River Corridor Redox Heterogeneity and Cycling: Impacts on Water Chemistry

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Project Abstract:
Herein we report an integrated field, lab, and modeling analysis of redox cycling along the river corridor of the East River drainage in Colorado. Particular attention is paid to the sulfur (S) cycle as being not only an important elemental cycle but also a good indicator and integrator of multiple redox processes. To understand biogeochemical potential of river corridor topsoils, we conducted metagenomic and metatranscriptomic investigations of microbial communities inhabiting three floodplains separated by >15km along the East River reach. Results have shown that the capacity for sulfide oxidation was found among the most abundant biogeochemical transformations, encoded in ~30–40% of the genomes detected across all three floodplains; capacities for thiosulfate or sulfite oxidation were found in < 20% of the genomes. Furthermore, transcription of genes encoding enzyme subunits involved in S transformations was found between the 50^{th} and 75^{th} percentile median range of transcription for all genes encoded in the genomes. These results suggest that sulfur transformations are a critical component of sulfur cycling in floodplains along the river corridor. In addition, analysis of meander sediments indicates a complex and redox variable array of S compounds supporting the idea of active S-cycling within the meanders. Modeling efforts have focused on understanding the functioning of individual meander features, as well as connected series of meanders and have been driven by synoptic sampling of river chemistry and Rn^{222} concentrations along two separate river reaches. As an example of single meander analysis, we quantified carbon (C) and S fluxes from representative high and low permeability sediments under seasonally transient hydrologic conditions. We assessed the sensitivity of these fluxes to (i) variable permeability distributions and (ii) changes in the timing and magnitude of hydrologic transients finding that C and S fluxes are greatest along flowpaths in high permeability sediments adjacent to low permeability zones. Further, we found that C and S fluxes increase as the duration and magnitude of peak river stage decreases and increases, respectively. To quantify subsurface geochemical exports along a full river reach, we carried out three-dimensional reactive flow and transport simulations for a 10-meander sub-system of the East River. Simulation results demonstrated that multi-directional exchanges were influenced by river stage, bathymetry, and meander geometry leading to both hot spot and hot moment controls on redox speciation. Results further demonstrate that scaling exponents typical for meanders are significantly different for oxidizing and reducing conditions.