Prolonged Effects from Short-Term In Situ Microcosm Deployment in Monitoring Wells at a Chlorinated Solvents Remediation Site

GROUP 2

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OBJECTIVES

Historical degreasing operations at an aircraft parts manufacturing facility located near St. Louis, Missouri, resulted in chlorinated solvent groundwater contamination that presented unacceptable risks to occupants of on-site industrial buildings and downgradient, off-site residential dwellings. Elevated levels of tetrachloroethylene (PCE), trichloroethylene (TCE), and their daughter products (i.e., cis-1,2-dichloroethylene [cis-1,2-DCE] and vinyl chloride) are present within the shallow saturated overburden and underlying bedrock. The groundwater plume extends from the area of the former degreaser at the facility into the adjacent residential and industrial/commercial areas to the south and southeast of the facility. Treatability studies were completed in 2020 within overburden (low-permeability clay) and shallow bedrock (shale) hydrostratigraphic units as part of the response action evaluation for the site. The dense, low permeability clay material that resides above the bedrock zone is a significant challenge at this site. Previous chemical injection applications have had limited success due to the characteristics of this material. Other in-situ treatment methods are expected to experience the same challenges. Treatability tests were completed to assess what alternatives would most efficiently reduce concentrations in this zone. One of the technologies selected for treatability testing was enhanced in situ bioremediation (EISB).

FIGURE 1: Aerial image of the facility and downgradient residential neighborhood. The condensed nature of the residential buildings provided unique challenges associated with equipment access for subsurface characterization activities.

ACTIVITIES

Several shallow overburden and shallow bedrock monitoring wells, located in both source and plume treatment areas, were selected for evaluation during the EISB treatability study. In-well sampler units were used to conduct in situ microcosms that evaluated the presence and activity of multiple degradation mechanisms in each well. Each in situ microcosm assembly included three individual units:

- A monitored natural attenuation (MNA) unit containing only unamended media.
- A biostimulation (BioStim) unit containing media amended with electron donor.
- A bioaugmentation (BioAug) unit containing media amended with electron donor and inoculated with a microbial culture.

The microcosm units were deployed for approximately 75 days to allow the sample media to reach equilibrium with ambient aquifer conditions, including the formation of representative microbial colonies. Upon retrieval, the sampler units were submitted to a laboratory for analysis of microbial, chemical and geochemical parameters.

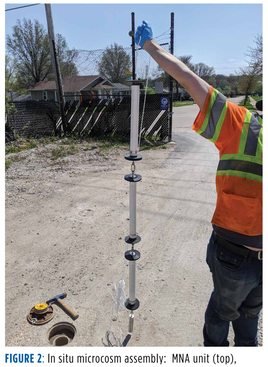


FIGURE 2: In situ microcosm assembly: MNA unit (top), BioStim unit (middle), bioaugmentation unit (bottom).

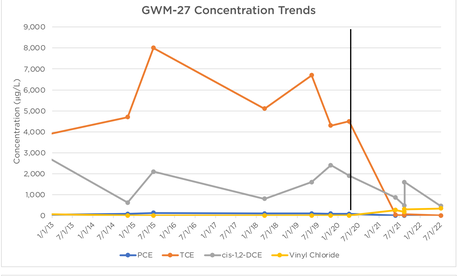
FIGURE 3: In situ microcosm assembly being lowered into monitoring well.

FIGURE 4: In situ microcosm retrieval and disassembly to obtain samples for laboratory analysis.

FIGURE 5: Filling laboratory containers from passive sampling bags deployed in the monitoring well.

RESULTS AND LESSONS LEARNED

The results of the EISB treatability study generally indicated that EISB could meet the cleanup goals for the groundwater plume, assuming adequate distribution of nutrients into the low permeability clay material. The MNA and BioStim units showed potential of biodegradation with generally increased biological activity in BioStim units. However, the BioAug units showed levels of biodegradation that were often orders of magnitude higher than those achieved in the MNA unit. Based on this study, the combined addition of an electron donor and bioagumentation culture offered the greatest potential for growth and survival of microbial populations responsible for complete anaerobic reductive dechlorination of site contaminants.



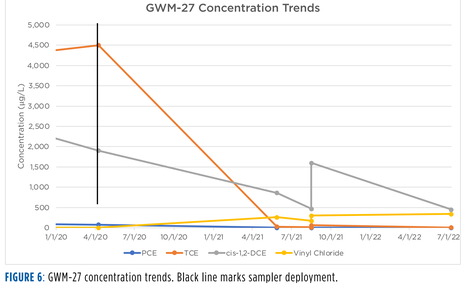


FIGURE 6: GWM-27 concentration trends. Black line marks sampler deployment.

Typically, the effects of sampler deployment are short-lived and wells are anticipated to return to background conditions in a relatively short time. However, prolonged effects have been detected in these wells since deployment in 2020. PCE and TCE concentrations have been significantly reduced in these wells. Additional sampling for microbial populations was conducted in 2021. The sampling indicated that the microbial communities introduced in the BioAug units continued to thrive and proliferate in the wells where the samplers had been previously deployed. The BioAug culture also significantly raised the concentration of microbial strains capable of degrading vinyl chloride over the course of the deployment; more detections of indigenous strains were observed in the August 2021 sampling event. It is presumed that the effects of sampler deployment have persisted due to the initial presence of contaminant-degrading microbes at the site, low groundwater flux, and site conditions that are favorable for microbial growth.

Based on these results, in situ microcosms — like the ones used in this evaluation — may be effective on specific low groundwater flux sites as a low-cost, passive MNA enhancement option.