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Quantification and Distribution of Naphtha-Range Compounds in Oil Sands Reclamation Samples

HAN BAO, CHENLU WANG AND GREG F. SLATER

McMaster University

Presenting Author: baoh18@mcmaster.ca

The microbial methane production in petroleum-impacted sediments has important implications for the bioremediation of petroleum compounds and their possible transport through ebullition. Syncrude's Base Mine Lake (BML) is the first full-scale pit lake used for reclaiming mine sites and tailings in Alberta Oil Sands Region. Microbial production and subsequent transport of methane from fluid fine tailings (FFT) underlying BML have a recognized impact on the oxygen consumption within the overlaying water column, the potential ebullition-facilitated transport of organics and the greenhouse gas emission. It is therefore critical to ascertain the carbon sources driving methane production and evaluate their distribution and potential for future methane generation and release. It is hypothesized that residual low molecular weight compounds derived from naphtha used in froth treatment process are driving methane production. Here we optimized an analytical methodology to extract and quantify these naphtha-range compounds in the FFT by a backflush GC-FID system, and applied this approach to assess naphtha partitioning coefficients and concentrations at several sites and depths within the FFT. Method optimization experiments determined that adding pure water and using more vigorous mixing (paint shaker) resulted in more efficient hydrocarbon extraction. This method was used to assess equilibrium partitioning of naphtha-range compounds between bitumen and water, resulting in bitumen-water partitioning coefficients ($\log_{BW}$) ranging from 2.6 to 5.3 for the naphtha-range compounds under different laboratory conditions. This range indicates that residual naphtha is more than 99% (by concentration) adsorbed within the bitumen except for a few compounds that are more than 95% adsorbed. Analysis of residual naphtha concentrations within the FFT in BML yielded heterogeneous results ranging from 17 to 3200 µg/g of FFT within and between sites. Finally, measured naphtha concentrations were statistically correlated with methane production experiments ($p<0.05$), consistent with the hypothesized role of naphtha-range compounds in methanogenic processes within the FFT.