

Side-by-Side Evaluation of Biogeochemical, ISCR and ERD Reagents for Treatment of CVOCs

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Background/Objectives. Reactive iron sulfide minerals may be formed in situ under sulfate reducing conditions and can be an important mechanism for chlorinated solvent removal during in situ chemical reduction (ISCR) and enhanced reductive dechlorination (ERD). This effect has been observed during the application of traditional ISCR and ERD substrates at sites with naturally high sulfate concentrations in groundwater, but may also be engineered by directly applying the needed building blocks. A potential key advantage of generating reactive minerals in situ as opposed to directly applying minerals or zero-valent iron (ZVI) as solid particles would be the potentially much greater surface area generated. Electron microprobe analyses performed on iron sulfide precipitation products collected one year after the application of organic carbon substrate and ferrous iron to a high sulfate aquifer showed that each 1.0 L of groundwater with sulfate at 3,000 mg/L generated about 4.7 ft² of very reactive FeS surface area. Furthermore, high CVOC degradation rates and exceptionally long-lasting results have been observed following the application of EHC[®] ISCR reagent at sites with high native concentrations of sulfate, but without any controls to quantitatively measure the contribution from biogeochemical reactions at those sites. The goal with this study was to evaluate the effectiveness of engineered biogeochemical systems relative to organic carbon and ISCR substrate alone at the bench.

Approach/Activities. Both liquid and solid biogeochemical reagent combinations were evaluated in a series of batch tests for the treatment of chlorinated ethenes. For each test, batch reactors were established with soil and groundwater and amended with various substrate combinations composed of ZVI, organic carbon substrate, ferrous iron and/or sulfate. Overall degradation rates achieved were compared to systems amended with organic carbon substrate (emulsified lecithin substrate, ELS[®]) alone or EHC ISCR reagent alone.

Results/Lessons Learned. The biogeochemical systems were overall found to support higher CVOC degradation rates compared to organic carbon substrate alone or ISCR alone. At the same dose rate, a solid biogeochemical reagent composed of organic carbon, ZVI and sulfate exhibited 67% higher removal rate relative to EHC for the treatment of 1,1-DCE. In another more comprehensive study, early results show 47% higher degradation rates in the solid biogeochemical system relative to ELS and 21% higher removal rates relative to EHC for the treatment of chlorinated ethenes (TCE and degradation products). The liquid biogeochemical reagent, combining soluble organic carbon substrate, ferrous iron and sulfate but without ZVI, exhibited 35% higher removal rates compared to traditional ERD. The generation of daughter products was in less than stoichiometric amounts for both solid and liquid biogeochemical systems indicating that an abiotic degradation pathway was promoted without the direct addition of ZVI.