

Post-Bioremediation Bulk Vinyl Chloride Attenuation Rate Estimation in an Overburden Groundwater Aquifer in Kansas

Christopher J. Voci (chris.voci@terraphase.com) and **Alexandra Gulli** (Terraphase Engineering, Conshohocken, PA, USA)

Background/Objectives. Enhanced in situ bioremediation for the remediation of chlorinated ethenes in groundwater is a common remedial approach that is widely applied to degrade parent compounds like tetrachloroethene (PCE) and trichloroethene (TCE) to the innocuous daughter endpoint, ethene. The presence of the penultimate daughter product, vinyl chloride, can be transient and short-lived, but vinyl chloride can accumulate if its rate of conversion to ethene is lower than its production from cis-1,2-dichloroethene (cDCE). We calculated vinyl chloride and other chlorinated ethene degradation rates of a mature plume in an overburden aquifer in Kansas. This work was performed to support a risk-based site closure strategy by integrating our bulk attenuation rate estimates with our conceptual understanding of the overall chlorinated ethene plume behavior.

Approach/Activities. The study investigators were presented with an incomplete body of groundwater data collected over two decades, during which time an enhanced in situ bioremediation source treatment was implemented. An initial analysis of historical data trends was performed to update the conceptual site model and resolve the disposition of the site's chlorinated ethene sources and their associated dissolved groundwater plumes. Compound specific isotope analysis (CSIA) and molecular tests including vinyl chloride reductase (vcrA) gene testing were performed to assess degradation and quantify microorganisms critical in vinyl chloride degradation. The bulk attenuation rates were calculated using a linear regression of chlorinated ethenes and travel time along the groundwater plume transect. Together, the groundwater quality data, CSIA data and bulk attenuation rate estimates provided a holistic understanding of the groundwater plume behavior.

Results/Lessons Learned. The commercialization of enhanced in situ bioremediation products and methods has made the technology accessible to most environmental consulting firms. However, the outcomes of some applications are not well understood due to performance monitoring failure and a lack of rigorous scientific assessment after treatment. CSIA data provided a greater understanding of chlorinated ethene plume behavior on the Site. The data show two distinct TCE plumes based on the isotopically unique TCE sources. The primary shallow groundwater VOC plume wells have positive $\delta^{37}\text{Cl}$ and more negative $\delta^{13}\text{C}$ values, which is characteristic of an older source. The degradation rate constant for vinyl chloride, cDCE, TCE and PCE were 0.069, 0.016, 0.015 and 0.0126 per year, respectively.