# Mercury – a priority pollutant

Over the past 10 years, the Arctic Monitoring and Assessment Programme (AMAP) has conducted two major assessments of the pollution status of the Arctic. These have documented the sources, levels and trends, and effects of a wide range of contaminants, including mercury. The main conclusions of these assessments are that: *"In comparison with most other areas of the world, the Arctic remains a clean environment. However, for some pollutants, combinations of different factors give rise to concern in certain ecosystems and for some human populations. These circumstances sometimes occur on a local scale, but in some cases may be regional or circumpolar in extent."* In response to the AMAP findings, the Arctic Council Action Plan to Eliminate Pollution of the Arctic (ACAP) was initiated. Mercury is one of the priority pollutants that have been selected for action under ACAP, and in 2001 the project "Reduction of Atmospheric Mercury Releases from Arctic States" was launched.

SOURCES: Mercury occurs in the environment as a result of both natural releases and releases associated with human activities.

The main sources associated with human activities include burning of fossil fuels, in particular coal, for heat and energy; production of metals, cement, chlorine and caustic soda; and incineration of mercury containing waste.

Releases to the air from human activities have been reduced in Europe and North America over the past 20 years.

In Asia, however, and in China in particular, releases appear to be increasing due to industrial expansion and small-scale coal burning for heat by rapidly increasing populations.

PATHWAYS: Gaseous elemental mercury - the main form of mercury emitted to air - has a sufficiently long residence-time (ca. 1-2 years) in the atmosphere, to allow it to be transported to the Arctic from sources throughout the northern hemisphere.

Recently, it has been shown that during the polar sunrise a significant increase in mercury deposition occurs. This is caused by a unique combination of photochemical reactions in the surface layers of the atmosphere. These reactions transform mercury to a form which is readily deposited to the surface and easily absorbed by organisms.

This mercury input coincides with the explosive production (algal bloom) that occurs in this period. It has been estimated that these .mercury depletion events. deposit some 150-300 tonnes of mercury annually in the Arctic, as opposed to the 80 or so tonnes that would otherwise deposit in the region. At snowmelt a fraction of the reactive gaseous mercury undergoes transformation once again to elemental mercury and is re-emitted. Preliminary data indicate that a large fraction can be re-emitted.

Mercury also reaches the Arctic via the large north flowing rivers of North America and Siberia – although riverine inputs to the Arctic Ocean (ca. 10 tonnes per year) are estimated to be much less than inputs from the atmosphere.

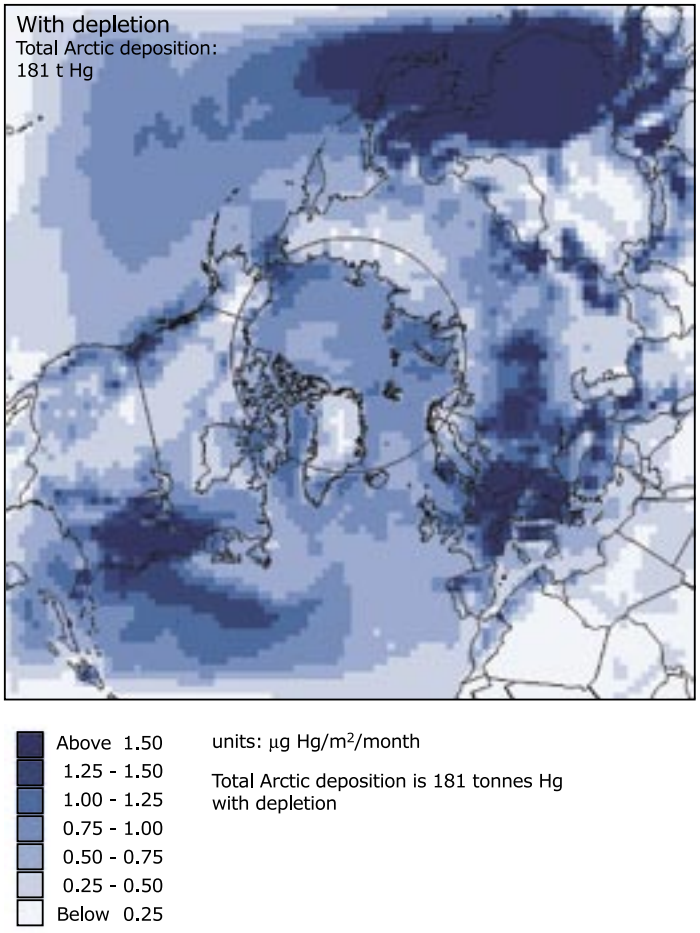


Figure 1. Distribution of mercury deposition in the Arctic including mercury depletion event in the model (total Arctic deposition: 181 tonnes Hg/year)
*Source: AMAP/ J. Christensen, NERI, Denmark.*

LEVELS: Evidence of increasing mercury contamination of the Arctic can be found in many environments- teeth of beluga and sediments from lakes and peat bogs demonstrate substantial increases between the pre- and post-industrial periods over much of the Arctic.

More recent temporal trends have been studied using a range of biota. There is evidence of increasing trends over the past 30 years, particularly in parts of northern Canada - despite decreasing trends in areas closer to sources.

Humans also reflect these increasing mercury trends. Hair in Greenlanders today has mercury levels 3 to 6 times higher than hair from mummified remains found in Greenland that date from the 15-16th century.

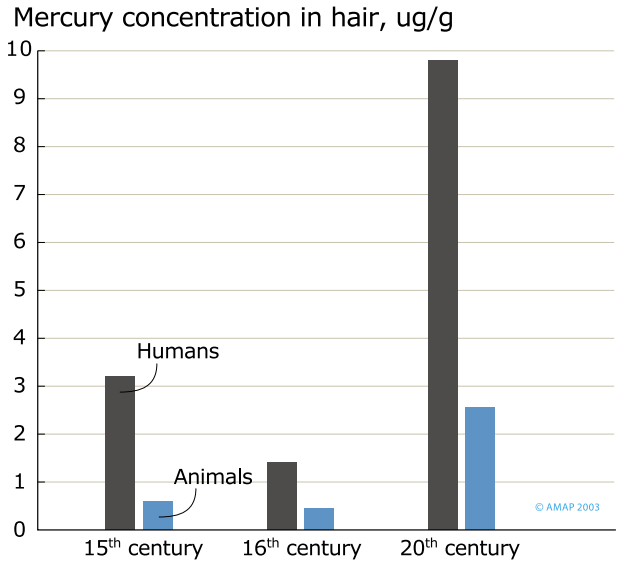


Figure 2. Mercury concentration in human and animal hair from Greenland
*Source: AMAP Assessment 2002: Human Health in the Arctic. AMAP, 2004.*

EFFECTS: Much of the mercury in the environment is strongly bound to sediments and organic matter and is unavailable for uptake by organisms. Microorganisms can, however, convert inorganic mercury into methyl mercury, which is fat-soluble and accumulates in animals. This form of mercury is of particular concern for effects on biota. Mercury is toxic to all living organisms. It bioaccumulates in Arctic marine food chains, reaching levels that could result in adverse effects in animals and humans. Nearly all mercury in fish is methylmercury. Fish are an extremely valuable component of the human diet in many parts of the world, providing nutrients that are often not available in alternative food sources. Consumption of fish with low mercury levels is not likely to result in exposures of concern.

Some human populations, however, such as the Inuit of northeast Canada and Greenland, that eat marine mammals and fish as part of their traditional diet, are exposed to methylmercury that exceed WHO tolerable weekly intakes.

Indigenous populations in several areas of the Arctic have blood mercury levels that exceed US and Canadian established guidelines. Methylmercury readily passes the placental barrier and the blood-brain barrier, it can therefore affect a growing fetus whose brain is much more sensitive than the adult brain.

Studies have shown that methylmercury in pregnant women's diets can result in subtle adverse effects on their children's learning ability. A doubling in prenatal exposure to mercury has been shown to correspond to a delay in child development of 1-2 months during the first seven years of life. It is not yet known how significant such a delay will be when the child grows up. Other studies of adult males suggest that small increases in methylmercury exposure may cause adverse effects on the cardiovascular system. The fact that there is evidence in the Arctic of effects or potential for effects of mercury on both humans and wildlife is a major cause for concern.

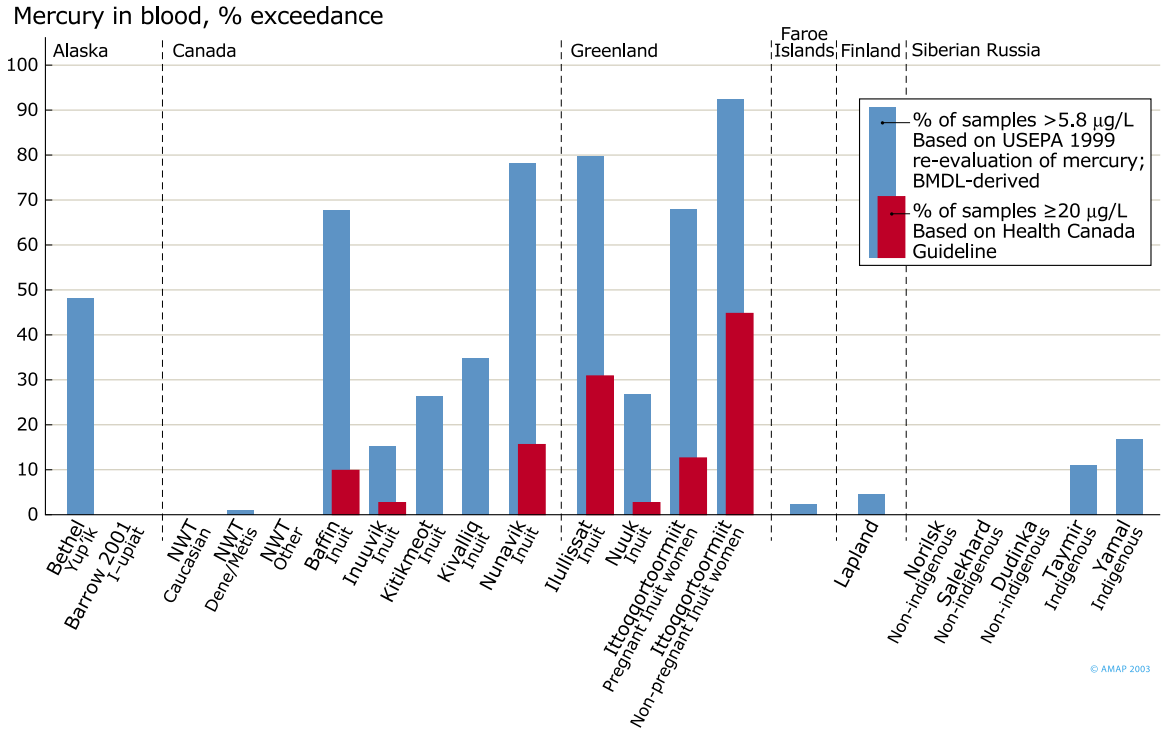


Figure 3. Mercury levels in blood of indigenous and non-indigenous women of reproductive age. Percentage of samples exceeding U.S. EPA and Health Canada guidelines for increasing risk range.
*Source: AMAP Assessment 2002: Human Health in the Arctic. AMAP, 2004.*

**ARCTIC COUNCIL ACTIONS:** In response to the above findings, the Arctic Council decided to implement a project on "Reduction of Atmospheric Mercury Releases from Arctic States" as part of the Arctic Council Action Plan to Eliminate Pollution of the Arctic (ACAP).

The project objective is to contribute to a reduction of mercury releases from the Arctic countries. This would partly be done by developing mercury release inventories and release reduction strategies, and partly by initiating actions to demonstrate release reduction options at one, or a few, specific sources located in an Arctic country, the Russian Federation. The sources are selected based on regional and national release inventories and a detailed evaluation of potential demonstration project sites. The project is coordinated by Denmark.

**ARCTIC MERCURY RELEASE INVENTORY:** This inventory was developed to provide a sound basis for the planned actions. It summarizes and discusses current releases, usage and disposal of mercury within all eight Arctic countries, as well as technical and legislative measures that are in use or could be considered to reduce mercury releases.

The inventory is based on nationally reported information on mercury releases, the assessment of mercury releases from the Russian Federation (described below), as well as contemporary literature.

Recognizing that the major proportion of the mercury deposited in the Arctic originates from outside the region, the inventory includes releases from the entire territory of the Arctic countries.

Comparisons need to be made with caution, due to differing data quality and reporting years, however the reported data provide valuable indications of major source categories, national contributions, and the current status of reduction efforts within the Arctic countries.

Contributions from different source categories varied somewhat between the countries. The main release sources were confirmed to be coal combustion, nonferrous metal production (gold, copper, nickel, zinc, lead, etc.), incineration of mercury-containing wastes, and the chlor-alkali industry.

Among the Arctic countries, the United States has the largest mercury releases followed by the Russian Federation, while the other countries have smaller releases. Atmospheric releases of mercury per inhabitant are lowest in Sweden, Finland and Norway; intermediate in Canada, Denmark and the Russian Federation, and somewhat higher in the United States.

When considering mercury releases in relation to economic activity, the Russian Federation releases per GDP are substantially above those found in other countries, primarily because of the lower per capita GDP in Russia than in the other countries.

Reducing mercury emissions has been a high priority in most Arctic countries, and current releases are, in countries with documented release trends, much lower than 10-20 years ago. However, there is still room for improvement in reducing releases of mercury from the Arctic countries.

**ASSESSMENT OF MERCURY RELEASES FROM THE RUSSIAN FEDERATION:** As a part of the project, a national mercury releases inventory for the Russian Federation was prepared and assessed by a Russian expert group assisted by international experts. This represented the first comprehensive assessment of mercury releases at the national level by the Russian Federation.

The assessment provides both an overview of relevant source categories, and a presentation of a considerable amount of detailed information and data, made available in English for the first time.

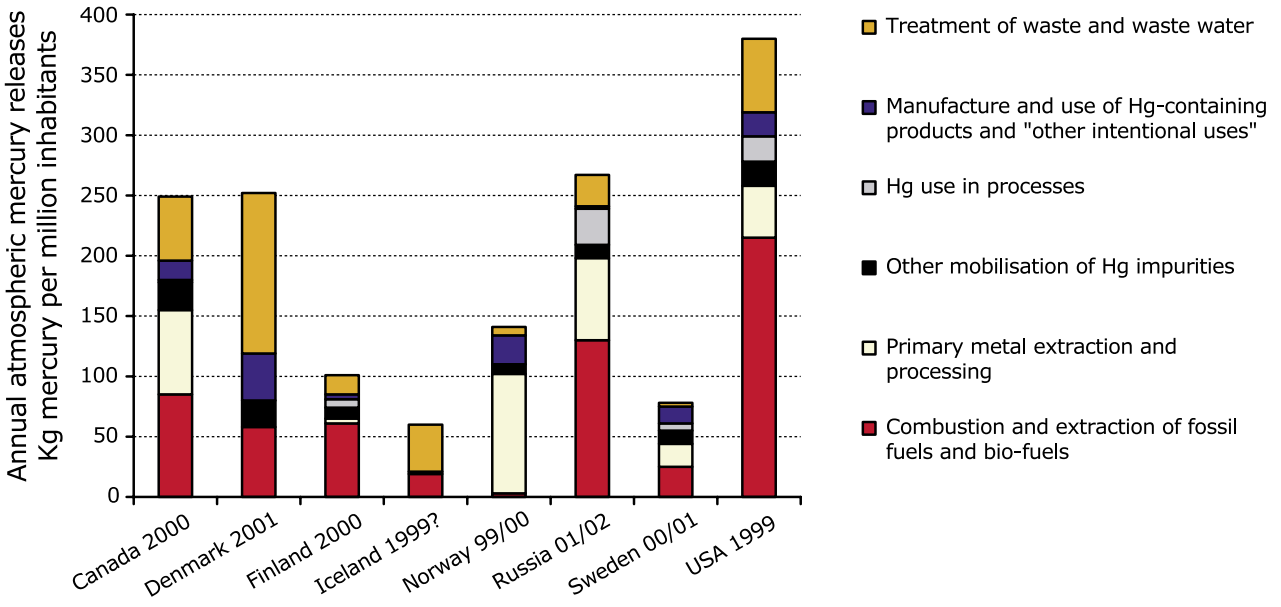


Figure 4. Annual atmospheric mercury releases from the Arctic States per million inhabitants
*Source: Arctic Mercury Releases Inventory, ACAP, 2005*

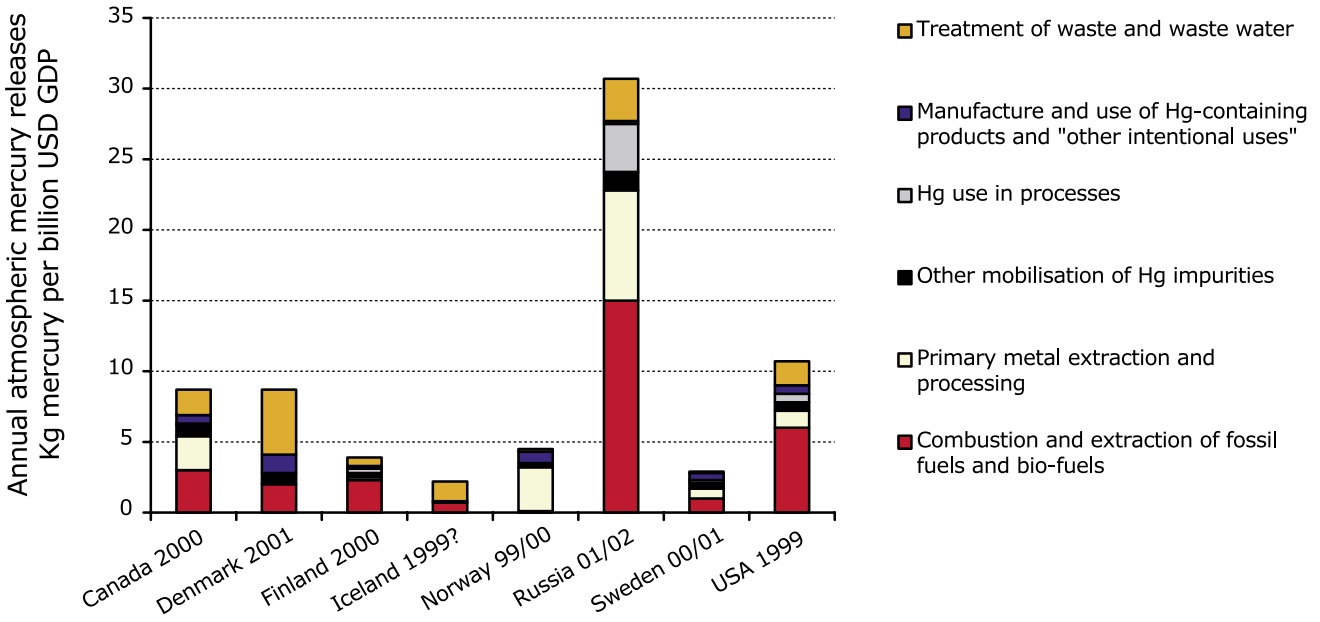


Figure 5. Annual atmospheric mercury releases from the Arctic States per billion USD Gross Domestic Product
*Source: Arctic Mercury Releases Inventory, ACAP, 2005*

The assessment includes data on mercury released to air, deposited in landfills and waste dumps, as well as estimated total mercury inputs to society (intentional use and unintentional human mobilization), by source category.

Major sources of mercury releases in the Russian Federation are coal combustion; production of oil and natural gas; production of gold, nickel, copper, zinc and lead; waste incineration and land-filling, and chloralkali production using mercury-based technology. Chlor-alkali production and the manufacture of mercury thermometers constitute the main sectors with respect to intentional mercury use. The assessment provides the basis for the selection and evaluation of potential sites for release reduction demonstration projects.

PROPOSAL FOR PRIORITY SETTING IN THE RUSSIAN FEDERATION: The Russian mercury release assessment provides inputs to a preliminary priority setting document on mercury release reductions, to be prepared by the Russian Federal Service for Environmental, Technological and Atomic Supervision (Rostechnadzor).

PRIORITY ACTIONS IN THE ARCTIC STATES: A regional assessment of existing and planned initiatives addressing the source categories in the Arctic States and possible measures for follow–up is also part of the ACAP's work on mercury, and a report is expected in the beginning of 2006.

DEMONSTRATION PROJECTS: As part of ACAP's activities a number of specific point sources in the Russian Federation have been studied in order to evaluate their potential as demonstration projects on mercury reduction measures. Based on this evaluation, ACAP intends to proceed with one or more demonstration project(s).

PARTNERSHIP CO-OPERATION: At the UNEP Governing Council in February 2005, global partnership co-operation was prioritised within the Global Mercury Programme. A partnership with the objective of implementing cleaner production techniques to reduce mercury use and releases from chlor-alkali plants in Russia has been initiated in co-ordination with ACAP.

The ACAP reports – *Arctic Mercury Release Inventory* and *Assessment of Mercury Releases from the Russian Federation* – are available from:

http://acap.arctic-council.org/projects.cfm