Assessment of Biogeochemical Processes to Manage Back Diffusion at a Fractured Sandstone Site

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Background/Objectives. In situ remediation options for sites with contrasting adjacent permeability zones are limited by poor forward diffusion of treatment amendments from higher to lower permeability zones. A method to address contaminant back diffusion from low permeability zones is to emplace amendments with extended in situ longevity into mass flux zones. Biogeochemical treatment has been demonstrated to be an effective long-term treatment technology at several permeable barrier sites and at bedrock sites with limited primary permeability. Soluble amendment formulations that stimulate the formation of long-lasting reactive ferrous minerals are ideally suited for emplacement within thin mass flux zones without significant risk of blocking groundwater flow in these zones and potentially diverting plume flow to unaffected areas. This study aims to assess activity along biotic and abiotic degradation pathways in a chlorinated aliphatic hydrocarbon (CAH) affected fractured sandstone aquifer.

Approach/Activities. Characteristics of CAH plume distribution within the sandstone aquifer were well defined using traditional groundwater sampling techniques along with pumping, slug, and tracer tests, borehole geophysical logging, and laboratory analysis of sandstone core samples that included petrographic analysis and XRD, XRF, and SEM microscopy. Amendments consisting of ferrous iron, sulfate, fermentable electron donor, buffer, nutrients and an augment consisting of organohalide respiring microbes were injected into the aquifer to stimulate formation of reactive iron sulfide (FeS) minerals and bioremediation. Stimulative effects on degradation pathways were assessed by examining impacts on contaminant concentration and geochemistry. Compound specific isotope analysis (CSIA) was employed to confirm the degradation of target compounds and quantitative polymerase chain reaction (qPCR) was used to evaluate the microbial population. The combination of these conventional and advanced diagnostics provided an in-depth evaluation of active degradation pathways before and after the amendment application.

Results/Lessons Learned. Overall, contaminant concentrations decreased over the year-long performance monitoring period. Innocuous daughter products ethene, ethane, and acetylene were detected in groundwater samples and demonstrate degradation by organohalide respiring microbes and by ferrous iron minerals. Multiple lines of evidence were used to assess activity along these degradation pathways to determine if biogeochemical treatment can act to extend amendment application intervals and manage long-term back diffusion at the site. The data show mixed results with most sampling locations showing strong biotic degradation pathway trends. Forthcoming isotopic data from the last round of sampling, which coincided with a concentration rebound and decreasing indicators of bioactivity, will provide additional information to elicit activity along the abiotic pathway.