AHCB, PC, and MC of the 28 PFAS Standard Suite in were 25.6, 15.3, and 38.3 microgram PFAS per gram fixant, respectively. The PC showed a significantly less removal capacity of short-chain PFAS compared to the AHCB and the MC. The sequential leaching test of the MC exhibited up to two order-of-magnitude decrease in leachability over the control sample. The overall mass of PFAS leached was approximately 1% of the total PFAS mass after an estimated 50 pore volumes of leaching. The test work simulation of ISS demonstrates the strong potential of this technology as an effective tool for mitigating migration of PFAS through soil and groundwater. This treatability test serves as the basis for a Department of Defense funded three-year field-scale comparison of commercially available fixants targeted for implementation in 2018.