Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19865

Laboratory and Field Studies of the Redox Dynamics of Fe and U in Fe Flocs in Riparian Wetlands within the Tims Branch Watershed, Savannah River Site, USA

EDWARD J O'LOUGHLIN[1], ANTHONY BOEVER[2], MAXIM I BOYANOV[1], DANIEL I. KAPLAN[3], CONNOR PARKER[4], BRIAN POWELL[4], MARTIAL TAILLEFERT[2], PAMELA WEISENHORN[1] AND KENNETH M. KEMNER[1]

[1]Argonne National Laboratory

[2]Georgia Institute of Technology

[3]University of Georgia

[4]Clemson University

Presenting Author: oloughlin@anl.gov

Discharge of metallurgical process wastewater containing U and co-contaminants (Ni, Cr, Zn, Pb) from a former nuclear material production facility (M-Area at the Savannah River Site) led to extensive contamination of downstream wetlands along Tims Branch. Abundant orange and reddish-brown flocs have been repeatedly observed along gaining sections of Tims Branch, where anoxic groundwater containing Fe(II) discharges into oxygenated stream water. These flocs contain high levels of Fe (8–17 wt%, primarily in the form of ferrihydrite and lesser amounts of lepidocrocite and Fe-organic complexes as determined by Fe K-edge EXAFS spectroscopy), and are effective scavengers of P (2–4 wt%), U (32–600 ppm), and trace metals. The flocs initially form under oxic conditions. However, accumulation of flocs can lead to burial of older floc material and the development of anoxic conditions. Furthermore, during periods of enhanced stream flow, accumulated anoxic floc material can become resuspended in oxic stream water. Thus, biogeochemical processes and attendant changes in redox conditions within the flocs are likely to affect the speciation of redox active constituents (e.g., Fe and U), and potentially the bioavailability of nutrients such as P. Our laboratory microcosm studies of flocs show that the transition from oxic to anoxic conditions leads to reduction of Fe(III) to Fe(II) and U(VI) to non-uraninite U(IV), as determined by XAFS analysis; following a return to oxic conditions, Fe(II) and U(IV) oxidize back to Fe(III) and U(VI). XAFS analysis along the depth profile of accumulated floc material collected in Tims Branch shows a progressive reduction of Fe(III) to Fe(II) and U(VI) to U(IV) with depth, consistent with the observed decrease in redox potential and analogous to the behavior of Fe and U during redox manipulations in our microcosm study. Given that Fe flocs are frequently observed in a broad range of wetland environments, our studies of Fe floc biogeochemistry in Tims Branch and its potential impact on U speciation and transport, expand our understanding of their role in the speciation and cycling of trace elements in wetlands, which in turn can lead to more robust modeling of trace element behavior in aquatic and terrestrial environments.