CSMI Cooperative Science and Monitoring Initiative

Mercury in the Great Lakes: Possibly Not Where You Think You'll Find It

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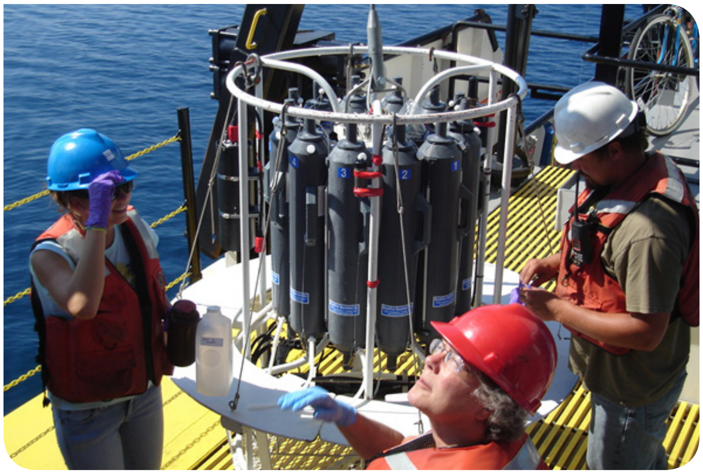
Mercury is an element that has a part of humanity's life at least since the Romans, who used it to extract gold from ore. It's a natural pigment used by Native Americans, it's contained in coal burned for heat and electricity production, and up until rather recently, it was a component of many cosmetic products. The problem is that, despite being a natural element, mercury displaced from where it occurs in nature can cause severe environmental and health issues.

Mercury is a globally dispersed pollutant, as many industrial processes discharge mercury into the atmosphere, where air currents help it travel to every corner of the world. It has been known to cause problems in the Great Lakes for about 50 years, but has been understudied in the past, in part because sample collection and analysis of mercury in anything but fish is extremely difficult to do without contaminating the sample.

"Clean techniques," which focus on making sure that anything a sample touches is as free of trace mercury as possible, were developed in the late 1980s to address this problem. Subsequent research showed that mercury concentrations in water had been severely overestimated due to contamination, which made researchers realize that mercury sources in a given environment did not have to be as obvious as a plant discharge pipe on the shoreline. Mercury-related problems could easily be caused by atmospheric mercury being washed out of the sky by rain. This helped the Environmental Protection Agency (EPA) and other agencies decide on the best approaches to reducing that mercury pollution.

Since those regulations, such as the Clean Air Act, were put into place, researchers at agencies like the U.S. Geological Survey (USGS) have been monitoring mercury in the air, water, sediments and fish to make sure regulations have the desired effect of reducing contamination. Collaboration with the 2014 CSMI Lake Erie research cruise allowed the scientists to more extensively explore the nearshore areas of the lake, which receive mercury input from onshore sources, in addition to the offshore regions that are more affected by atmospheric mercury. What they found in one of the largest coordinated effort for Great Lakes mercury sampling was that, when it comes to water and sediments, mercury contamination in the Great Lakes has been declining steadily over the past two decades. Water mercury levels in Lake Superior and Lake Michigan, for example, have dropped three- to five-fold since the mid-90s, while atmospheric mercury has been cut in half.



Sampling crews prepare to lower the sampling rosette to collect water samples using clean sampling techniques on Lake Erie.

But with fish, it's a different story. Fish bioaccumulate mercury in their tissues, so as they age and grow, the concentration of mercury in their system increases. Because the Great Lakes are relatively cold, fish grow more slowly than they would in more tropical waters, and the fish that eventually reach a harvestable size represent about 15 years of mercury contamination in water. This means even though mercury input to the Great Lakes has dropped significantly, fish mercury concentrations are controlled by multiple factors including legacy contamination in sediment, so fish do not necessarily respond in concert with changes in loading.

In addition, the Great Lakes' uniquely clear waters, especially in Lake Huron and Lake Superior, increase fish mercury levels because mercury tends to attach to particles instead of remaining suspended in water. Clear water means fewer algae, which means each algal cell that a fish consumes there carries a larger amount of mercury. In the lower lakes, the opposite takes place in a process called biodilution, when the sheer number of algae reduces the amount of mercury a fish takes in with each bite. This makes it important to also monitor mercury concentrations in the lower food web, to get a clearer picture of how that contaminant is distributed and how management efforts can best address different types of mercury pollution.

USGS sampling crews process a bottom sediment sample from Lake Erie.

This concentrated Lake Superior algae sample is the amount of algae collected from 16,000 liters (about 4,200 gallons) of water.

Further adding to the intricate nature of mercury monitoring is the fact that fish accumulate mercury in their tissues as methylmercury, the most bioaccumulative form of mercury, while processing inorganic mercury and removing it from their body. Scientists have only really been able to measure methylmercury since the early 1990s, but once those methods were fine-tuned for environmental samples, scientists quickly realized that ecosystems that were highly contaminated with mercury in general were not necessarily also high in methylmercury.

It turns out that pristine ecosystems often have intact microbial communities that, by pure chance of nature, are perfectly suited to converting the inorganic mercury deposited from the atmosphere into methylmercury, so that many of these locations actually have quite high mercury concentrations in their fish communities, while mercury in the water and sediments remains relatively low.

Another big step forward in mercury monitoring in the Great Lakes and elsewhere is the ability to "fingerprint" mercury to determine where it came from. For the past five years, researchers have been able to use mercury isotopes, which have different molecular weights, to tell whether contamination comes from atmospheric mercury deposition, from one of the rivers flowing into the lakes, or from industrial activity along the shoreline.

Being able to pinpoint those sources helps agencies like the EPA better target regulations to address the contamination, because a lake that mostly contains mercury from the atmosphere, such as Lake Huron and Lake Superior, is going to show improvement under new air quality regulations much more strongly than lakes where mercury pollution comes from industrial sources, such as the lower Great Lakes. Having that knowledge helps managers accurately evaluate the impact of their actions, in addition to guiding development of regulations that are more likely to have the desired impacts.

That guidance, in all matters related to mercury in the Great Lakes, is really the goal of this ongoing monitoring program. The more scientists and agencies know about pollution, the better they can address it in ways that make sense for industry and the environment alike.