Recent mercury pollution on the rise, but quick to change

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Dartmouth Assistant Professor Erich Osterberg and his colleagues' analysis of a 600-year-old ice core shows that present-day efforts to cut mercury emissions will reduce pollution more quickly than current models predict. Credit: Dartmouth College

A Dartmouth-led study using a 600-year-old ice core shows that global mercury pollution increased dramatically during the 20th century, but that mercury concentrations in the atmosphere decreased faster than previously thought beginning in the late 1970s when emissions started to decline.

The findings suggest that present-day efforts to cut mercury emissions will reduce pollution more quickly than current models predict.

The study appears in the journal *Environmental Science & Technology*.

Toxic metal mercury is emitted to the atmosphere from coal burning, mining, volcanoes, weathering and other human and natural sources, contaminating ecosystems around the world. Past mercury emissions persist in the environment for decades, and this "legacy" mercury can continue to pollute ecosystems even after emissions decrease.

Past mercury emissions are estimated from historical records of metal production and industrial/commercial activity or from natural archives of atmospheric mercury deposition, including lake sediment cores and glacier ice cores. Mercury has been measured in ice cores since the 1970s, but many of those early cores were later shown to have been contaminated during handling in the field and laboratory. To date, the only published ice core mercury record covering the entire Industrial Period is from a glacier in Wyoming. This record has been used extensively in scientific literature on the global mercury cycle, but the glacier's proximity to upwind historical mining and industrial mercury sources, among other factors, have led to uncertainty about how accurately the record represents global trends in atmospheric mercury levels.

New ice core mercury records could provide insight on past global mercury emissions, so the Dartmouth-led team analyzed an ice core spanning the years 1410 to 1998 from the summit of Mount Logan, Yukon, Canada, which is swept by winds traversing the North Pacific Ocean. The ice core, which was collected by the study's co-authors

David Fisher and Christian Zdanowicz in 2001 while at the Geological Survey of Canada (GSC), was almost destroyed in 2011 when budget cuts threatened the GSC ice core archive.

The analysis showed that the first major mercury pollution peak occurred during the North American Gold Rush of the late 19th century when mercury was used to extract gold and silver from ores and sediments. Following the end of the Gold Rush, mercury levels quickly returned to near natural levels. Starting in the middle of the 20th century, mercury pollution began an unprecedented increase to maximum levels in the early 1970s, most likely due to industrialization in the United States and Europe. Mercury pollution decreased through the late 1970s and 1980s as mercury was removed from many commercial products and emissions regulations were enacted in North America and Europe. But the ice core shows a renewed increase in mercury pollution since the early 1990s until the record ends in 1998 due to the rise of coal burning in Asia and small-scale gold mining in developing countries that is thought to have continued through at least 2008.

Overall, the new study shows 78 percent of mercury pollution occurred during the 20th century, 14 percent during the Gold Rush (1850-1900), and 8 percent during the Colonial Period (1603-1850). Those figures differ significantly from emissions estimates that are used to drive global mercury models, which attribute 43 percent of mercury emissions to the 20th century, 27 percent to the Gold Rush and 30 percent to the Colonial Period. The smaller amounts of pre-20th century emissions found in this study suggest there is significantly less "legacy" mercury from early mining in the modern environment than previously thought.

Most importantly, the new study shows that mercury concentrations in the atmosphere respond more quickly to changes in emissions than most current models predict. For example, concentrations decreased quickly after the Gold Rush and after environmental legislation was enacted to reduce emissions in the 1970s. This suggests that future efforts to cut mercury emissions will have a larger impact on reducing pollution than current models predict.

"The ice core record shows clearly how efforts to reduce mercury emissions have decreased pollution in the past. But the recent rise in mercury pollution from coal burning and small-scale gold mining show that there is more work to be done," says lead author Sam Beal, a research chemist at the U.S. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory who conducted this work as a Ph.D. student in Dartmouth's Department of Earth Sciences.

Co-author Erich Osterberg, an assistant professor in Dartmouth's Department of Earth Sciences, and his colleagues will continue to study recent pollution trends from Asia using a new ice core collected in 2013 from Mt. Hunter in Denali National Park, Alaska. "We're interested to see how mercury and other toxic metal pollutants have changed from the late 1990s to the present day," Osterberg says. "The collection of new ice cores for this work demands urgency as glaciers around the world melt at an accelerating rate with warming temperatures."

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