Arsenic sequestration and mobilization in AMD sediments

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Arsenic (As) contamination is a significant concern at numerous mining-impacted sites across the globe, particularly where low-pH, sulfate- and metal-rich acid mine drainage (AMD) is present. AMD sites can have elevated As levels as high as 850 mg/L. AMD sediments are often comprised of Fe(III)-rich neoformed nano-scale particles (NP) and detrital clay NP [1], and understanding the mechanisms governing As uptake by these NPs is critical for assessing the sequestration capacity of As by AMD sediments as well as the long-term fate of As during microbially-mediated redox cycling of iron in the AMD-impacted systems.

In this study we investigated the uptake mechanisms of As by AMD sediments during sustained redox cycling of iron by the combined use of microbial community structure characterization (16S rRNA), chemical extractions and synchrotron-based X-ray fluorescence (XRF), diffraction (XRD), and absorption (XANES) [2]. The analyzed AMD sediments were from an abandoned coalmine site in Southern Illinois and span a gradient in sediment composition (Fe/Al ratios) and environmental (i.e., pH, redox) conditions.

We found As was heterogenously distributed in the AMD sediments, and the concentration of As was positively correlated with that of Al and negatively correlated with that of Fe. High-permeability, $\mathrm{Fe(III)_{NP}}$-rich areas, containing on average 40 µM/kg As, had high As remobilization capacity due to microbially-mediated reduction of $\mathrm{Fe(III)_{NP}}$ and thus may constitute a more-persistent but dilute As source. Low-permeability, $\mathrm{clay_{NP}}$-rich areas had up to 300 µM/kg As and low As remobilization capacity. The primary mechanisms of As uptake was (1) adsorption on $\mathrm{Fe(III)_{NP}}$ surface, and (2) surface sorption, precipitation, and co-precipitation by $\mathrm{clay_{NP}}$.

Collectively, our results indicate that $\mathrm{clay_{NP}}$ have a higher capacity to retain As long-term and thus could become a promising, low-cost material for As removal from AMD or other acidic, high-As contaminated waters.

[1] Lefticariu, et al. (2017) *Sci. Total Environ* 575, 941–955.
[2] Sutton, S. et al. (2017) *J Environ Qual.* 46, 1158-1165.