Results of Multi-Year Study on Methods for Estimation of NSZD Rates under Natural and Solarization Conditions

Ian Hers, Parisa Jourabchi, Anne Wozney, and Ehsan Pasha (ihers@golder.com)
(Golder Associates, Ltd., Vancouver, BC, Canada)
Harley Hopkins (ExxonMobilEnvironmental & Property Solutions, Spring, TX, USA)
Sean Mercer (Imperial, Sarnia, Ontario, Canada)
Colleen Gosse and Nick Nickerson (EoSense, Dartmouth, Nova Scotia, Canada)

Background/Objectives. Natural source zone depletion (NSZD) is increasingly being considered in evaluations of remedial alternatives for management of sites impacted with petroleum hydrocarbons (PHCs). Multiple methods may be used to estimate NSZD rates. Aerobic and anaerobic biodegradation reactions produce CO_2 resulting in elevated CO_2 efflux at the ground surface, which may be measured using flux chambers or static traps. Aerobic biodegradation of hydrocarbons produces heat and consequently NSZD rates may be estimated from thermal gradients. NSZD rates may also be estimated from soil gas concentration gradients. Field trials are needed to test and compare these methods and improve understanding of seasonal variations and site conditions. There is also interest in the use of enhanced bioremediation such as solarization and bioventing to accelerate mass depletion rates and affect compositional change. The objectives of this research are to identify improved methods for estimation of NSZD rates, to better understand key factors affecting rates and to assess solarization and bioventing as technologies to enhance natural biodegradation rates.

Approach/Activities. A comprehensive, multi-year study that involves multiple field trials and monitoring campaigns is being conducted in one area of a former refinery. There is shallow petroleum hydrocarbon contamination (generally between 1-4 m depth) and silty to sandy soil. An initial comparison of dynamic closed chamber (DCC) and static trap tests were performed and seasonal DCC testing was conducted to enable the influence of moisture content and temperature on CO_2 efflux to be assessed. A novel method for quantifying the contribution of natural respiration on efflux was developed based on radiocarbon testing and a two-component mass balance. More recently the site was instrumented with continuous CO_2 efflux sensors (forced diffusion type), digital thermistors, multi-depth soil gas probes and soil moisture sensors and weather station. Laboratory testing of soil samples for thermal conductivity was performed. After baseline data were obtained, a solarization plot consisting of plastic placed on the ground surface was constructed to assess the effect of increased subsurface temperature on biodegradation rates.

Results/Lessons Learned. Practical lessons learned on instrumentation are described with respect to types of equipment, installation procedures, data logging and telemetry, power requirements (all equipment is solar powered) and costs. Relative good correlations of CO_2 efflux between DCC and static trap and DCC and forced diffusion sensors were completed. Repeat DCC monitoring indicated the importance of soil moisture and seasonal conditions on efflux measurements. The continuous CO_2 efflux measurements were highly valuable in understanding diurnal efflux trends and synoptic or periodic events at test locations above contamination and at background locations. Based on the data obtained, the three main methods for evaluating NSZD rates, CO_2 efflux, soil gas gradient and temperature, are compared and contrasted. The construction of the solarization cell and initial results for monitoring temperature and soil gas conditions below the cell are described.