Sulfidated Zerovalent Iron: An Innovative ISCR Technology for Discrete Source Remediation

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Background/Objectives. The overall objective of this ESTCP demonstration project is to evaluate sulfidated zerovalent iron (S-ZVI), an innovative in situ chemical reduction (ISCR) amendment, for treating residual chlorinated solvent sources. The advantages of S-ZVI have been extensively demonstrated in recent laboratory studies but have not been rigorously evaluated in the field. The specific technical objectives of this project include: (i) identify an effective S-ZVI formulation specifically tailored to site conditions; (ii) demonstrate the effective distribution of S-ZVI in the subsurface; and (iii) assess the long-term performance of S-ZVI for source treatment.

Approach/Activities. Laboratory treatability tests were carried out to identify the most appropriate S-ZVI using site material from the demonstration location (former Boeing University of Michigan Aeronautical Research Center [BOMARC] Missile Site) in Newport News, Virginia. Several ZVIs were initially screened in batch experiments that contained TCE (4 mg/L) and cDCE (12 mg/L) representative of site conditions. The two best performing S-ZVIs were then further assessed in column studies to not only determine reactivity but also examine longevity, column distribution and retention.

Results/Lessons Learned. Batch test results show significant reduction of TCE, but less reduction of cDCE, in most cases. The two best performing SZVIs in these tests based on reactivity and longevity were a commercial S-nZVI (Nanofer 25DS) and the sulfidated Ferox Target (S-mZVI), which were tested in the column test. Nanofer 25DS was injected into a column packed with aquifer solids, while the S-mZVI was mixed with aquifer solids and prepacked into the column. Injection of Nanofer 25DS showed addition of carboxymethyl cellulose (CMC) was necessary to achieve sufficient transport and distribution. With respect to CVOC degradation, both of these S-ZVIs (Nanofer 25DS and Ferox Target) showed significant removal (> 90%) of TCE in the column flow-through tests. However, only Nanofer 25DS showed significant cDCE reduction (~ 50%) and its reactivity also decreased over time. Stop-flow column experiments were then used to better simulate the field residence time, and the extent of cDCE reduction increased to greater than 80% under stop-flow conditions. After column operation, the columns were dissected to measure magnetic susceptibility and total iron. The results showed significant iron retention within the Nanofer 25DS column and the strong magnetic response indicates most of the remaining iron remained as Fe(0), indicating longevity of Nanofer 25DS.