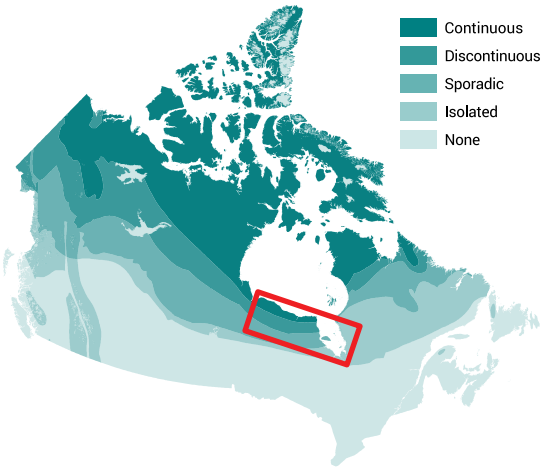
Mercury storage and cycling in permafrost peatlands of the Hudson Bay Lowlands



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Study locations: Hudson Bay Lowlands, with field data from northern Manitoba and Ontario.

Keywords: Mercury, peatland, methylmercury, Hudson Bay Lowlands, permafrost, thermokarst.

This research has provided a stronger understanding of mercury storage in peatlands of the Hudson Bay Lowlands, in North America's lowest latitude continuous permafrost. This work shows that storage of mercury, a heavy metal contaminant, is 20x lower than previously estimated, but permafrost thaw enhances conversion to methylmercury, a highly neurotoxic form of mercury. Understanding the relationship between permafrost thaw and methylmercury production is important, because methylmercury accumulates in fish, which are important subsistence foods in Indigenous communities. This work facilitates future studies on the impact of thaw in lowland permafrost regions on mercury accumulation in aquatic systems.

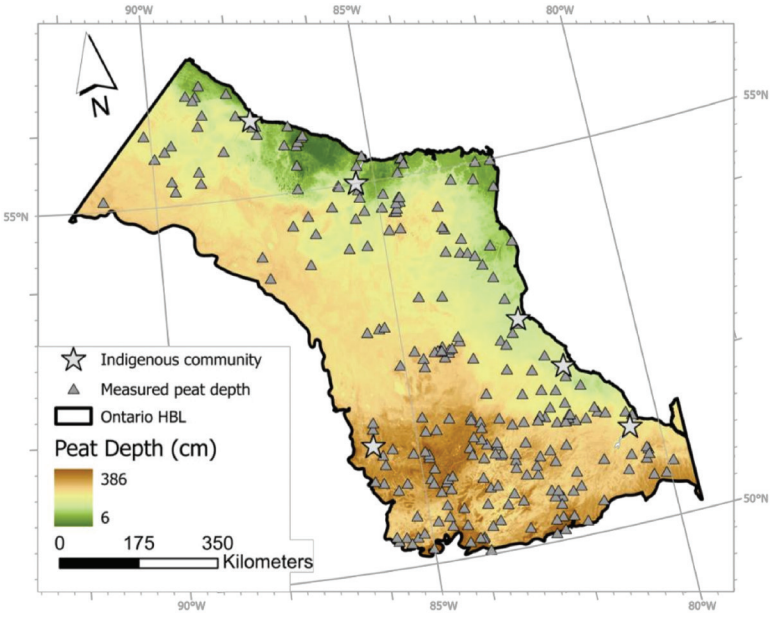

Figure 1. Modelled peat depth map for the Ontario portion of the Hudson Bay Lowlands based on measured peat depths. The peat depth map was used to estimate mercury storage in peatlands, and shows that >50% of mercury is stored in the top 75 cm of the soil profile, the portion most susceptible to permafrost thaw, which enhances production of methylmercury.

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Research summary

Estimates of mercury (Hg) storage in permafrost generated by applying mercury:carbon (Hg:C) ratios to existing carbon maps show large amounts of Hg are stored in permafrost. Despite these large estimates, there is limited evidence showing the relationship between permafrost thaw and the production of methylmercury. We estimated Hg storage in the Hudson Bay Lowlands (HBL), and investigated whether thawing permafrost led to changes in microbial community and peat chemistry affecting Hg methylation through extensive field sampling, spatial modelling, and analytical chemistry. We show that the Hg:C ratio varies widely across the Circumpolar North, and caution is required for using it in future estimates of Hg storage in permafrost regions. Using a revised Hg:C ratio, we show the HBL stores between 2.16-2.56 Gigagrams (Gg) of Hg, compared to previous estimates of 42.6 Gg. We show that both active layer deepening and thermokarst encroachment led to increased methylmercury concentrations.

Taking action

Next steps include connecting the impacts of permafrost thaw on mercury methylation, and export of MeHg to downstream aquatic ecosystems. This includes evaluating post-thaw mobility of Hg through understanding post-thaw hydrological connectivity. Additionally, evaluating rates and abundance of permafrost thaw is required to determine if enhanced thaw leads to elevated concentrations of MeHg in aquatic organisms like benthic invertebrates and fish. Additionally, the role of ground ice and the permafrost thermal regime should be assessed to develop a more complete understanding of permafrost thaw and mercury cycling.

Connections to other projects

4 5 Permafrost hazards are often thought about in relation to infrastructure, but this work shows that permafrost hazards also relate to contaminants and the health of ecosystems. This work was a partnership between Theme 4 - *Hazards and impacts associated with permafrost thaw* and Theme 5 - *Adaptation to permafrost thaw.*

Partners, team members and support

This work was completed in partnership with the Ontario Ministry of Natural Resources and Forestry, and the Arctic Gateway Group, with support from Weenusk First Nation. This project included an interdisciplinary team composed of peatland biogeochemists, permafrost geomorphologists, a civil engineer, and geomatics experts from universities across Ontario and Québec. Partners supported fieldwork activities, sample collection and analysis, and spatial modelling.

Acknowledgment, thanks, and funding

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References

Kirkwood, A. (2024). *Mercury storage and cycling in permafrost peatlands of the Hudson Bay Lowlands*. MSc thesis, Carleton University. Available at: https://doi.org/10.22215/etd/2024-16357

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