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Worldwide Accumulation of Atmospheric Mercury in Glacier Cryoconite

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Mercury (Hg) is a chemical element recognized as one of the most toxic among all naturally occurring elements, with health risks depending on its form, concentration, route and time of exposure. Mercury appears in the environment as a result of human activities, which include burning coal or lignite, improper waste disposal, oil refining, use of mercury-containing pesticides and fertilizers, and industrial development such as mining, chemical, pharmaceutical and paper industries. The element also appears in the environment as a consequence of natural phenomena, among which are volcanic emissions, rock erosion, biomass burning and geothermal processes, but also as a result of re-emissions. Mercury can persist in the atmosphere for up to several months, which promotes the transfer of the element to areas far from the emitting source.

Cryoconite, a sediment accumulating on the surface of glaciers, is known to accumulate atmospheric contaminants such as Hg likely due to biofilm producing extracellular polymeric substances. Mercury is a contaminant of primary concern in the global environment, including cryosphere environments such as glaciers, due to its high toxicity to biota. This study, for the first time, presents a comprehensive global analysis of the variation in Hg concentrations, observed in cryoconite holes and deposits from the surface of 27 glaciers in both hemispheres, comprising 105 samples in total. Concentrations of Hg were determined through ICP-MS/MS.

The results indicate a higher Hg content in cryoconite from glaciers located in the Northern Hemisphere, which can be linked to the proximity of highly industrialized areas, which contrasts to glaciers located in the Southern Hemisphere. The highest Hg content was measured in cryoconite located in Norway and Alaska (up to 0.7 ppm), and the Alps (close to 0.5 ppm), correlated with the levels of industrialization in these regions. Our results reveal a broad pattern of reduction in Hg concentrations in cryoconite with altitude, which may be related to the topographical relief affecting the transport of contaminants from higher altitudes to lower.

As a result of global warming, the majority of glaciers are retreating. The accumulated Hg in the cryoconite can be released during melting of glaciers and thus may also contribute to contamination of the downstream ecosystems and local communities through consumption of contaminated food and water in polar and alpine regions. Therefore, studies like this are needed to monitor the levels and fate of Hg in glaciers and ice caps.