Biogeochemical Remediation at a Highly Fractured Bedrock Aquifer

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Background/Objectives. The objective of the project is to optimize the remedial outcome by stimulating the biogeochemical remediation of chlorinated solvents and 1,4-dioxane in a highly fractured bedrock aquifer, where in situ enhanced bioremediation (ISEB)/bioaugmentation was implemented via injection of emulsified vegetable oil (EVO) and SDC-9™ since November 2015. This bedrock aquifer contains a commingled plume of chlorinated ethenes, chlorinated ethanes, chlorinated methanes, and 1,4-dioxane. The commingled plume extends more than one mile from the source.

Five post-injection monitoring results between 2015 and 2017 indicated that effective reductions of chlorinated methanes were achieved. Chlorinated ethenes, especially cis-1,2-DCE, were reduced to moderate levels. A notable observation was that 2-foot thick iron precipitate built up at within injection wells and one downgradient well. Groundwater iron concentrations were up to 400 mg/L at the iron precipitate wells in 20 months after the injection. Concurrently, the sulfate levels were reduced from the site-wide 20 mg/L to less than detection in 3 months at the iron sludge wells. Coupling the geochemical changes and contaminant concentration trends, it was concluded that excessive biological mediated iron-reduction activity could be interfering with the effective biodegradation of the chlorinated ethenes. Further, due to the recent regulatory changes, 1,4-dioxane became a potential contaminant of concern. The impact of ISEB/bioaugmentation has been mixed for 1,4-dioxane.

Approach/Activities. Biogeochemical remediation can stimulate abiotic degradation through the active iron complexes, such as iron sulfide. Therefore, an innovative approach of stimulating biogeochemical processes to convert the negative impact from the excessive iron formation was tested. However, because of the generally low level of naturally occurring sulfate, it was determined that supplementing sulfate or sulfide could enhance the abiotic degradation of the site contaminants. A treatability study started in May 2017 at the Langan Treatability Facility at New Jersey Institute of Technology. A total five microcosm treatments including live control, killed control, bioaugmentation (EVO and SDC-9), sulfated amended (EVO, DHC, and Epsom salt), and sulfide amended (EVO, DHC, and calcium polysulfide) were performed. All microcosm bottles contained rock fragments, groundwater and trichloroethene spiked at 7 mg/L. Up to 7 microcosm sampling events are projected to be completed. Between the third and fourth events, ferrous iron chloride along with either Epsom sulfate or calcium polysulfide was amended to sulfate amended and sulfide amended treatments. The last phase of the study is to investigate 1,4-dioxane degradation in an existing and active biogeochemical system. The final treatability study results will be available before the end of 2017.

Results/Lessons Learned. In the sulfate and sulfide amended treatments, reduced conditions were generated much more rapidly than in the bioaugmentation microcosms. Similarly, higher alkalinity levels, more dissolved metal production, and lower pH were observed in the sulfate and sulfide amended treatments than these in bioaugmentation treatment. More rapid reduction of TCE was observed in the sulfate and sulfide amended treatments. However, the stall of cis-1,2-DCE seemed to be more prevalent in the sulfate and sulfide amended treatments. Meanwhile, the black precipitates formed initially had disappeared. Thus, additional alkaline reagent, ferrous iron, and sulfate or sulfide were amended into the sulfate and sulfide treatment on September 1. Black precipitates were observed within three days of the addition, suggesting that metal sulfide was formed.