

NCER STAR GRANT ANNUAL REPORT

Date of Report: 30 August, 2002
EPA Agreement Number: R828771-0-01
Center Name/Institution of Director: Center for Hazardous Substances in Urban Environments, Johns Hopkins University
Identifier Used by Center for Project: RP #3
Title of Project: Geochemistry, Biochemistry, and Surface/Groundwater Interactions for As, Cr, Ni, Zn, and Cd with Applications to Contaminated Waterfronts
Investigator(s) and Institution(s): Barth F. Smets, University of Connecticut; Allison A. MacKay, University of Connecticut
Type of Research: Basic Research (Field and Laboratory)
Project Period: October 1, 2001 to September 30, 2003

Background/Objectives of Research:

Many industrial and urban sites with subsurface contamination are characterized by shallow aquifers that discharge to nearby surface water bodies. In such cases, pore water in the stream or pond sediments contain a mixture of surface water and groundwater and are herein referred to as the groundwater/surface water interface (GSI). There is little understanding of the extent to which groundwater contaminants may be immobilized in the GSI, or discharged to the surface water column. Studies in Montana have shown that high pH, oxygenated surface water induces precipitation of iron and manganese oxides and sorption of heavy metals from discharging groundwater (e.g., Fuller & Harvey (2000) Environ. Sci Technol., 34: 1150-1155). Biological processes may also be important in the GSI due to the greater abundance of nutrients in stream sediments than in groundwater zones. Thus, GSI processes may play an important role in attenuating groundwater contaminant discharges to surface water bodies.

The objectives of this research project are to identify and assess the relative importance of the complex, and potentially antagonistic, microbial and chemical processes that govern the retardation and migration of metals, specifically Cd, Zn, Ni, As, Cr, from a reduced aquifer zone through the GSI into an adjacent surface water body. Specific sub-objectives of this work are: (1) determine the significance of dissimilatory sulfate and iron reduction in the immobilization of typical cations and oxyanions; (2) determine the relative significance of microbial and chemical iron oxidation in the GSI; (3) characterize solid-phase and dissolved heavy metal species in groundwater as a function of location with respect to the reduced or GSI zones.

Progress Summary/Accomplishments:

The proposed experimental approach consists of field observations and controlled laboratory experiments. The progress in each of these two areas is described below:

Field Observations: Field tasks consisted of Geoprobe direct push sampling of pore water and solids in transects across the shoreline at a contaminated waterfront site. A doctoral student (Ping Gan) has primary responsibility for directing field sampling tasks in consultation with PIs. The proposed site location in Stratford, CT was chosen because of the extensive site characterization undertaken by other University of Connecticut researchers and because of the

working relationship between the site owner and the university. Upon review of the site characterization report, this site was deemed to be unsuited for this GSI study because the groundwater plume depth was too great to feasibly sample with the equipment available to us. Project tasks were thus revised to include a “Site Evaluation” stage.

Site evaluation is being conducted with the aid of EPA Region 1 (Mr. Dick Willey) and CT Dept. of Environmental Protection (Mr. Maurice Hamel). The goal of the site selection is to identify potential field sites with differing groundwater and surface water chemistries and where groundwater contaminants are known to impact adjacent surface water quality. In this way, this project can focus on biological and chemical processes without extensive hydrologic characterization. Thus, the criteria for site selection include: (1) a review of existing site data noting observations of groundwater seeps and sediment pore water concentrations of contaminants; (2) visual inspection and walk-through; (3) pore water collection and solids collection using hand-sampling techniques. To date, four potential sites have been identified and reviewed. Two sites have been eliminated from consideration for various reasons. Of the two sites under consideration, one is located in CT and has been sampled to obtain current groundwater samples and profiles of pore water chemistry through the GSI. Chemical parameter analyses are currently being conducted. A review of existing site data is being conducted of the final New England site under consideration. It appears to hold greatest promise as anecdotal reports of iron precipitation at groundwater seeps in the adjacent river have been correlated with arsenic immobilization in the solid phase. Sampling of this site will commence in the coming month after some optimization tests of the push-point pore water samplers are conducted.

Laboratory Studies: Laboratory studies of the types of microbial populations present in solids from the GSI will be undertaken with the specific objectives of identifying impacts of carbon fluxes on microbial processes. A Masters student (Jenna Shea) is currently being trained to conduct microbial assays with 16S rRNA-targeted PCR primers. Isolation of sufficient quantities of DNA from complex environmental samples is a challenge being addressed by Ms. Shea before solid cores are obtained.

Publications/Presentations: -NA-

Future Activities:

Field Observations: We will collect solid and groundwater samples from both the upgradient and GSI zones of the heavy metal contaminated waterfront site. The tasks will employ both Geoprobe techniques and low volume push-point samplers. The low volume push-point samplers are recently available sampling tools to achieve high resolution (cm) pore water profiles that are critical for delineating the GSI location and guiding larger sample collections with traditional techniques. Correlations of pore water and solid phase concentrations of a variety of chemical parameters, including conductivity, dissolved oxygen, pH, iron species, heavy metals will be used to support laboratory investigations of key GSI processes.

Laboratory Studies: Microcosm tests will be used to determine the significance of dissimilatory sulfate and iron reduction in the direct or indirect immobilization of typical cations and oxyanions and the mobilization of bound arsenic species under reducing conditions. Microcosm studies will also be used to determine the relative significance of microbial and chemical oxidation of iron.

Supplemental Keywords: GSI, metal transport, arsenic, chromate, bacteria