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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION RESEARCH

Impacts of DNAPL Source Zone Treatment: Experimental and Modeling Assessment of Benefits of Partial Source Removal

Background

Innovative source-zone treatment technologies that offer cost-effective risk reduction are needed at thousands of public and private sites impacted by dense nonaqueous-phase liquids (DNAPLs). Because the cost of source-zone treatment is high, the anticipated benefits need to be understood before significant resources are committed to source-zone removal. Because it is not economically practical to remove all DNAPL mass from many source zones, the focus of this project is on the likely benefits from partial DNAPL mass removal using an aggressive in situ technology (e.g., alcohol or surfactant flushing, thermal treatment, air sparging, and chemical oxidation).

Objectives

The primary goal of this research is to develop a scientifically defensible approach for assessing the long-term environmental benefits of DNAPL removal from source zones. The premise is that contaminant flux from the source should be used as the basis for evaluating the effectiveness of remediation.

Project objectives are to:

- Characterize the functional relationship between DNAPL architecture, mass removal, and contaminant mass flux in laboratory aquifer models under well-defined conditions
- Assess the response to DNAPL mass removal through mass flux and plume behavior at several field sites
- Develop and evaluate numerical simulators for describing the relationship between DNAPL removal, mass flux, and subsequent plume response for the laboratory and field systems
- Compile statistics on the general relationship between partial DNAPL removal and contaminant flux reduction for simulations of several hydrogeologic templates of actual field sites

Approach

An integrated approach, composed of laboratory experiments, field observations, and numerical simulations, will be used. To evaluate the functional relationships between DNAPL mass reduction, contaminant mass flux, and plume behavior, data from selected DNAPL source zone remediation field tests using a variety of source remediation technologies (refer to Table 1) will be used to demonstrate the ability of selected numerical simulators to realistically forecast the performance of remedial activities. Codes such as T2VOC and UTCHEM will be used to simulate remediation processes during steam, surfactant, or co-solvent flooding, and to predict the temporal and spatial distribution of contaminant flux leaving the source zone.

Table 1: Field Site Source Remediation Technology

Hill Air Force Base, Operable Unit 2	Surfactant flushing
Fort Lewis East Gate Disposal Yard	Resistive heating
Dover National Test Site	Co-solvent and surfactant flushing, air sparging
Borden Canadian Forces Base	Surfactant-enhanced air sparging
Sages Dry Cleaner	Co-solvent flushing

Laboratory studies will be conducted to supplement existing field data and to further assess the relationship between mass removal and resultant contaminant flux for a broad range of hydrogeological conditions. Contaminant flux distributions generated with these laboratory and field-tested models will be used as input to dissolved-plume models to forecast the natural or enhanced attenuation expected within the plume. Plume transport simulations will be carried out using codes that simulate aqueous-phase transport explicitly coupled with important geochemical and biological reactions.

Coupling these two types of modeling approaches at the interface of the DNAPL source zone and the dissolved plume is a new approach that is computationally efficient and incorporates the dominant physical, chemical, and biological features in each region.

Accomplishments

- Measured pre- and post-treatment contaminant mass fluxes at Hill Air Force Base, Operable Unit 2, and Dover National Test Site
- Measured pre-treatment flux at Fort Lewis East Gate Disposal Yard
- Initiated laboratory studies to evaluate the influences of hydrodynamic heterogeneity, DNAPL architecture, and remedial technology on the relationship between DNAPL mass reduction and contaminant mass flux

Wood, A.L., M.D. Annable, J.W. Jawitz, C.G. Enfield, R.W. Falta, M.N. Goltz, and P.S.C. Rao. (Submitted). "Impact of DNAPL Source Treatment on Contaminant Mass Flux." Presentation, Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California.

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