SLAC Groundwater Quality SFA: Linking Riparian Microbial Communities and Biogeochemical Cycling to Vertical Groundwater Flow Across Oxic-Anoxic Interfaces at Slate River, CO

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Project Abstract: Riparian floodplains along Slate River in Gunnison County, CO are contaminated by heavy metals leached from mine operations. Fine-grained riparian sediments are anoxic and veneer underlying oxic basal gravel aquifer, creating a sharp *inverted* oxic-anoxic transition. Field measurements and hydrological modeling indicate that summer ET drives upward groundwater flow, carrying oxic groundwater from the basal gravel bed into overlying fine-grained anoxic sediments and creating biogeochemical hot zones that condition ground- and river water quality. We have observed intense redox cycling in the fine sediments, generation of metal-organic colloids, and mobilization of Fe, Mn, organic C, Zn, and Pb. Riparian flood plains are aerially extensive (10s of km^2 in the upper Slate River watershed) and their gravel beds are well connected to adjacent rivers. Moreover, gravel beds are the dominant river-bed form throughout the intermountain West. It therefore likely that these coupled hydrological-biogeochemical processes influence watershed scale trace metal and nutrient behavior across this large region.

We posit that metabolic and community responses of riparian microorganisms to variations in the composition of vertically flowing groundwater control mechanistic linkages between hydrology and biogeochemistry. To lay the foundation for studies of groundwater triggers and microbial responses, we collected vertical profiles of sediments and pore-water in riparian sediments along Slate River for geochemical and microbial analyses. Using 16S rRNA amplicons obtained from sediment DNA extracts, we observed aerobic microorganisms (including nitrifiers) at depths ≤90 cm, while anaerobic microorganisms (including methane- and sulfur-cycling groups) reside only in the deepest depths (130-150 cm). A well-defined aerobic (above)-anaerobic (below) transition was observed within the saturated zone of the fine sediments at ~110 cm depth. This zone appears to harbor members of both aerobic and anaerobic communities, suggesting that this depth also likely experiences fluctuating oxygen conditions. The microbial groups identified can mediate biogeochemical reactions that mobilize metal contaminants and play a role in extensive Fe-bearing colloid formation observed in the anoxic zone. These findings offer a new view of alluvium- groundwater dynamics and microbial community responses. Further investigation of these dynamics alongside microbial community data will enhance our understanding of the drivers of biogeochemical cycling at oxic/anoxic transition zones.