Assessing Impact of Mechanical Remediation Systems on Natural Attenuation Using Tetrahedral Analysis

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BTEX analytical data are collected for petroleum hydrocarbon-contaminated sites that are undergoing active remediation using mechanical systems such as multi-phase extraction (MPE), air sparging (AS) and/or soil vapor extraction (SVE). While BTEX concentration-time series plots can be used to assess performance effectiveness of these systems, these data do not assist in understanding the reasons for concentration changes over time or space. During a mechanical remediation system operation, BTEX concentrations can be impacted by physical processes such dilution, diffusion, sorption, and volatilization but also by co-occurring processes like biodegradation related to enhanced air exchange within the target zone. This understanding is relevant for optimization of mechanical remediation systems, to ascertain timing of system shutdown and manage expectations for monitored natural attenuation as a polishing step post-shutdown. Utilizing the existing BTEX data for performing tetrahedral analyses to address these objectives is a cost-effective strategy.

Tetrahedral plot is a three-dimensional (3-D), simultaneous plotting of BTEX molar fractions in the aqueous or vapor phases that can provide insights that concentration-time series data cannot. These rotatable 3-D plots are constructed by translating relative BTEX fractions on to a 2-D plane with one vertex each of the tetrahedral occupied by BTE or X. Using this approach, existing data from multiple PHC-contaminated sites that have undergone MPE or AS/SVE remediation are analyzed using the tetrahedral approach to help understand existing removal processes. Theoretical curves for known transformation processes relevant to mechanical systems (i.e., aerobic biodegradation) and physical removal processes (i.e., volatilization) can be similarly generated to establish expected trends from these processes. The 3-D analyses can help to evaluate the co-occurring removal processes, the impact of mechanical remediation systems on MNA and provide supporting evidence for MNA post-remediation.

Impact of mechanical systems on natural attenuation and underlying contaminant removal process can be potentially evaluated utilizing tetrahedral analyses. Understanding of these underlying processes can help in optimization of mechanical remediation systems, to inform timing of system shutdown along with mass removal trends and to allow understanding of the potential for MNA post-shutdown. Tetrahedral analyses offer a cost-effectiveness opportunity to address these potential goals at typical mechanical remediation sites.