

Long-Term Evaluation of Chlorinated Solvent Attenuation Rates in Groundwater

Mark L. Ferrey (mark.ferrey@state.mn.us) and Will Bouchard (Minnesota Pollution Control Agency, St. Paul, MN, USA)
John T. Wilson (Scissortail Environmental Solutions, LLC, Ada, OK, USA)

Background/Objectives. The former Twin Cities Army Ammunition Plant (TCAAP) is located north of St. Paul, Minnesota. Disposal of trichloroethylene (TCE) at the site resulted in extensive groundwater contamination. Remediation efforts included a soil vapor extraction system at the source area and a system of extraction wells at the site boundary. In 1999, groundwater contaminant modelling showed that natural attenuation was an important factor in limiting the magnitude and extent of the groundwater contamination. Subsequent microcosm studies with aquifer sediment revealed that abiotic degradation of the contaminants could explain the attenuation of cis-DCE observed at the site. In monitoring wells along the vertical axis of the plume, the average rate of attenuation over time was 0.3 yr^{-1} . Annual groundwater contaminant monitoring has continued at the TCAAP as part of the Record of Decision at the site. Contaminant concentration data was re-evaluated including years since the attenuation study to determine whether the rate of attenuation has stayed the same.

Approach/Activities. Data from monitoring wells at TCAAP were analyzed to determine long-term attenuation rates. These wells included those that were used in the natural attenuation study in 1999 with additional data up to 2020. Piecewise regressions were fit to the relationship between days from the start of monitoring and the natural log of TCE. Significant models ($p < 0.05$) were fit to data for 25 of the 29 wells with adjusted R-squared values ranging from 0.34 to 0.99. The most common relationship observed (20 wells) was a rapid decline in TCE with a slower decline following the determined changepoint. Other patterns observed were a decline in TCE with no lower breakpoint (3 wells) and an increase in TCE followed by a gradual decline in TCE following the changepoint (2 wells). For the wells with a rapid then slower decline, the breakpoint was observed from 2636 to 9058 days with an average of 4913 days.

These results may indicate a transition from the relatively rapid abiotic degradation in the outwash sands to a rate that reflects transport in the deeper dolomite formation where abiotic degradation of the contaminants is not expected to occur. While attenuation of the contaminants continues to occur in the groundwater, the observed rate change refines the site conceptual model and alters the original estimates of time to groundwater restoration.

Results/Lessons Learned. While monitored natural attenuation is not the selected remedy for the deep groundwater at TCAAP, this analysis demonstrates the utility of and the need for continued monitoring at sites where groundwater is contaminated with chlorinated solvents. Long-term monitoring is a key component of MNA. Observed changes in the rate of contaminant attenuation may alter the original estimates of the time of groundwater cleanup, the possible need for evaluation of additional remediation measures, and the conceptual model of contaminant transport in the aquifer.