Regional and Localized Distribution of Arsenic in Soil in the Yellowknife Region

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Historical mines in the Yellowknife area produced airborne emissions containing arsenic trioxide (As_2O_3) from the roasting of gold-bearing arsenopyrite (FeAsS) ore. Recent studies have highlighted a persistent legacy in local lake sediments and surface waters 50 years after the bulk of these emissions were released. Questions still remain about the amount and nature of arsenic residing in soils. The objectives of this research are: 1) to characterize the regional distribution of arsenic in Yellowknife area soils; 2) to identify factors that explain regional and local patterns of distribution; and 3) to identify the various phases of arsenic present in local soils.

A total of 479 near-surface soil samples were collected within a 30-km radius of Yellowknife during the past three summers to explore regional variation in soil arsenic concentrations. Site locations were focused on undisturbed areas to minimize human influence and determine the effects of legacy airborne emissions. Sampling targeted soils from four distinct terrain units, including: outcrop soils, forest canopy soils, forest outcrop soils, and peat.

Total elemental analyses have been completed on samples from the Public Health Layer (0 to 5 cm) at all sites. Arsenic concentrations in peat samples range from 2.9 to 3,400 mg/kg with a median of 96 mg/kg. Concentrations in outcrop soils range between 3.5 and 3,000 mg/kg with a median of 165 mg/kg. Forested outcrop soils range from 2.1 to 4,700 mg/kg arsenic with a median of 150 mg/kg. Finally, arsenic concentrations in samples from forested canopy areas range from 1.0 to 1,300 mg/kg with a median value of 38 mg/kg. Non-parametric comparisons determined that arsenic concentrations in forested areas are significantly different than all other terrain units ($p < 0.018$), and no significant differences were observed between the remaining terrain units.

Distance from the Giant Mine roaster is an important control on the concentration of arsenic in regional soils (R adj. = 0.543) despite substantial local variations. Spatial analyses performed in ArcGIS indicate that soils surrounding Giant Mine, and to a lesser extent Con Mine, are elevated in arsenic relative to background concentrations. Micro-analytical techniques were used to characterize the mineralogy and arsenic hosting phases in soils. Anthropogenic sources of arsenic are characterized by the presence of As_2O_3 and distinctive arsenic-bearing iron-oxides derived from roaster stack emissions. Preliminary results indicate As_2O_3 is present in 89% of samples tested (n = 71). Identification of the mineralogy of arsenic is important because speciation influences the bioaccessibility of arsenic, which is essential to consider for risk assessment.

This regional soil sampling initiative complements previous lake, sediment, and soil geochemical surveys undertaken in the area. This research provides important insight into connections between terrestrial and aquatic systems in the region by providing information on soil geochemistry, mineralogy, and mobility. This research is also an important source of information to support ongoing risk assessments to human and ecological health from arsenic derived stack emissions.