Biogeochemical Controls on River Water Quality under Transient Hydrological and Thermal Conditions

DIPANKAR DWIVEDI[1], CARL I. STEEFEL[2], BHAVNA ARORA[3], MICHELLE NEWCOMER[4], BAPTISTE DAFFLON[5], BORIS FAYBISHENKO[6], PETER NICO[7], KEN WILLIAMS[8]

[1]Lawrence Berkeley Laboratory, ddwivedi@lbl.gov
[2]Lawrence Berkeley Laboratory, cisteefel@lbl.gov
[3]Lawrence Berkeley Laboratory, barora@lbl.gov
[4]Lawrence Berkeley Laboratory, mnewcomer@lbl.gov
[5]Lawrence Berkeley Laboratory, bdafflon@lbl.gov
[6]Lawrence Berkeley Laboratory, bafaybishenko@lbl.gov
[7]Lawrence Berkeley Laboratory, psnico@lbl.gov
[8]Lawrence Berkeley Laboratory, khwilliams@lbl.gov

Biogeochemical transformations at the groundwater-surface water interface and subsequent geochemical exports to the river system influence river water quality. Transient hydrological and thermal conditions have a significant impact on biogeochemical gradients in the subsurface and exports of redox species such as carbon, nitrogen, nutrients, and metals. The specific objectives of this study are to (1) investigate the impact of transient hydrological and thermal conditions on redox zonation; (2) examine how biogeochemical processes within the groundwater-surface water interface respond to changes in microbial activity, sediment compositions, and hydrological flow paths; and (3) quantify subsurface geochemical export to the river system as function of fluctuation in temperature and groundwater levels. To identify primary drivers affecting biogeochemical transformations at the groundwater-surface water interface and subsequent geochemical subsurface exports to the river system, we performed reactive flow and transport simulations at two-active meanders of the lower East River site in southwestern Colorado, USA. Modeling results suggested that hydrological events and vertical hydro-stratigraphy together exerted a substantial influence on the lateral redox zonation and drove exports of carbon and iron. In the intrameander region of the lower East River, Fe (II) showed significant variability across and along the flow paths, unlike dissolved oxygen, nitrate, and pH. Moreover, low water conditions followed by high water conditions lead to approximately two-fold geochemical exports to the river from groundwater. This study demonstrates the importance of including hydrologic and thermal transients, using a modern reactive transport approach, for developing a reliable predictive capability to quantify geochemical exports and river water quality at the riverine scale.