THE EFFECT OF SOIL HETEROGENEITY ON DISSOLUTION AND MICROBIAL KINETICS DURING ENHANCED BIOREMEDIATION OF DNAPL SOURCE ZONES

Amalia Kokkinaki, University of Toronto, 416-978-6069, a.kokkinaki@utoronto.ca

1. Amalia Kokkinaki, University of Toronto
2. Brent E. Sleep, University of Toronto

The application of enhanced bioremediation at DNAPL source zones has been shown to increase the dissolution of DNAPLs to the aqueous phase and to accelerate source zone depletion. This is achieved by promoting microbial reactions that reduce the contaminant aqueous concentrations and thereby increase the concentration gradients at the DNAPL-water interfaces. While there are many studies on enhanced bioremediation that examine the effect of microbial reaction rates on dissolution rates, the effect of dissolution kinetics on microbial reaction rates has received less attention. The latter effect can be critical, since rate - limited dissolution can significantly reduce the availability of the contaminant, thus reducing the attainable reaction rates and the potential enhancement of DNAPL dissolution due to reaction. Common modeling assumptions, such as constant dissolution rate coefficients or equilibrium conditions, tend to overpredict DNAPL depletion, especially when soil heterogeneity introduces variations in the groundwater flow field and the corresponding DNAPL source zone architecture.

In this study, enhanced bioremediation of a trichloroethene (TCE) DNAPL source zone located in a heterogeneous aquifer is simulated. Simulations are performed using CompSim, a finite differences multi-phase groundwater model. DNAPL dissolution is modeled according to a linear driving force model, which explicitly links the dissolution rate coefficient with the changing interfacial area between the DNAPL and water phase. In this way, the temporal and spatial variations in the DNAPL distribution caused by soil heterogeneity are reflected in the dissolution rates, and result in a non-uniform plume emanating from the DNAPL source zone. The simulated TCE plume is sequentially reduced to less chlorinated compounds using Monod kinetics.

The model is used to investigate how the varying dissolution rates caused by soil heterogeneity affect the kinetics of reaction and microbial growth and what are the implications for the effectiveness of enhanced bioremediation. Soil heterogeneity is represented by spatially correlated random permeability fields. Various small- and large- scale heterogeneity scenarios are simulated and relationships between permeability spatial statistics and key remediation performance measures are shown. Finally, the employed dissolution model is compared to simpler, less computationally intensive dissolution models and implications of using the various approaches are discussed.