Investigation of Biogeochemical Degradation Pathway of Chlorinated Aliphatic Hydrocarbons

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Background/Objectives. Historic chemical manufacturing operations at a facility located in South America have resulted in the release of chlorinated aliphatic hydrocarbons (CAHs) into soil and groundwater. Several laboratory and field investigative procedures were utilized to investigate the degradation of these CAHs via natural biotic and abiotic processes. These studies sought to identify the mechanism of degradation (if present) as well as the feasibility of utilizing these intrinsic degradation processes as part of an overall groundwater remedial approach. Specifically, the presence of reactive iron minerals and their correlation to observed degradation of CAHs was of primary interest.

Approach/Activities. Historic groundwater sampling data, to include volatiles analysis and various geochemical analyses were reviewed to establish an understanding of microbiological conditions. Soil was collected from the saturated zone in both pristine and impacted areas and analyzed for the presence of iron sulfides via chemical extraction and magnetic iron minerals via magnetic susceptibility. A laboratory microcosm study was performed using site soil and groundwater to investigate intrinsic abiotic/biotic degradation and the potential for in situ bioremediation via the addition of emulsified vegetable oil. The Biological Pathway Identification Criteria screening tool (BioPIC) was utilized to develop expectations regarding the use of the observed degradation pathways for full-scale remediation.

Results/Lessons Learned. Existing geochemical groundwater monitoring data demonstrate the presence of anaerobic conditions in impacted areas and CAH biotransformation. Areas containing elevated CAH concentrations in groundwater contained high ferrous iron, increased methane and decreased sulfate concentrations. Dechlorination daughter products typically produced during anaerobic biodegradation were also observed. The iron sulfide analysis of saturated soil determined that concentrations in impacted areas were over one order of magnitude higher than unimpacted areas. Coupled with the measured geochemical differences, these data suggest that iron sulfides are being formed in situ via biotic mechanisms. Saturated soil also had measurable levels of magnetic susceptibility. Abiotic control treatments of the microcosm study observed decreases in parent compounds, no increases in daughter products and increases in ethene. This may indicate that elevated iron sulfides and/or magnetic iron minerals are present and actively reducing CAHs. The biotic microcosms stimulated with emulsified vegetable oil yielded no significant accumulation of dechlorination byproducts despite their observation in site monitoring wells. Estimation of CAH half-life, derived using data provided within BioPIC, suggests that intrinsic degradation rates are insufficient for source areas, but may possibly be effective for lower concentration areas throughout the plume.