Methanogenic microbial metabolism releases metals in porewater from iron minerals

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Vast oil sands activities in northern Alberta, Canada produce large volumes of fluid fine tailings that are deposited in tailings ponds for containment. Tailings are aqueous slurries comprised of fine particles (fine silt and clay) in addition to unrecovered bitumen (<5% wt) and residual hydrocarbon solvent (<1% wt). Effective management of the current tailings inventory (~1 billion m^3) is a big challenge for all stakeholders where suspended fines hinder tailings consolidation. Previously, we discovered that microbial metabolism in oil sands tailings under methanogenic conditions increased settling of tailings by altering porewater and solid phase chemistry.

In an effort to accelerate this process, a bench-scale bioreactor study was performed where tailings were amended with hydrolyzed canola meal as a substrate for methanogenic activity by indigenous microbes. After anaerobic incubation in a bioreactor for 5 weeks, tailings were poured into glass columns and observed for consolidation and porewater recovery comparing with the unamended tailings that did not undergo any bioreactor treatment.

The results revealed that the amended tailings incubated in the bioreactor settled quickly yielding significantly higher volumes of porewater recovered at the surface, compared to unamended tailings. Chemical analyses showed higher concentration of ions (Ca^{2+}, Mg^{2+}, and HCO_3^-) and trace metals (V, As, Co, Ni, Cu, and Sr) in the porewater recovered from amended tailings after consolidation as compared to unamended tailings. Concentrations of Zn and SO_4^{2-} decreased below detection levels in the porewater recovered from the amended tailings. Iron fractionation revealed that Fe^{III} clay minerals in the amended tailings were transformed into Fe^{II} minerals predominantly of amorphous nature during microbial metabolism. The sequential extraction of metals from the tailings solid phase is in progress to determine the host phases of trace metals in tailings. The results have great implications in assessing water quality of end-pit lakes being established to manage huge volumes of tailings in Alberta.