A Review of Arsenic in Soil as Part of the Port Hope Area Initiative

TB161022-REP-191218
August 26, 2021

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Evaluation of Arsenic and other Primary COPCs during the Risk Assessment & RVSOP Process			
Document Title	A Review of Arsenic in Soil as Part of the Port Hope Area Initiative		
Document No.	TB161022-REP- 191218	Revision	R1

EXECUTIVE SUMMARY

The history of the Port Hope area extends back many millennia to the period of the last glaciation. In the post-glacial period, the area has been host to generations of Indigenous people who have relied upon the resources offered by the land and waters. Colonial settlement of the area began in the 18th century with Port Hope becoming incorporated in 1834. The town grew rapidly with the arrival of the railway and was host to a variety of light and heavy industries. Eldorado Nuclear (originally Eldorado Gold Mines Ltd) began its operation in 1932. Over the decades that Eldorado operated, low-level radioactive waste (LLRW), which is defined as a set of 21 radiological and non-radiological contaminants, was generated from the processing of radium and uranium containing ores and was dispersed throughout the municipality of Port Hope and neighbouring Clarington. Of these 21 contaminants, four are most closely associated with LLRW (radium-226, thorium-230, uranium and arsenic) and are used to define areas of contamination.

The Port Hope Area Initiative (PHAI) is a community-based solution for the long-term management of historic LLRW in the municipalities of Port Hope and Clarington. Soil containing LLRW that exceeds the PHAI Clean-up Criteria (PHAI CC) is subject to removal and relocation to one of the project's new, secure long-term waste management facilities. The clean-up criteria being used for the contaminants of potential concern are largely based on site condition standards established under Ontario Regulation 153/04 (the exceptions are radiological parameters for which the Ontario Ministry of the Environment, Conservation and Parks (MECP) has not established site condition standards). For arsenic, because standard risk assessment approaches result in health-based criteria below background levels in soil, the PHAI CC of 18 µg/g is based on what is estimated by the MECP as background levels in undisturbed soils in Ontario (defined as the Ontario Typical Range, i.e., 98th percentile concentration found in old urban parkland soil).

Based on the results of more than 25,000 soil samples collected to date as part of the PHAI Radiological Property Survey of 3,600 properties that include both LLRW-containing and "native" soils, arsenic concentrations in Port Hope soils exceed this value approximately 10% of the time, meaning the majority of remediation decisions are being driven by the presence of arsenic (uranium, radium-226 and thorium-230 exceed their PHAI CC 2.5%, 3.2% and 1% of the time respectively). It has become apparent through the remediation design process that began in 2016 and the residential clean-up program that began in 2018, that remediation to background levels for arsenic (after all other LLRW contaminants on the property have been removed) is having a number of unintended consequences, including longer and more extensive clean-ups than originally anticipated, increased disturbance to residential property

owners, as well as a significant change to the nature of the community through loss of the mature tree canopy.

Exposure to arsenic can result in a number of adverse health outcomes. Inorganic arsenic is a known carcinogen producing cancers of the skin, bladder and lung. Non-cancer effects associated with arsenic exposure include cardiovascular disease, developmental effects, diabetes, pulmonary disease and adverse pregnancy outcomes and infant mortality.

Standard risk assessment approaches that estimate how much arsenic a person is exposed to from soil and dust, drinking water, home-grown produce and the normal food basket (i.e., foods purchased from grocery stores that originate in a set of diverse locations/geographies) derive estimates of risk that are already generally considered "unacceptable" by regulatory agencies (i.e. incremental lifetime cancer risks greater than one in one million (provincial) or one in one hundred thousand (federal) or hazard quotients greater than one). This is true whether one lives in Port Hope or another community in Canada.

Estimated lifetime cancer risk associated with arsenic exposure for the Canadian population range from 9.7 to 26 per 100,000. Based on a mean arsenic soil concentration of 9.7 µg/g in Port Hope soil, the estimated lifetime cancer risk associated with arsenic exposure for residents of Port Hope is 20.4 per 100,000. With the implementation of a remediation program that removes any soil exceeding the current clean-up criterion for arsenic of 18 µg/g, the estimated lifetime cancer risk improves by only 1.5%, to 20.1 per 100,000. The same relative changes are true for non-cancer endpoints.

Standard risk assessment approaches provide an understanding of relative risk and the contribution of different exposure pathways to that risk. However, they typically employ conservative assumptions, meaning they are more likely to over predict than under predict estimates of risk. Consequently, when the potential for unacceptable risk is identified, multiple lines of evidence are often used to arrive at conclusions regarding health risk in a community and the need for active management measures such as soil removal.

For arsenic in soil, a line of evidence that is often used to understand community health risk is biomonitoring – that is, measuring the amount of arsenic that is present in a biological sample (typically urine) obtained from people living in the community. A number of studies have evaluated the relationship between soil arsenic levels and arsenic exposure using urinary arsenic levels as an indicator of exposure. These studies have involved communities where mean soil concentrations for arsenic range from 16 µg/g to over 300 µg/g. Risk-based studies undertaken in a number of Canadian communities have not shown a relationship between arsenic exposure and soil concentrations up to a mean of 239 µg/g. In all studies examined, the

objective of the biomonitoring was to supplement the standard risk assessment approaches by providing a metric of exposure that would help understand the health risk associated with the levels of arsenic in the community and inform decision-making. Similar international studies, which generally involve higher overall soil arsenic concentrations than the Canadian studies (up to 4,500 µg/g) illustrate a trend towards increasing urinary arsenic levels and mean soil concentrations of greater than 100-140 µg/g arsenic. These studies have been used to support regulatory decision making in each of these communities and whether soil removal is warranted.

The conclusions of these studies have been extended to Port Hope as evidence to support revising the clean-up criterion from its existing value of 18 µg/g. The reliance on these studies is supported by the consistency in their observations regarding the relationship between elevated levels of arsenic in soil and exposure in the community; the fact that the form of arsenic in Port Hope soil is comparable to these other communities as evidenced by both the source of arsenic (mill tailings) and its behaviour in *in vitro* bioaccessibility tests; and that the residents of Port Hope are exposed to soil in the same manner as people in the other communities examined, namely through routine day-to-day activities such as outdoor and indoor play, gardening and the consumption of home-grown produce. The commonality in purpose and study design amongst these studies provides confidence that the conclusions can be relied upon without the need for independent biomonitoring data in Port Hope.

On the basis of the information reviewed, this report recommended revising the clean-up criterion for arsenic in Port Hope soil from **18 µg/g** to **100 µg/g** to be implemented on the basis of a single exceedance. As this criterion would be implemented on the basis of a single sample and not the mean of multiple samples across the community, it provides a level of conservatism to the interpretation of the community-based studies discussed above.

It is understood that the recommendation to change the clean-up criterion from 18 µg/g to 100 µg/g means that estimates of health risk change accordingly. Based on mean soil concentrations within the community, the implementation of the revised clean-up criterion changes the predicted cancer risk by only 1%, from 20.1 per 100,000 to 20.3 per 100,000 (this compares a predicted risk of 20.4 per 100,000 based on the current soil mean). As opposed to average concentrations of arsenic in soil within the community, if one assumes that people are exposed to the maximum concentration in soil for their entire lifetime (i.e., 18 µg/g or 100 µg/g) a revision of the clean-up criterion to 100 µg/g results in only a 29% increase in the estimated cancer risk, from 21 per 100,000 to 27 per 100,000.

While there is there is little evidence to support removal and replacement of soils with arsenic concentrations less than 100 µg/g, individuals within the community may, nevertheless, wish to limit their exposure to arsenic, and any other contaminants that may be present in soil. Practical

risk management measures that can be taken to limit exposure to contaminants in soil are discussed within the body of the report.

In conclusion, soil arsenic concentrations of up to ~100 µg/g are not expected to result in elevated arsenic exposure. Consequently, there is little evidence to support removal and replacement of soils with arsenic concentrations below this threshold.