

Poster #21-52

SLAC Groundwater Quality SFA: Biogeochemical-Hydrologic Coupling in the Capillary Fringe at the Riverton, WY Site

Callum Bobb¹, Kristin Boye², Vincent Noël², Katharine Maher¹, Kenneth Williams³, and John Bargar²

¹Earth System Sciences, Stanford University, Stanford, CA

²Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Laboratory, Menlo Park, CA

²Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA

Contact: cabobb@stanford.edu

BER Program: SBR

Project: SLAC Groundwater Quality SFA

Project Website: <https://www-ssrl.slac.stanford.edu/sfa/>

Seasonal and synoptic hydrological changes in the Western U.S. drive complex and spatially- temporally variable biogeochemical transitions within the capillary fringe, with profound implications for groundwater quality. Springtime saturation of the capillary fringe triggers the onset of reducing conditions, which mobilizes iron and associated organic carbon and nutrients, initiates denitrification, and can drive reductive immobilization of sulfide-hosted and redox- active contaminants. Ebbing late-summer water tables expose formerly water-saturated sediments to air, oxidizing the accumulated reduced species and again impacting the mobility of contaminants. Thus, capillary fringe ecosystems mediate the coupling of water and biogeochemical cycles to govern the fate of contaminants of significance to water quality and management. However, our ability to scale hydrologic-biogeochemical coupling in capillary fringe transiently-reduced zones (TRZs) is limited, particularly between the fine (pore/micrometer) and meter scales. In particular, little is known about soil moisture thresholds that regulate successive biogeochemical reducing regimes, active N cycling pathways, contributions from microsites, and mechanisms of metal and radionuclide mobilization, yet these subjects are central to assessing the impact of biogeochemical transitions on water quality.

To address these needs, we characterized biogeochemical transitions in the capillary fringe at the former uranium ore processing site at Riverton, WY and are developing numerical representations of the key biogeochemical processes. Pairing porewater and sediment compositions with groundwater elevations over the course of a full snowmelt-driven runoff-to- drainage cycle, we observe coincident shifts in water level, redox potential, and contaminant concentrations. As spring runoff fully saturates the aquifer, a reducing front propagates upward through the soil profile, reaching a steady state within six weeks of the flood event. Reducing conditions are reflected in the porewater for nearly three months after reaching steady state. Rapid oxidation recovers the initial oxidized state within four weeks, suggesting that the rate of oxidation is more rapid than the onset of reducing conditions. The persistence of reducing conditions suggests that accumulation of reduced species (e.g. iron sulfide minerals) during the transient reduced phase serve as a redox buffer as the soil drains and is exposed to air, whereas the rapid re-oxidation suggests a threshold in soil moisture controls oxidation. These results are crucial to understanding redox-active capillary fringe behavior within the Western U.S. This research is further laying the groundwork for modeling contaminant mobility within these hydrologically active alluvial sediments.