Methanogenesis, iron transformation and partitioning of contaminants under end pit lake scenario

TARIQ SIDDIQUE[1]*, PETR KUZNETSOV[1], NAJMEH SAMADI[1], KAI WEI[2] AND ANIA C. ULRICH[2]

[1] Department of Renewable Resources, University of Alberta, Edmonton T6G 2G7, Canada. (*Correspondence: tariq.siddique@ualberta.ca, pkuznets@ualberta.ca, najmeh@ualberta.ca)

[2] Department of Civil and Environmental Engineering, University of Alberta, Edmonton T6G 1H9, Canada. (weikai870203@gmail.com, aulrich@ualberta.ca)

In the northern Alberta oil sands region of Canada, establishment of end pit lakes (EPL) is a potential strategy to reclaim huge volumes of oil sands fluid fine tailings (FFT) and oil sands process-affected water (OSPW). Bitumen extraction from oil sands ore produces over a million m^3 of FFT day^{-1} that are are aqueous slurries comprised of fine particles (fine silt and clay), unrecovered bitumen (<5% wt) and residual hydrocarbon solvent (<1% wt). The first full-scale (~8 km^2) demonstration EPL (containing ~186 million m^3 of FFT covered by ~52 million m^3 of fresh water-diluted OSPW) has been established at Syncrude's Base Mine Lake to assess the feasibilty of its development into a self-sustained multitrophic ecosystem. A major concern associated with EPL is ebullition of gases from underlying FFT which resuspends fine clays and might transport contaminants to the overlying cap water.

In this study (130 L large columns containg 50 L of FFT covered by 20 L of cap water collected from Base Mine Lake), chemical, mineralogical and molecuar approaches were used to investigate biogeochemical processes in the underlying FFT and their impact on contaminants' transport to cap water. Labile hydrocarbons endogenous to FFT were added to FFT columns (amended columns) to accelerate microbial metabolism. The columns were anaerobically sealed and incubated at 10 °C, 20 °C and 30°C in the dark.

The results revealed higher chemical flux rate in the amended FFT due to microbial metabolism that decreased pH, increased cap water turbidity, and concentrations of ions (Ca^{2+}, Mg^{2+} and HCO_3^-) and and trace metals (Sr, Ba, and Ti) in cap and porewater, and faster FFT settling as compared to unamended FFT. Iron fractionation showed transformation of Fe^{III} to Fe^{II} minerals during methanogenesis and sequential extraction determined host phases of metals in FFT that could suggest mechanism of trace metal partitioning in EPL. The results have great implications in assessing water quality of EPL being established to manage huge volumes of tailings.