Mercury Pollution

Mercury (Hg) is a potent neurotoxin with worldwide distribution. Levels of mercury in the environment have increased dramatically since the industrial revolution, and risk of exposure to humans and sensitive ecosystems is a major concern, particularly in Arctic regions.

Emissions from the United States and Europe are declining, but emissions from Asia (responsible for about 50% of current global emissions) continue to increase. The majority of world-wide emissions come from the stationary combustion of fossil fuels, such as coal burning power plants, and also from production of iron, steel, and other metals, cement production, and waste disposal.

Why is Mercury a Problem in the Arctic?

While mercury is not a common metal in the earth's crust, because it is volatile, it can be redistributed through the atmosphere, and also through water bodies. Once volatilized, mercury can remain in the atmosphere for as long as two years, and during that time, it can be carried far away from its source. Air-borne mercury arrives in the Arctic via prevailing winds. As air masses cool they deposit mercury onto land, ice, and snow surfaces via precipitation (wet deposition). Under certain conditions, mercury can react with other chemicals in the air and dry deposition then occurs.

Methylmercury (MeHg) is the most dangerous and bioaccumulative chemical form of Hg. This compound naturally concentrates in organisms, especially those at the top of food webs, such as long-lived predators in freshwater, marine, and terrestrial systems. The most common route of exposure is dietary. (See next page for a diagram of the mercury cycle)

The indigenous people of Canada have one of the highest exposures to methylmercury in the world because of their reliance on traditional local foods. While the majority of methylmercury exposure occurs due to consumption of marine animals, high levels of mercury are also found in landlocked fish populations (i.e., fish found in lakes and rivers not connected to the ocean), especially when the fish prey on other fish. Humans exposed to methylmercury can sustain permanent neurological damage and experience toxic effects to the reproductive and immune systems.
The Char Monitoring Project

Top predators in Arctic lakes are important indicators for mercury contamination across the Arctic ecosystem. The Char Monitoring Project, led by Günter Köck from the Austrian Academy of Sciences and Derek Muir from Environment Canada has been monitoring levels of contaminants, including mercury, in several populations of landlocked Arctic char since 1989 near the remote community of Resolute (population: 214) on Cornwallis Island in the central Canadian Arctic. The project helps to make dietary recommendations to people in the community who rely directly on the lakes for food, and also to other communities in the area.

Source: www.thecanadianencyclopedia.com
Our research project

For our study, we selected four of the lakes included in the Char Monitoring Project located very close to Resolute, which we know are used as community fisheries and water supply: Char, Resolute, Meretta, and Small Lakes. Our project focuses on: 1) the methylation process, 2) methylmercury in lake food webs, and 3) the trends in climate that could affect mercury deposition and methylation.

Arctic Lake Food Webs

Since lakes are low points in the landscape, they concentrate nutrients (and contaminants) that wash in from the surrounding land or watershed, making them very important study sites for biologists and toxicologists.

Lakes in the Arctic have a short growing season, low amounts of nutrients, simple food webs, and low productivity compared to their lower-latitude counterparts. The lakes included in our project occur in the polar desert region of Arctic Canada, which means that there is very little vegetation around the lakes and not much nutrients washing into the lakes.

In many high-latitude lakes, the bulk of the productivity occurs at the surface of the sediments (the benthos), where nutrient concentrations are enhanced by sedimentation of particles and chemicals from the water column. Nutrients and chemicals are also released from the sediments to the water column via the decomposition processes occurring within the sediments. In addition, the physical environment at the sediment-water interface is more stable than that of the water column.

Benthic primary producers include aquatic mosses, algae, and bacteria. A type of single-celled algae known as diatoms provides food for the majority of the primary consumers. The primary consumers are mostly insect larvae, especially that of chironomids (non-biting midges). The chironomid larvae live in the sediments for 2-3 years before emerging, swimming to the lake surface, and molting into adults to mate. The adults live for only a few weeks, during which they do not feed, but simply mate and lay eggs on the surface of the ice or near the lake shore.

The emerging larvae are preyed upon by the only species of fish in the lakes, Arctic char. Arctic char (Salvelinus alpinus) are a salmonid fish related to brook trout, lake trout, and salmon, but are
higher growth rate of organisms in warmer water and sediment could help to counteract the effects of increased methylation. Temperature increases have already led to subtle changes in the study lakes, such as the appearance of new diatoms species in one of the lakes.

More about our Research Project

Our approach includes incubating lake sediments at different temperatures, sampling the chironomids and fish in the lakes, monitoring lake water temperatures, and examining the climate record and the fossil diatom record from one of the study lakes.

During the summer of 2012, sediment incubations were carried out and thermistors (devices which record water temperature at several depths) were installed in each of the four study lakes. Sediment cores were collected for analysis of the fossil diatom record. In the summer of 2013, chironomids were collected from the study lakes, and sediment incubations were carried out. Thermistor chains were recovered and the data downloaded before the thermistors were put back
to continue recording lake temperatures. Fish samples were also collected, as part of the Char Monitoring Project. All the chironomid and fish samples will be analyzed for Hg and MeHg.

Overall in this project, we hope to track the biomagnification process up the food chain, linking the methylation rate to the concentration of methylmercury in the chironomid larvae, pupae, and finally the Arctic char. This will allow better understanding of the bioaccumulation process, and how this process might be affected by temperature as climate change continues to impact Arctic lakes.

Community participation in the project

Alicia Manik (photo), a high school student from Resolute, assisted with the research during the summer of 2013. Debbie Iqaluk, another resident of Resolute, has been assisting with the Char Monitoring Project for several years. Both have been an integral part of the research and have enriched the quality of the data and samples, not to mention making it fun!

To learn more about…

Polar desert ecosystems:
www.arctic.uoguelph.ca/cpe/environments/land/northarctic/north_arctic.htm

Contaminants research in the Arctic:

Mercury as a contaminant – Environment and Health:

Mercury and climate change in the Arctic
www.amap.no

Fish consumption advisories across Canada:

Research in Resolute, including this project:
http://arcticprofiles.wordpress.com/
(For this project: click on Archive, July 27 and August 1)