Advancements in Remedial Performance Assessments at Complex Sites with Incorporation of Advanced Data Analytics and Innovative Characterization Tools

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Background/Objectives. Remediation of complex sites typically requires years to decades of active treatment followed by decades of monitored natural attenuation (MNA). Often multiple remedial technologies are implemented, either in tandem or in treatment trains. As such, these sites often have a long history of monitoring data that have been compiled over the years. This historical dataset can provide a treasure trove of information that can significantly enhance the conceptual site model (CSM), which in turn can lead to more informed remedial decisions. Supplementation of this dataset with advanced diagnostic tools such as molecular biological tools (MBTs), treatability studies, or compound-specific isotope analysis (CSIA) and selective detailed characterization of sources can further enhance the CSM to allow for identification of areas where MNA is proceeding well and areas where implementing more active remediation may lead to cost savings over the long term.

Approach/Activities. A multiple lines of evidence approach has been taken at a complex site to better understand the contaminant attenuation mechanisms, variability in decay rates, plume persistence drivers, and source decay rates. Historical data mining has been completed to identify areas of stable, growing, or attenuating plumes, and plume attenuation/source decay models were fitted to concentrations and dissolved mass temporal changes. This information was used to identify areas of the plumes and sources where attenuation behavior differed, and source mass decay models were incorporated into numerical models to better represent concentration changes within the sources over time as the DNAPL attenuates. Limited additional characterization was undertaken to address data gaps. Treatability studies were undertaken along with expanded groundwater geochemical analyses (monitored natural attenuation parameters), soil coring and subsampling to quantify reactive iron species (that drive abiotic degradation mechanisms) and identify soil parameters driving sorption/desorption, detailed microbial community profiling using next generation sequencing (NGS) and quantitative polymerase chain reaction (qPCR) analysis, and compound specific isotope analysis (CSIA) to better quantify degradation rates.

Results/Lessons Learned. The incorporation of advanced data analytics and advanced tools provided several insights that have improved remedial performance monitoring to focus on key information driving long-term plume persistence. For example, significant variability in microbial diversity, attenuation mechanisms and rates (over a matter of meters) was observed and appeared to be driven by inhibitory factors (e.g., high chloroform concentrations) and/or presence of organic matter (providing electron donors but also driving sorptive behavior); highlighting the need to monitor areas/depths of rapid and slow attenuation. Rapid attenuation of a parent product (carbon tetrachloride) was observed, which was previously thought to be the longer-term remedial driver, and the likely longer-term remedial driver (tetrachloroethene; PCE) was identified, which resulted in a modification of data collection activities to also monitor PCE source areas. Desorption was identified as a primary plume persistence mechanism for ethylene dichloride, highlighting the importance of sorption as a secondary source.