The In Situ Treatment of TCE- and PFAS-Impacted Groundwater Using Anaerobic Bioremediation, Polylactate Ester, and Colloidal Activated Carbon

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Background/Objectives. Laboratory and pilot testing for the in situ treatment of chlorinated ethenes and per- and polyfluoroalkyl substances (PFAS)-impacted groundwater has demonstrated that sorptive reagents such as colloidal activated carbon (CAC) and the addition of organic carbon and micro sulfidated zero valent iron (mSZVI) are effective at attenuating PFAS and chlorinated ethenes, respectively. However, in situ field testing on commingled chlorinated ethene and PFAS plumes has not been reported to date and thus the ettectiveness of combining theseremedial reagents to treat groundwater impacted by both chlorinated ethenes and PFAS is not well shown. The objective of this study was to evaluate if CAC, organic carbon, and mSZVI could be injected into a shallow silty sand heterogeneitic aquifer to create a permeable reactive zone (PRZ) and to treat chlorinated ethenes such as trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE) and vinyl chloride and various PFAS over a prolonged period. Secondary objectives of the study were to evaluate the effect of the CAC, organic carbon, and mSZVI on various phyiscal and chemical parameters including general groundwater chemistry, the microbilogy of the aquifer system and if heterogeneity impacted the distribution of the reagents within the targetted injeciton zone.

Approach. A PRZ was created in a shallow, unconfined heterogenetic aquifer situated underneath a former manufacturer facility. The groundwater was impacted with TCE, 1,2-DCE and vinyl chloride at concentrations up to 985 µg/L, 258 µg/L, and 54 µg/L, respectively. In addition, five PFAS including PFPeA at concentrations up to 12,800 ng/L, PFHxA at concentrations up to 3,240 ng/L, PFBA at concentrations up to 795 ng/L, PFOA at concentrations up to 950 ng/L, and PFOS at concentations up to 2,140 ng/L were present within the groundwater. The PRZ was created using a series of 10 injection wells installed in a 10 foot grid configuration over the target injection area. The remedial reagents chosen to create the PRZ were CAC, polylactate, and mSZVI. Groundwater samples for the chlorinated ethenes and PFAS and other organic, inorganic, and biological parameters were collected over a 24-month period (two pre-injection samples, and Days 122, 248, 362, 547, and 724 post injection). Finally, cores were collected from the PRZ to evaluate the pre- and post-injection distribution of the reagents using total organic carbon (TOC) as an indicator as well as the horizontal hydraulic conductivity variability of the aquifer.

Results. The results from the two-year testing period suggested that the CAC, polylactate, and mSZVI were effective at attenuating the chlorinated ethenes and PFAS within the groundwater entering the PRZ. Sampling of the groundwater over a 24-month period indicated that the five PFAS detected within the groundwater prior to treatment were treated to either their detection or below the analytical detection limit over the monitoring period. Post-injection results for TCE, cis-1,2-DCE and vinyl chloride determined that the concentrations of the three compounds decreased by an order of magnitude within four months of injection with all ethenes decreasing by over 99 percent within 8 months of injection.

Analysis of soil cores collected pre- and post-injection indicated that the distribution of the CAC was influenced by small-scale heterogeneities within the aquifer. However, all aquifer samples collected within the targeted injection zone contained TOC at an average increase in concentration of greater than 1,000 percent compared to the pre-injection TOC concentrations.