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Melting Arctic Permafrost Could Release Tons of Toxic Mercury

Scientists have found large natural stores of the toxin in the Arctic. It's not clear how much will get into food webs as the planet warms.

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Scientists have uncovered another hidden threat buried in the icy frozen north—massive natural reserves of mercury, a toxic heavy metal that in some forms can build up in fish and other animals and cause serious health problems in humans.

A study published Monday in the journal *Geophysical Research Letters* reports that the amount of natural mercury bound up in Arctic permafrost may be 10 times greater than all the mercury humans have pumped into the atmosphere from coal-burning and other pollution sources over the last 30 years. As climate change warms the land, this thawing permafrost could release significant quantities of mercury back into the environment, potentially allowing far more of the pollutant to build up in the atmosphere and the food web.

"Prior to the start of the study, people assumed permafrost contained little to no mercury," says study co-author Kevin Schaefer of the National Snow and Ice Data Center at the University of Colorado. "But it turns out that not only is there mercury in permafrost, it's also the biggest pool of mercury on the planet."

Put another way, says lead author Paul Schuster, a U.S. Geological Survey hydrologist, "This is a complete game-changer for mercury. It's a natural source, but some of it will be released through what we're doing with climate change."

What's not yet clear, however, is how much mercury could be released, or when, in a form that is toxic to humans.

A Natural Poison

Mercury is found naturally in the environment and is released by forest fires, volcanic eruptions, and the weathering of rock. But roughly two-thirds of the mercury in the air at any one time is released by humans, primarily through the burning of coal or medical waste or some types of mining. Once airborne, mercury eventually falls back to Earth, winding up in water or on land. There it's picked up by fish and animals, accumulating in ever-higher amounts as it works its way up the food web.

In some forms, mercury is a powerful neurotoxin, and in children it can harm brain development, affecting cognition, memory, language and even motor and visual skills. Even in adults, excessive amounts can hamper vision, speech and muscle movements, compromise the reproductive and immune systems, and cause cardiovascular problems. That's why there are often fish advisories for

mercury near polluted rivers and streams, and why children and pregnant women are urged to avoid eating tuna or other long-lived fish such as swordfish.

Thanks to complex atmospheric and ocean processes, more mercury winds up in the high northern latitudes than anywhere else. It's already known to build up there in birds, fish, seals, walrus, polar bears and some whales, even in areas thousands of miles from pollution sources. As a result of this long-distance pollution, indigenous people across the Arctic who rely on subsistence hunting for food have some of the highest levels of mercury in their blood.

The same winds and currents that send mercury north today have been at work for tens of thousands of years, depositing natural mercury in high concentrations across the Arctic. Since that mercury has been trapped in frozen ground for millennia, it hasn't done damage to wildlife or humans. But now Arctic permafrost, which accounts for 24 percent of all land in the Northern Hemisphere, is thawing and threatening to release this massive store. And, until recently, we didn't have any idea how much was there.

A Decade-long Study

At USGS Schuster has been studying mercury in the atmosphere for several decades. In the 1990s he collected ice core samples from a glacier in Wyoming's Wind River Range and developed a record of mercury deposition dating back to before the Industrial Revolution. That work, he says, eventually played a role in convincing federal regulators that human sources of mercury had risen so much that that the U.S. should start requiring coal-burning facilities to use scrubbers to cut mercury from their emissions.

Eventually, Schuster found his way to Alaska's Yukon River basin and realized that no one had ever attempted to quantify how much mercury might be stored in permafrost. In fact, not every expert was convinced there would be much there at all.

Between 2004 and 2012, Schuster and his team collected more than 13 ice core samples from around Alaska. They chose their sites—and spent years perfecting models—in such a way that the results from Alaska could be extrapolated to permafrost all over the Arctic.

The results show that Arctic permafrost holds roughly 15 million gallons of mercury—at least twice the amount contained in the oceans, atmosphere and all other land combined. "The concentrations were huge—a lot higher than we expected them to be," Schuster says. "That was a big surprise."

The big question is: What's going to happen to that mercury?

It's unlikely that all of it will stay sequestered in permafrost. Once the ground begins to thaw, plants will grow in it, taking up mercury, and the microbes that decompose the plants will release some amount of methylmercury, a more toxic form. Some portion of that will spread through water or air into the ecosystem and eventually into animals.

"That's the vector, the avenue into the food chain," Schuster says.

How Much Gets Into Food?

But determining how significant a risk that will pose is a challenge.

First off, how much temperatures warm depends on how quickly—or not—humans limit emissions of greenhouse gases. That will determine how much permafrost thaws, which will influence how much mercury gets released. But even that is only part of the equation.

"How much winds up in the food web, and where? That's the $100,000 question," Schuster says. "When you jump over to the food chain in this research, things get gray."

Mercury releases initially would pose increased risks to Arctic people and wildlife, "but what happens in the Arctic doesn't stay in the Arctic," Schaefer says. "Eventually it would be dispersed throughout the Earth. It moves around."

The bottom line is there will almost certainly be some impact to humans.

"We know permafrost is going to thaw and we know some portion of the mercury will be released," Schaefer says. "At this point we don't have specific estimates about how much or when—that's the next phase of our research."

Craig Welch writes about the environment for National Geographic.