

Different Forms of Arsenic in Gold Mine Tailings in Nova Scotia May Pose Different Risks

MITHE-SN • CANADIAN NETWORK OF TOXICOLOGY CENTRES

The Problem

Historic gold mine tailings in Nova Scotia, Canada contain significant amounts of arsenic, a result of mining and processing naturally arsenic-rich ore during a time of unregulated industrial activity (1860 to the mid-1940s). Many of these sandy tailings areas are now located close to residential areas, are publicly accessible, and are used for recreational purposes such as dirt biking, all-terrain vehicle (ATV) use and trail walking (**Figure 1**). Accidental oral ingestion or inhalation of arsenic-bearing particles may present a health risk for humans.



Figure 1. Children driving dirt bikes on historic gold mine tailings at Montague Gold Mines near Halifax. The device for collecting airborne particles is shown at the right. Photo: courtesy of C. Craigen.

Arsenic in the tailings was originally present mainly as arsenopyrite (a mineral containing arsenic, iron, and sulfur), but decades of exposure to the atmosphere has transformed much of the arsenopyrite into different arsenic minerals. Arsenopyrite is not considered particularly hazardous if ingested; however, human health risks from ingestion of other arsenic minerals that have been formed through weathering of the tailings are not well understood. Identifying the arsenic minerals present in the tailings particles, as well as their size and texture, are important steps in understanding the potential health risks to nearby residents.

Seeking Solutions

Samples of tailings were taken from several abandoned mine sites which are now publicly accessible. Our research team also used specially-designed filters to collect the windblown and vehicle-raised particles that could be inhaled by humans. The total arsenic concentration in all samples taken directly from the near-surface tailings was significantly higher than the Canadian Soil Quality Guideline. Some of the samples also exceeded the maximum arsenic guideline indicated by the Ontario Ambient Air Quality Guideline (there is no equivalent guideline in Nova Scotia).

We used a combination of traditional chemical and mineralogical techniques as well as recently-developed synchrotron* methods to determine that each tailings sample contained a mixture of several arsenic minerals. By focusing a powerful X-ray beam on individual particles, we were able to simultaneously determine the identity of the arsenic mineral, the chemical composition, and the crystal size (**Figure 2**).

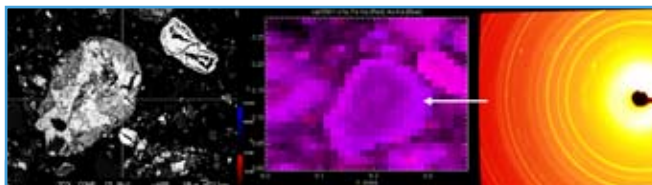


Figure 2. An example showing how arsenic-bearing particles are identified using a combination of techniques. LEFT: Two particles from a tailings sample as they appear using an electron microscope. The larger particle is approximately one-tenth of a millimeter in diameter. MIDDLE: A chemical map of the particles showing arsenic (blue) and iron (red) concentrations. Most particles appear purple because they contain both arsenic and iron, but the larger particle has more arsenic than the smaller one (appears bluer). RIGHT: The results of an experiment performed by focusing a synchrotron-generated X-ray beam on the point indicated by the white arrow. The pattern of the concentric arcs can be used to identify the arsenic mineral. (Images courtesy of S.R. Walker)

Benefits to Canadians

Natural weathering of historic mine tailings exposed to the atmosphere creates new minerals. Characterization of these minerals provides important information that can be used to understand and reduce potential risks to human and environmental health. The new methods shown here can be used to analyze many different types of metal-contaminated mine tailings, soils, dust, and other particles that might be accidentally ingested or inhaled, and might pose a risk to environmental and/or human health. The results assist in risk assessment and risk management.

In Nova Scotia, the results of our research are being used by the Historic Gold Mines Advisory Committee, which has representatives from five federal and five provincial departments. Our studies are being used to help understand potential risks, and to plan appropriate

action to protect human health. To date, the Province of Nova Scotia has posted warning signs (**Figure 3**), sent information letters to nearby residents, cancelled a 4x4 rally previously held on mine tailings, and completed Environmental Site Assessments at two of the sites.

MITHE-SN research related to this project includes collaboration with the Royal Military College to study the release of arsenic from these tailings and soil samples under conditions that are typical of human exposure. The success of this work has also led to a new three-year project that will focus on designing the best clean-up method for arsenic-rich gold mine wastes.

For Additional Information

Metals in the Human Environment Strategic Network (MITHE-SN)

www.mithe-sn.org

Nova Scotia Historic Gold Mines Advisory Committee

www.gov.ns.ca/nse/contaminatedsites/goldmines.asp

What is a Synchrotron?

www.lightsource.ca/media/quickfacts.php#WaS

Acknowledgement

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Figure 3. Halifax, Nova Scotia.
Warning sign posted at a tailings site .

About MITHE-SN

The **Metals in the Human Environment Strategic Network** is a collaboration between academia, government, and industry. The Network conducts research to assist in advancing of science-based environmental and human health risk assessments for metals in water, soil, and food, within well articulated and planned inter-disciplinary research themes. Our research program is strongly linked across Canada, with field sites in the Maritimes, Québec, Ontario, The Prairies, British Columbia and Alberta, the Yukon, and Nunavut. The Network also features strong links among academic and government scientists. Implicit in the MITHE-SN approach is a commitment to joint, interactive, centralized planning, project accountability for both intellectual and financial objectives, and regular reporting of research progress beyond the usual publication in scientific journals. ♻️ Printed on 100% recycled paper.

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MITHE-SN Secretariat, Canadian Network of Toxicology Centres, University of Guelph

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