Molarity Provides Better Clarity: Using Molar-Based Data for Evaluating Chlorinated Volatile Organic Compound-Impacted Sites

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Background/Objectives. When evaluating chlorinated volatile organic compounds CVOC plume behavior, care should be taken in how the data are evaluated. For example, most CVOC sites are comprised of families of compounds where parent compounds degrade into daughter compounds. The authors have observed that at a vast majority of groundwater assessment and remediation sites, CVOC families and individual compounds are evaluated on a weight concentration basis (e.g., µg/L). When evaluating the behavior of CVOC families, it is not uncommon for practitioners to evaluate degradation or sourcing trends by adding up the weight concentrations (e.g., µg/L) of each CVOC species detected in groundwater and reporting the data as "total CVOCs". While this is a common approach in the environmental industry, it is not necessarily the most accurate approach and can lead to misinterpretation of the data with unintended consequences.

Approach/Activities. In lieu of, or in conjunction with, evaluating CVOC data on a weight basis, it is more accurate and useful to evaluate CVOC data on a molar basis. This is especially the case when evaluating the degradation of parent compounds to daughter compounds for contaminant "families" such as chlorinated ethenes, ethanes, and methanes. This session will present easy to understand examples and analogies that describe degradation of chlorinated ethenes, although the principles described would apply to any family of parent-daughter degradation sequences. Using engineering principles, rates of contaminant accumulation and decay can be determined from site analytical data. The analysis presented is based on molar mass within a groundwater plume, and accumulation and net decay rates are determined for each species in the degradation sequence. An important application of molar based analysis is detecting a stall in the degradation sequence. Oftentimes, observed increasing trends in concentrations of daughter products is interpreted as a stall in degradation (e.g., "DCE stall"). By assessing individual constituent loading and accumulation on a molar basis, an evaluation of the existence and degree of a stall in degradation, if any, can be determined.

In addition, molar analysis provides a better understanding of plume attenuation. A common misconception is that a reduction in "total CVOCs" on a weight-based concentration (e.g., µg/L) basis is evidence of attenuation, which is not always the case. However, a reduction or increase in total molar-based concentration of CVOCs is strong evidence of attenuation or sourcing, respectively. Furthermore, molar ratio patterns within a plume will provide insight into the nature of attenuation observed whether natural (biological or abiotic degradation) or anthropogenic.

Results/Lessons Learned. The principles of molar data analysis will be demonstrated through a case study of the Chem-Dyne Superfund Site in Hamilton, Ohio. A groundwater pump and treat (P&T) system was installed at the site in 1987. The P&T system, consisting of 25 extraction wells, operated from 1987 through June 2015, at which time the system was shut down as part of a pilot test to evaluate the efficacy of monitored natural attenuation (MNA) as a final remedial action for the remaining VOC plume. The results of the pilot test demonstrating natural biodegradation (including accumulation and decay rates) of CVOCs will be presented.