# 'Fingerprinting' method reveals fate of mercury in Arctic snow

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A study by University of Michigan researchers offers new insight into what happens to mercury deposited onto Arctic snow from the atmosphere.

The work also provides a new approach to tracking mercury's movement through Arctic ecosystems.

Mercury is a naturally occurring element, but some 2000 tons of it enter the global environment each year from human-generated sources such as coal-burning power plants, incinerators and chlorine-producing plants.

"When released into the atmosphere in its reduced form, mercury is not very reactive. It can float around in the atmosphere as a gas for a year or more, and it's not really an environmental problem at the concentrations at which it occurs," said Joel Blum, the John D. MacArthur Professor of Geological Sciences.

But once mercury is oxidized, through a process that involves sunlight and often the element bromine, it becomes very reactive. Deposited onto land or into water, the mercury is picked up by microorganisms, which convert some of it to methylmercury, a highly toxic form that builds up in fish and the animals that eat them.

As bigger animals eat smaller ones, the methylmercury is concentrated. In wildlife, exposure to methylmercury can interfere with reproduction, growth, development and behavior and may even cause death. Effects on humans include damage to the central nervous system, heart and immune system. The developing brains of young and unborn children are especially vulnerable.

The research is described in a paper published online Feb. 7 in the journal *Nature Geoscience.*

In the Arctic, mercury remains in its benign gaseous form through the dark winter, because there's no sunlight to drive oxidation and little bromine to catalyze the process. But in polar springtime, that all changes. As sea ice breaks up, water vapor rises in great clouds through the openings in the ice, bringing with it bromine from the sea water. The bromine enters the atmosphere, where it conspires with sunlight to convert mercury gas into the reactive form. The activated mercury sticks to snowflakes and ice crystals in the air and travels with them onto the surface of the snow.

This leads to what's known as a mercury depletion event. The normally steady levels of mercury in the atmosphere quickly drop to near zero, as concentrations of mercury on the surface of the snow rise to extremely high levels.

"When we first started observing these events, we didn't know how much of that mercury returned back to the atmosphere, so the high level of mercury in snow was a great concern," Blum said. "But the more we learned, the more we realized that the sunlight shining on the snow typically will cause much of the oxidized mercury to become reduced and return to the atmosphere as a gas. And it turns out that its re-release to the atmosphere has a striking "fingerprint' that we can use to study the progress of this reaction through time."

The fingerprint is the result of a natural phenomenon called isotopic fractionation, in which different isotopes (atoms with different numbers of neutrons) of mercury react to form new compounds at slightly different rates. In one type of isotopic fractionation, mass-dependent fractionation (MDF), the differing rates depend on the masses of the isotopes. In mass-independent fractionation (MIF), the behavior of the isotopes depends not on their absolute masses but on whether their masses are odd or even.

In the work described in the Nature Geoscience paper, the researchers confirmed, through sample collection and experiments, that MIF occurs during the sunlight-driven reactions in snow, resulting in a characteristic MIF fingerprint that is absent in atmospheric mercury.

"This finding allowed us to use the MIF fingerprint to estimate how much mercury was lost from the snowpack and how much remained behind, with the potential to enter Arctic ecosystems," said U-M graduate student Laura Sherman, the paper's first author. "Our experiments showed that a significant portion of mercury deposited to snow was re-emitted. Any mercury that is not re-emitted is likely to retain the unique fingerprint, so we hope future researchers will be able to use our discovery to track mercury through Arctic ecosystems."

**More information:** Nature Geoscience---www.nature.com/ngeo/index.html

Provided by University of Michigan