Bioremediation and Sustainable Environmental Technologies—2017. Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies (Miami, FL; May 2017). ©2017 Battelle Memorial Institute, Columbus, OH, www.battelle.org/biosymp. A. Barton and S. Rosansky (Chairs)

Use of MIN3P-Dusty Numerical Model to Simulate Rates of LNAPL Depletion for Natural and Bioventing Conditions

Ian Hers (ihers@golder.com) and Parisa Jourabchi (Golder Associates, Ltd., Vancouver, BC, Canada)
Andrew Kirkman (BP Remediation Management, Naperville, IL, USA)
Ulrich Mayer (University of British Columbia, Vancouver, BC, Canada)
John Wilson (Scissortail Environmental Solutions, Ada, OK, USA)

Background/Objectives. Natural source zone depletion (NSZD) is a significant process for LNAPL mass depletion and compositional change at many petroleum hydrocarbon impacted sites. While NSZD can be an effective and sustainable approach for management of petroleum hydrocarbon impacts, enhanced attenuation through oxygen delivery from bioventing is of interest because of its potential to accelerate LNAPL mass depletion and compositional change during early stages of the remediation process. Bioventing potentially represents a large cost savings compared to liquid recovery by pumping and not only degrades the mobile fraction of LNAPL but also the residual fraction of LNAPL. There are few published studies that include comparisons of NSZD and enhanced attenuation rates to the presumptive LNAPL recovery technologies, or that provide a basis for quantifying the relative benefit of LNAPL remediation technologies including NSZD. The objective of this study is to develop an improved mechanistic or process-based understanding of LNAPL depletion using the MIN3P-Dusty numerical model under natural and bioventing conditions for representative ranges of site and contaminant conditions and to compare model predicted rates to typical liquid recovery rates.

Approach/Activities. Bioventing technology has existed since the 1990's; the approach here is conceptually different because the goal is to develop a new metric for bioventing based on enhanced LNAPL depletion as informed by model simulations. The MIN3P-Dusty model offers significant capabilities for multi-dimensional simulation of natural and enhanced LNAPL depletion and compositional change from biodegradation, volatilization and dissolution using a process-based multicomponent modeling approach. The model is used to simulate a baseline NSZD scenario and bioventing scenario with air injection. LNAPL composition is modeled using surrogates to represent key hydrocarbon components (alkanes and aromatics) and markers (isoprenoids) representative of weather fuel releases at refinery sites. The approach to model validation is comparing model predicted to available measured surface gas efflux and LNAPL depletion rates for a typical range of conditions (synthesized data set characteristic of refineries) and for case study sites. MIN3P-Dusty simulation results were also compared to LNAPL depletion rates predicted by the Vadose Zone Biodegradation Loss (VZBL) model, a 1-D model for simulating aerobic and anaerobic processes by the gradient method.

Results/Lessons Learned. [to be updated when modelling is completed]: New insights are provided on LNAPL depletion rates for typical range of site conditions under natural and bioventing conditions and on relative change in rates during the project life-cycle (i.e., when NSZD may become a more sustainable option). Model simulations indicate the potential importance for correcting for natural respiration when estimating NSZD rates. The differences in degradation behavior with respect to importance of anaerobic versus aerobic processes is compared for NSZD and bioventing simulations. The key factors affecting mass depletion for bioventing include vertical LNAPL distribution relative to the water table, soil moisture content and biodegradation rate. The MIN3P-Dusty model simulations also show how bioventing system design can be optimized and provide data that can be used to help design soil gas and surface gas efflux monitoring programs.