Passive, In Situ Treatment of PFAS-Impacted Groundwater Using Foam Fractionation in an Air Sparge Trench

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Background/Objectives. Passive and in situ PFAS treatment approaches have yet to be demonstrated at the field-scale settings. Currently available ex situ treatment approaches involving groundwater extraction and conventional sorption-based treatment of the extracted groundwater are generally inadequate in removing residual PFAS from AFFF-impacted groundwater, require extensive above- and under-ground infrastructure, and generate a large volume of PFAS-impacted waste that also requires disposal or treatment. Our proposed approach employs the use of a conventional air sparge trench to intercept a shallow PFAS-contaminated groundwater plume, which is often observed emanating from former fire training areas that employed the use of AFFF. For PFAS, the sparging bubbles provide a high air-water interfacial area that facilitates "stripping" of the surface-active PFAS from the groundwater. This sparging process results in formation of a foam on the water surface, which can be subsequently removed via a vacuum and/or skimming system, resulting in orders of magnitude decreases in bulk groundwater PFAS concentrations. This PFAS removal process has been well demonstrated, including in an ex situ field-scale foam fractionation system. Typical PFAS concentration factors are typically in the range of 1-L of reconstituted foam to 5000-L of groundwater. This low volume, high concentration recovered PFAS waste can then be treated via conventional high temperature incineration, or treated via promising technologies such as electrochemical oxidation (ECO), reactive electrochemical membrane (REM), and enhanced contact plasma (ECP). The proposed treatment approach has the potential to treat PFAS-impacted groundwater in situ, passively, and economically with very little energy consumption, waste generation, and little to no chemical additives. With proper optimization, it is foreseeable that the proposed approach can be scaled up and implemented at multiple DoD installations at a fraction of the life-cycle cost of conventional ex situ treatment and including onsite PFAS destruction in the very near future.

Approach/Activities. A comprehensive site data review was performed to select the most appropriate site for this field demonstration project. Following site selection, a site characterization was performed to assess the nature and extent of PFAS contamination in site groundwater, to verify groundwater flow direction and velocity, and to collect samples required for bench testing. Bench testing using site-specific groundwater was performed at CDM Smith laboratory to assess the potential for, and effectiveness of the proposed treatment approach using small batch and tall column reactors to best simulate an air sparge trench. Impacts of bubble size, flow rates, and surfactant addition on treatment efficacy for target versus suspect PFAS and for short- versus long-chained PFAAs were evaluated. Multiple prototypes for efficient recovery of the PFAS-laden foams were also designed, constructed, and testing under laboratory settings. PFAS destruction using ECO, REM, and ECP was assessed and compared. Results from the pre-design field characterization and bench testing activities were used to facilitate the design and construction of the air sparge trench at a DoD facility in Southeastern United States.

Results/Lessons Learned. Results from the bench-scale treatability study indicate that the sparge trench technology can be used to effectively remove PFAS from impacted site groundwater (with as much as 250 μg/L of total target PFAS). All project-specific performance objectives with respect to PFAS removal via foam fractionation, including 2-log removal of all long-chained PFAAs, reduction of PFOS and PFOA to below 70 ng/L, 1-log removal of ToF, and good PFAS mass balance, were reasonably achieved. In addition to target PFAS, suspect PFAS compounds were also effectively removed via foam fractionation; these results are consistent with the ToF measurements and serve as another line of evidence of effective treatment. At least 2-log destruction of all PFAAs was attained using ECO, ECP, and REM. Details pertinent to the design and construction of the air sparge trench in the field, as well as preliminary field results will also be presented.