Arsenic in Alberta's groundwater: the where and the why

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Introduction

Arsenic is a ubiquitous element in our natural environment, and one that can be extremely toxic if consumed in high enough concentrations. The unfortunate situation In Bangladesh and West Bengal, where millions of people have inadvertently been exposed to arsenic contaminated groundwater, has led to an increased focus on this health risk by global health authorities. Here in Canada, the occurrence of groundwater with arsenic concentrations in excess of the current maximum acceptable concentrations for drinking water of 10 μg/L has been noted in Newfoundland and Labrador, Nova Scotia, New Brunswick, Québec, Saskatchewan, Alberta, and British Columbia. In many of these provinces these elevated concentrations are restricted to distinct "hot spot" areas. In Alberta, the most notable, and studied, area has been the Cold Lake-Bonnyville region, where concentrations as high as 90 μg/L (or more) have been recorded.

Theory and/or Method

To gain a better understanding of arsenic in Alberta's groundwater, Alberta Innovates – Energy and Environment Solutions commissioned a study in 2013 to address this knowledge gap. A research team from the University of Alberta was selected to conduct this work. Part of the investigation was to determine the source and cause of this water quality concern. Data from various public agencies were accessed, combined, and put through a rigorous QA/QC process to produce a final unified data set of over 2900 wells with roughly 58 water quality parameters assessed, including arsenic.

Conclusions

Statistical assessment (i.e., Spearman ρ-values, HCA, and PCA, identified notable correlations between certain parameters (i.e. depth, Si, Fe, Mn) and arsenic. Visual assessment identified four main clusters of elevated concentrations associated with the Slave Lake, Cold-Lake Bonnyville (as noted previously), Spruce Grove, and greater Red Deer areas.

Common characteristics in areas displaying elevated arsenic concentrations included:

- well depths generally greater than 15 m, with the highest values falling with a depth interval of roughly 40-100 m;

- pH values between 7.5 and 8.5; and

- a dominance Na-HCO_3 type waters with a total alkalinity in the range of 300-800 mg/L (as $CaCO_3$).

When compared, some of the regions showed similar correlations between arsenic, Fe, Ba, and Mo. In one case a somewhat unique correlation between As, Se and Cr was noted (the greater Red Deer area).

Correlation with underlying geology and various human development activities identified the occurrence of elevated As to be a natural phenomenon, and likely connected to reductive dissolution of metal oxyhydroxides source from pyrite weathering. Further assessment revealed a significant correlation with buried bedrock channels (formed prior to the last continental glaciation) eroded into marine shales and coal-bearing continental deposits. Based on these findings, a preliminary arsenic risk map was developed.

This presentation will summarize findings from this provincial-scale investigation and the processes employed to achieve an enhanced understanding of the "where" and "why" regarding elevated arsenic in Alberta's groundwater.

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