

## **Making NSZD-Related Decisions in the Context of Measurement Uncertainty: Common Sources of NSZD Rate Measurement Error**

*Julio A. Zimbron*, Ph.D. (jzimbron@soilgasflux.com) (E-Flux, LLC, Fort Collins, CO, USA)

**Background/Objectives.** Light non-aqueous liquid (LNAPL) contaminated sites still make up a large portion of the world-wide environmental liabilities. While many remedial technologies are available to deal with these sites, biodegradation-mediated natural source zone depletion (NSZD) is gaining widespread use, both as a candidate remedy and as a reference to evaluate the efficiency of active remedies.

NSZD has become a widely accepted remedial strategy for mid- to late-stage petroleum-impacted sites. Several technical guidance documents, including API (2017) and ITRC (2018), address the implementation of NSZD and the importance of including NSZD processes in the development of a site conceptual model for petroleum-impacted locations. The availability of multiple methods to measure NSZD rates at field sites has been a major factor contributing to these developments. Most available methods measure NSZD rates as total contaminant mass losses based on mass or energy balances on biodegradation byproducts (i.e., carbon dioxide or heat).

This presentation will address common error sources on the application of multiple methods to measure NSZD rates. Best practices that help achieve a degree of measurement uncertainty commensurate with different measurement objectives will be discussed.

**Approach/Activities.** Three examples will be presented to illustrate sources of common measurement error of NSZD field rates: a) the use of background correction versus a radiocarbon-based location specific correction for a mass balance method based on CO<sub>2</sub> efflux measurements; b) the error sources from short-term versus long-term measurements based on CO<sub>2</sub> efflux measurements; and c) the use of a background correction versus a single stick method for a heat balance method. These examples will be illustrated with site data. Practices that help control different error sources will be discussed.

**Results/Lessons Learned.** Among the different methods available, each method can control some error sources and is susceptible to others. Awareness of the specific traits of each method will allow practitioners to select methods compatible with the monitoring goals for each contaminated site and remedial stage combination.