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# Innovative Use of Tetrahedral Plots to Evaluate Remedial Performance and Pre-Screen Monitoring Wells at Petroleum Hydrocarbon-Contaminated Sites

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**Background/Objectives.** BTEX analytical data are generally available at petroleum hydrocarbon-contaminated sites and typically constitute a regulatory driver for monitoring and/or remediation at those sites. BTEX concentration-time series plots or equivalent spatial plots can convey plume stability characteristics, but typically do not provide information that helps assess the reasons for concentration changes over time or space. Concentration data can be affected by physical processes (e.g., dilution, diffusion, sorption, and volatilization) as well as by processes that include chemical transformations (e.g., biodegradation, chemical oxidation). Distinguishing between the two types of processes is not only relevant for demonstration of monitored natural attenuation or evaluation of remedial performance for engineered remediation systems, but also useful in understanding of the existing site conditions. Ability to monitor the progress of a remedial strategy or the site conditions and to screen locations for further diagnostics by using already available or collected data is an attractive and cost-effective proposition which can be realized through the proposed tetrahedral plots.

**Approach/Activities.** 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 two-dimensional (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 were plotted temporally and/or spatially to assess trends and to develop understanding of existing removal processes. Theoretical curves for known transformation processes (i.e., aerobic and anaerobic biodegradation) and physical removal processes (i.e., volatilization) can also be similarly generated to establish expected trends from these processes and used in conjunction with geochemical data. For some sites, the 3-D illustration can potentially become a part of MNA evaluation and supporting arguments. Similarly, the tetrahedral plots for the sites with active remediation systems could assist with evaluation of remedial performance by following changes to the 3-D curves for pre- and post-treatment data. Significantly, specific well locations at these sites can be examined and pre-screened for their suitability for further diagnostic evaluation using more advanced but expensive tools such as compound-specific isotope analysis (CSIA) or molecular biological tools (MBTs).

**Results/Lessons Learned.** Tetrahedral plotting of BTEX data can potentially provide insights into removal mechanisms and spatial and temporal trends beyond those captured by concentration-time series data. These plots can be used to assess and optimize remedial performance via better understanding of responsive wells and timely intervention to support system shutdown. Complementing the geochemical data, these illustrations can also act as pre-screening tools for selection of sampling locations for further advanced diagnostic including CSIA or MBTs which are efficacious albeit expensive.