Regional distribution of arsenic in the Cold Lake – Beaver River watershed: Implications of groundwater – surface water interactions

Michael C. Moncur, S. Jean Birks, Emily Taylor
InnoTech Alberta, Calgary, Alberta, Canada
John J. Gibson
InnoTech Alberta, Victoria, British Columbia, Canada

ABSTRACT
Elevated arsenic (As) concentrations are widely observed in shallow groundwater across the Cold Lake-Beaver River Basin (CLBR), Alberta. Occupying 3% of the province, the CLBR spans portions of both the Athabasca and Cold Lake Oil Sands Regions. Here, groundwater and surface water are used for a variety of activities including domestic, municipal, industrial and agricultural use, as well as recreation. Surficial geology is comprised of up to 200 m of unconsolidated glacial deposits, with six regional interglacial sand and gravel aquifers, underlain by marine shale. Arsenic concentrations in unconsolidated glacial sediments generally range between 1 and 17 ppm. A sampling survey of 800+ water wells throughout the basin revealed that 50% of wells contained As concentrations in water exceeding drinking water guidelines of 10 µg/L. Arsenic speciation of 175 groundwater samples showed that As(III) was the dominant species in 76% of wells. Higher As concentrations in groundwater were associated with increasing depth and reducing conditions. The distribution of As did not show any obvious spatial pattern or trend along groundwater flow paths suggesting heterogeneities in the aquifer mineralogy. Within near-surface weathered sediments, the oxidation of arsenian pyrite was the source of As released to shallow groundwater whereas in unweathered sediments below the water table, reductive dissolution of Fe oxy-hydroxides was likely the main source of As in groundwater. Water samples collected from 61 lakes across the CLBR showed an average As concentration of 2.3 µg/L (max. 19.4 µg/L), elevated compared to average concentrations for lakes located elsewhere across the province (1.3 µg/L). Water isotopes reveal that evapoconcentration is not a factor contributing to elevated As in lakes. In general, lakes with higher As tended to be in contact with deeper aquifers, suggesting that groundwater discharge with elevated As may contribute to greater loading of As to lakes in the region.