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Biogeochemical cycling of petroleum hydrocarbons and naphthenic acids during reclamation of organic rich tailings in an oil sands Pit Lake

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Biogeochemical cycling of organic compounds is a central component of reclamation and remediation of sites where petroleum hydrocarbons and related compounds are present such as harbours, spill sites, aquifers, and tailings from extraction of oil sands. However, there can be complex inter-relationships between biogeochemical processes that make assessing and predicting the future behaviours of systems challenging. The first application of water capped tailings technology for the reclamation of tailings resulting from oil sands extraction in the Alberta Oil Sands Region, Base Mine Lake (BML), provides an opportunity to investigate such complex interactions. Commissioned in 2012, ongoing research is working to understand the interplay of biogeochemical and physical processes affecting the residual hydrocarbons and naphthenic acids, a key driver of residual chronic toxcity, within the BML system. This presentation will integrate results of several research efforts. Our research has demonstrated ongoing microbial methanogenesis within the fluid fine tailings (FFT) underlying BML at rates comparable to natural systems. We have identified the presence of a range of low molecular weight compounds residual from naphtha used during extraction as the potential carbon source, though modelling indicates they should primarily reside within the residual bitumen present. Concurrently, anaerobic biodegradation of hydrocarbons via the succinate pathway is producing naphthenic acids within the FFT and may also represent a pathway to produce carbon sources for methanogenesis. Ebullition of methane is associated with transport of organic compounds from the FFT into the water cap, along with diffusion and porewater advection. Within the water cap, there is evidence of aerobic degradation of adamantane naphthenic acids, as well as of photooxidation of high molecular weight hydrocarbons near the BML surface. Ongoing work aims to assess the timeframe over which transport of FFT derived organics to the water cap may occur and the capacity of the water column biogeochemical processing to consume any ongoing inputs. The insights from BML will not only inform planning for future pit lakes containing organic rich tailings, but also ideally be transferrable to other sites where similar situations exist.