Chemical and toxicological differentiation of groundwaters in the Alberta oil sands region

James W. Roy, Richard A. Frank
Environment and Climate Change Canada, Burlington, ON, Canada
Anthony Bauer, George Dixon
University of Waterloo, Waterloo, ON, Canada
Craig Milestone
Sheridan College, Mississauga, Ontario, Canada
Angela Sun
University of Alberta, Edmonton, AB, Canada
Jonathan Martin
Stockholm University, Stockholm, Sweden
Alan G. Scarlett, Charles E. West, Steve J. Rowland
University of Plymouth, Plymouth, United Kingdom
Adrienne J. Bartlett, Patty L. Gillis, Joanne L. Parrott, Greg Bickerton, H. Malle, R. Strub, L. Mark Hewitt,
Environment and Climate Change Canada, Burlington, ON, Canada

ABSTRACT
Natural groundwaters in the oil sands region of Alberta and those affected by oil sands process water (OSPW) leaching from tailings ponds can both contain complex mixtures of neutral and polar organic compounds, including naphthenic acids, as well as elevated levels of metals and major ions. Many of these compounds can be toxic to aquatic life. Here we summarize key findings on i) chemically differentiating OSPW-affected and naturally bitumen-influenced groundwaters, and ii) toxicological assessments of these two types of groundwaters. Chemical differentiation focused on two families (termed A and B) of suspected monoaromatic acids analyzed with comprehensive multidimensional gas chromatography time-of-flight mass spectrometry (GC × GC-TOF). Differentiation studies also utilized non-target analyses with liquid chromatography-quadrupole time of flight mass spectrometry (LC-QTOF) coupled with bioinformatics datamining to identify unknowns unique to OSPW leaching. These methods were applied to several OSPW samples, a variety of background groundwater samples and samples collected along a known OSPW-affected groundwater plume. For the toxicological assessment, a preparative extraction and fractionation protocol was applied to a smaller sample set of natural and OSPW-affected bitumen-influenced groundwaters and OSPW (>150L each). The protocol afforded chemically distinct fractions of soluble organics based on polarity that allowed comparisons between fractions and the original source waters. These were tested with a suite of invertebrate and vertebrate bioassays to identify the compound classes of interest within the soluble organic mixtures of bitumen-influenced waters, as well as the most sensitive and relevant test organisms and endpoints. This chemical and toxicological information is important for the proper assessment and management of tailings ponds, end pit lakes, and OSPW generally, in the oil sands region.