Use of MBTs for Decision-Making Following Thermal Remedy

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Background/Objectives. Source area remediation for chlorinated volatile organic compounds (cVOCs) including tetrachloroethene (PCE) and carbon tetrachloride (CT) in fractured bedrock was achieved via electrical resistance heating (ERH), resulting in approximately 95% removal of PCE and 100% of the CT. Due to the residual PCE concentrations at greater than part per million within the source area and large dissolved plume extending beyond the source area, the remedial strategy for the Site contemplated additional remedial polishing actions. The approach for post-ERH remedial action in the source area was evaluated using a variety of molecular biological tools (MBTs) to determine the need and timing of additional remedial amendments to achieve the Site remedial goals.

Approach/Activities. We now have MBTs in our toolbox that give us the ability to identify intrinsic bacterial populations, such as the determination of specific dehalococcoides (DHC)/dehalobacter (DHB) species populations, and the genus level and the biomass bacterial species, to provide insight into alternative metabolic pathways for intrinsic and/or enhanced in-situ biodegradation from the implementation of remedial technologies at complex sites. These advanced MBTs enable the:

- Ability to obtain a snapshot of biological populations to make decisions on remedial progress,
- Ability to predict when to amend the subsurface conditions to enhance the growth of the "right bugs" following aggressive remedial technology applications,
- Ability to identify additional bacterial populations that may be useful in the biodegradation of the site contaminants via direct or indirect pathways.

Source area and downgradient plume groundwater samples were collected for the determination of the bacterial populations via biomass quantitative polymerase chain reaction (qPCR),) and spp. population densities, 16S ribosomal gene sequencing, and "shotgun" metagenomic gene sequencing. The data has been evaluated to determine how the thermal remediation affected the site conditions to enhance or inhibit the intrinsic bacterial populations and if there are viable amendments that could be introduced to the subsurface that would stimulate the identified bacterial species to further reduce the remaining cVOC concentrations present in the source area and downgradient groundwater plumes. More importantly, the data has been evaluated to determine the appropriate timing of additional remedial polishing actions.

Results/Lessons Learned. A cost-effective program of MBT analyses was designed for evaluation purposes. The biological testing conducted showed that thermophilic bacterial populations were predominant in both the source area wells as well as in the downgradient groundwater plume even after a year from ERH shutdown. The project team utilized the MBT data to determine if and/or when the need for additional remedial actions are necessary to enhance the natural attenuation of the residual cVOCs in the fractured bedrock matrix. Additional lessons learned include consideration of seasonal and equipment-related variability of the temperature data.