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High Resolution Delineation of Chlorinated Solvent Concentrations, Biogeochemical Processes, and Microbial Communities in Saturated Subsurface Environments

Haley Schneider (haley.a.schneider@ttu.edu) and W. Andrew Jackson (Texas Tech University, Lubbock, TX, USA)
Paul B. Hatzinger and Paul Koster van Groos (CB&I Federal Services, Lawrenceville, NJ, USA)

Background/Objectives. The primary objective of this SERDP research effort is to develop a high resolution passive profiler (HRPP) to quantify and delineate the distribution of chlorinated solvents, hydrogeologic conditions, geochemistry, and microbial community activity at fine scale within a complex layered aquifer. In particular, focus is placed on discerning differences in contaminant distribution and fate between low permeability and high permeability zones within stratified or heterogeneous media. Groundwater profilers are not a new concept in site remediation studies, but no design up to this point combines concentration data with microbial numbers and types, groundwater and contaminant flux, and contaminant degradation at centimeter scale resolution. The proposed design is also intended for direct push insertion into an aquifer, which is more cost effective than traditional methods requiring the installation of groundwater wells. We combine laboratory studies with field evaluations to demonstrate this technology.

Approach/Activities. The prediction of chlorinated solvent fate and transport in aquifers is often limited by the heterogeneity associated with the flow field, uncertain contaminant distribution, and an inability to accurately quantify relevant biotic and abiotic reactions. Processes occurring in low permeability zones are particularly important because contaminants residing in such materials can sustain groundwater plumes and impede overall contaminant attenuation. Groundwater in traditional monitoring wells is typically mixed across layers and derived largely from higher conductivity zones, making it difficult to distinguish and predict properties in low permeability soil layers in an aquifer. Therefore, methods are required that yield data in low permeability zones at a high resolution. This experimental approach consists of developing a HRPP designed to determine contaminant concentration and flux, groundwater velocity, microbial community structure, and, based on compound specific isotope analysis (CSIA), the potential for abiotic/biotic contaminant degradation *in situ* at the centimeter scale. This project consists of the following key components: (1) designing a HRPP that has been inserted via direct push at a total depth of at least 15 meters in an aquifer; (2) incorporating solid media that has proven effective in adsorbing contaminants for CSIA analysis and promoting bacterial attachment and growth to evaluate microbial communities at centimeter intervals; (3) using conservative tracers to determine hydraulic and contaminant fluxes.

Results/Lessons Learned. We have successfully correlated measured mass transfer coefficients with groundwater velocity in laboratory flow cells and validated these correlations in an initial field trial. During this initial field trial at a military site in New Jersey, microbial communities involved in reductive dechlorination were observed to vary appreciably over the depth of a highly stratified aquifer and to vary significantly from similar data obtained from nearby monitoring wells. Field deployments of the HRPP (~8 meters BGS) were able to produce chlorinated solvent concentration profiles and geochemical indicators (NO_3^-, SO_4^{2-}, Cl^-) at high resolution (~1 sample per 10 cm). A second field trial is currently underway at a US Navy site in California with an improved HRPP design. These data will be presented in addition to those from the first field trial.