

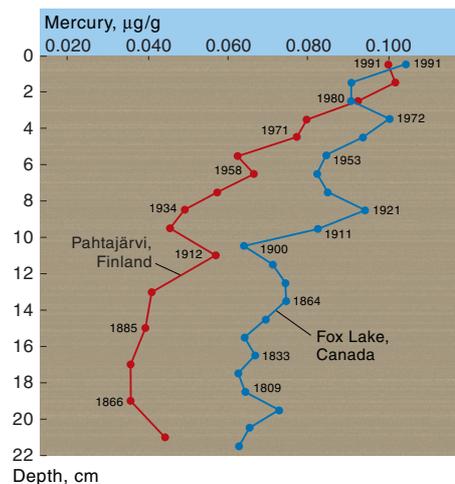
# Fact sheet #3

Produced for the Arctic Council by the Arctic Monitoring and Assessment Programme (AMAP)

## Heavy Metals

In 1997, Ministers committed 'to take [the AMAP] findings and recommendations into consideration in [their] policies and programmes.' They agreed 'to increase . . . efforts to limit and reduce emissions of contaminants into the environment and to promote international co-operation in order to address the serious pollution risks reported by AMAP' and to 'draw the attention of the global community to the content of the AMAP reports in all relevant international fora . . . and . . . make a determined effort to secure support for international action which will reduce Arctic contamination.' (Alta Declaration, 1997).

In September 2000, AMAP provided 'Updated information on mercury in the Arctic' as part of the 'AMAP Report on Issues of Concern' that was delivered to the Second Arctic Council Ministerial Meeting. Ministers 'noted with concern that releases of mercury have harmful effects on human health and may damage ecosystems of environmental and economic importance, including in the Arctic'. They therefore 'called upon the United Nations Environment Programme to initiate a global assessment of mercury that could form the basis for appropriate international action in which the Arctic States would actively participate.' (Barrow Declaration, 2000).



Elevated levels of mercury in upper levels of sediments reflect increasing inputs over time.

## Heavy Metals

Metals occur naturally in the environment, in different forms (compounds and species): as ions dissolved in water, as vapors, or as salts and minerals in rock and soil. They are also present in plants and animals. Metals can be bound in organic or inorganic molecules, or attached to particles in the air. Both natural and anthropogenic processes and sources emit metals into air and water.

In the Arctic, as elsewhere, there is concern that human activities, such as mining, metal processing, and burning of fossil fuels, will increase the release of metals that can be transported by wind and water and potentially become available to plants and animals. Moreover, heavy metals can enter the environment as a result of domestic and industrial waste disposal.

Some metals are emitted in gaseous forms or as species that associate with (ultra)fine atmospheric particles that can be transported over long distances. Metals that enter the aquatic environment, especially dissolved metals, can likewise be transported over large distances by rivers and oceans. Although metals can thus be subject to long-range transport, the most significant effects of emissions and discharges from point sources tend to be restricted to the environments in the local/regional vicinity of the point source.

Plants and animals depend on some metals as micronutrients. However, certain forms of some metals can also be toxic, even in relatively small amounts, and therefore pose a risk to the health of animals and people. A legacy of incidents tells us about the seriousness of high levels of exposure to some metals, especially cadmium and methyl mercury, however the effects of chronic exposure to trace amounts of metals are generally less well understood.

The major heavy metals of concern are mercury, cadmium, and lead. All three can be toxic at levels that are only moderately elevated above natural ambient levels. They are believed to be present in some regions of the Arctic at levels that may pose risks to the environment and to human health. Moreover, the Arctic region is a recipient of heavy metals generated in other regions of the northern hemisphere. This input adds to naturally high levels of cadmium and mercury in some parts of the AMAP region. Studies have also shown that selenium is important because it may reduce certain toxic effects of mercury. Arsenic, copper, chromium, nickel, vanadium, and zinc, are also of concern, especially close to sources.

## Ministerial Decisions

In 1993, Ministers 'agreed to support the development of appropriate protocols under LRTAP auspices, and to consult with non-ECE nations whose emissions and discharges may affect the Arctic, to achieve their participation in the protocols' and 'to continue to take measures to reduce and/or control the use of a number of . . . heavy metals . . .' (Nuuk Ministerial Report, 1993)

As a part of their commitment to take AMAP findings into consideration in their policies and programmes,

Ministers agreed 'to fully support the negotiations to conclude . . . protocols on heavy metals . . . [under the framework of the United Nations Economic Commission for Europe (UN ECE) Convention on Long-range Transboundary Air Pollution].' (Alta Declaration, 1997)

At the 1998 meeting of the Arctic Council, Ministers reaffirmed their 'commitment from the Alta Declaration to increase . . . efforts to limit and reduce emissions of contaminants into the environment and to promote inter-

*national cooperation and make a determined effort to secure support for international actions in order to address the serious pollution risks reported by AMAP . . . . They therefore 'agreed to work vigorously for the early ratification and implementation of the Protocols on the elimination or reduction of discharges, emissions and losses . . . of Heavy Metals under the framework of the United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution.'* and to 'encourage other states to do the same, with the aim to bring

*the Protocols into force as early as possible.'* Ministers expressed their full support for 'regional cooperation to facilitate the delivery of the measures that are needed to meet the obligations of the Protocols on . . . Heavy Metals.' (Iqaluit Declaration, 1998)

In 2000, Ministers repeated once more these messages, encouraging 'those countries, and in particular Arctic States, which have not yet ratified the UN ECE Protocols on heavy metals . . . to take all appropriate steps to become parties to the . . . protocols.' (Barrow Declaration, 2000).

## AMAP's Findings

In comparison with most other areas of the world, the Arctic remains a clean environment. However, the following conclusions illustrate that, 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.

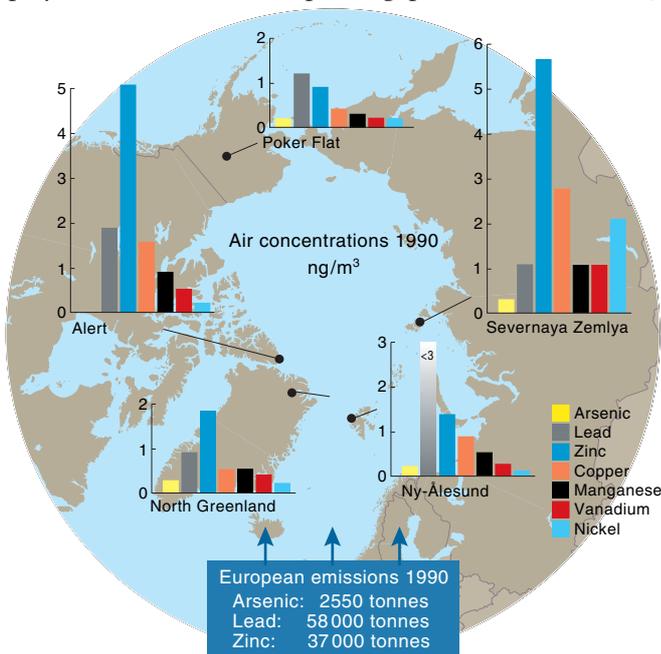
### Heavy metals sources, pathways and trends

Heavy metals occur in the Arctic due to ubiquitous natural sources. They also result from current and historical anthropogenic sources both within and outside the Arctic.

Two-thirds of heavy metals in air in the High Arctic originate from industrial activities on the Kola Peninsula, the Norilsk industrial complex, the Urals (outside the Arctic) and the Pechora Basin. Strong south to north air flows, particularly over west Eurasia in winter, also transport heavy metals to the Arctic from industrial sources in Europe and North America.

Some volatile mercury species are transported globally. At point sources such as mine sites, heavy metals may exceed local background concentrations at distances up to 30 km from the site.

Arctic rivers are also significant pathways for contaminant transport to the Arctic. Suspended solids carry high levels of contaminants and sedimentation processes play a critical role in depositing particles in estuaries,



Winter air concentrations of heavy metals at remote Arctic sites in 1990.

### UN ECE LRTAP Convention on Heavy Metals Protocol

The Executive Body [of the Convention on Long-range Trans-boundary Air Pollution] adopted the Protocol on Heavy Metals on 24 June 1998 in Aarhus (Denmark). It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, Parties will have to reduce their total annual emissions for these three metals below their levels in 1990 (or an alternative year between 1985 and 1995). The Protocol aims to cut emissions from industrial sources (e.g., iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration. It lays down limit values for emissions from stationary sources and suggests best available techniques (BAT) for these sources, such as special filters or scrubbers for combustion sources or mercury-free processes. The Protocol requires Parties to phase out leaded petrol. It also introduces measures to lower heavy metal emissions from other products, such as mercury in batteries, and proposes the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint. (text taken from [www.unece.org/env/lrtap/hm\\_h.htm](http://www.unece.org/env/lrtap/hm_h.htm))

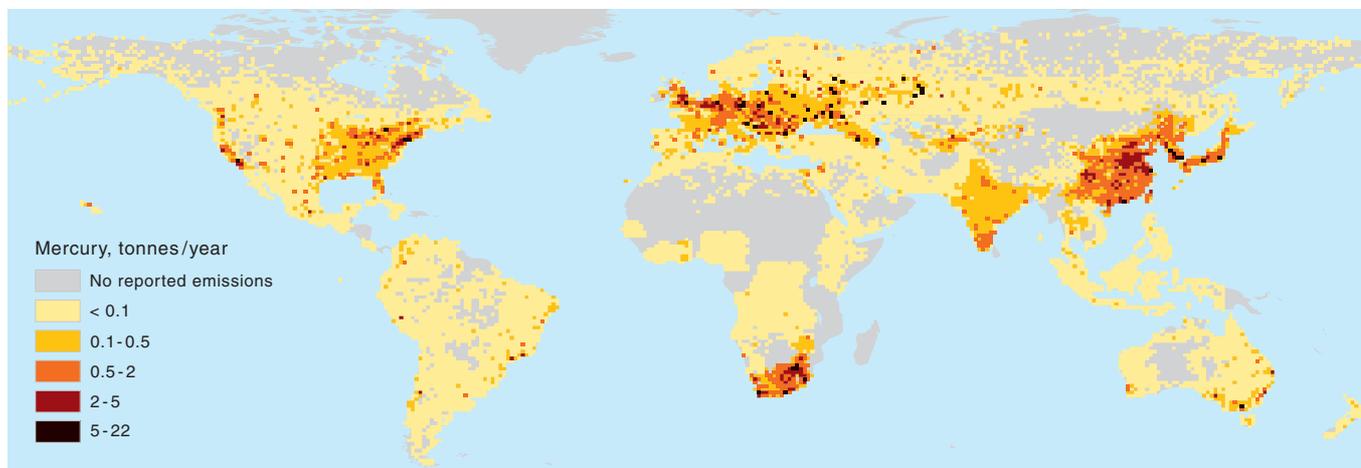
### Ratification of the UN ECE Protocol on Heavy Metals

The UN ECE LRTAP Convention Protocol on Heavy Metals was opened for signature in 1998. In order to enter into force, the protocol requires ratification by sixteen parties to the Convention. As of early 2001, 36 parties, including all Arctic countries except the Russian Federation, had signed the Protocol; eight countries, including Canada, Finland, Norway, Sweden and the United States had ratified the Protocol.

Updated information on the status of signing and ratification can be found on the Internet at: [www.unece.org/env/lrtap/protocol/98hm\\_s.htm](http://www.unece.org/env/lrtap/protocol/98hm_s.htm).

deltas, and Arctic coastal shelves, leading to local and regional dispersal of some heavy metals.

Several studies indicate that mercury levels are higher in the upper layers of Arctic marine and freshwater sediments than in the layers representing pre-industrial inputs. Mercury levels in marine sediment cores from Greenland indicate a doubling of the mercury flux to these sediments during the last century. Peat bog profiles from southern Greenland show a ten-fold increase in mercury concentrations during the last century. An increase over



Global emissions of mercury in 1990.

the past two to three decades is also evident in livers and kidneys from some marine mammals. This may indicate an increased global flux of mercury, which is deposited in the Arctic because of the cold climate. In some parts of the Arctic, notably Greenland and western Canada, any increase in the mercury load is in addition to high natural levels from the local geology.

These trends are also reflected in humans. Mercury levels in people living today in Northwest Greenland are up to three times higher than those that can be calculated from archeological hair samples from the late 1400s.

#### *Emissions to the atmosphere of some metals are being reduced*

Regulatory actions and controls on emissions have resulted in measurable reductions in input of some metals (e.g., lead due to the introduction of lead-free petrol). However, continued cycling in the environment of accumulated pools of long-lived contaminants can result in continued exposure long after controls have been enforced.

Between the early-1980's and mid-1990's, European and North American anthropogenic emissions to the atmosphere were halved for several heavy metals. These reductions are largely due to improvements in the efficiency of technological measures introduced at power plants and waste combustion facilities, etc., to control emissions of fine particles and SO<sub>2</sub>, which also reduce emissions of heavy metals. The increased use of oil and natural gas rather than coal for electricity generation has also reduced heavy metals emissions in Europe. The demand for coal-based energy in the Asian countries, however, increased significantly between the beginning of the 1980's and mid-1990's. Consequently, the pattern of decreasing heavy metal emissions in Europe and North America has been offset by increased emissions associated with the growing demand for electricity in Asia. Emissions of metals including cadmium and lead from stationary fossil fuel combustion did not, therefore, change significantly on a global basis between the beginning of the 1980's and the mid-1990's.

#### *Concern over mercury*

Mercury (Hg) emissions from coal burning sources (in particular power plants) in Asia are an increasing concern. A major part of the emission occurs in the form of gaseous mercury, which passes control equipment and enters the atmosphere. Almost 1500 tonnes of Hg were emitted from fossil fuel combustion in stationary sources

in 1995, with Asian countries responsible for 60% of these emissions. China followed by India are the main contributors. Increased mining and mineral processing activities in Russia and China, and other parts of the World, may also lead to additional emissions of mercury.

#### *New Initiatives under UNEP*

In the Declaration from the Barrow Ministerial meeting in 2000, Ministers called upon UNEP to initiate a global assessment of mercury that could form the basis for appropriate international action.

At the 21st session of UNEP's Governing Council, in February 2001, agreement was reached to undertake a global study on the health and environmental impacts of mercury, and to compile and summarize information about prevention and control technologies and practices, and their associated costs and effectiveness.

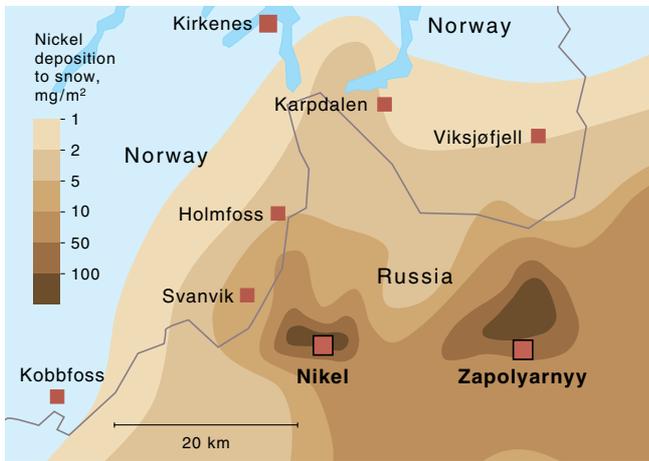
Other decisions taken at the meeting included a new initiative to tackle the issue of lead in petrol.

Further information can be found on the Internet at UNEP's web site at: [www.unep.org/GC\\_21st](http://www.unep.org/GC_21st)

Elemental mercury in the atmosphere is susceptible to long-range transport and can reach the Arctic from distant sources. Measurements of Hg in air in the Canadian High Arctic were the first to reveal a distinct seasonal pattern of springtime mercury depletion events (MDE) that suggested that Hg from the global background pool of elemental Hg might accumulate in the Arctic, possibly involving transformation of elemental mercury to reactive gaseous mercury species. Although the majority of atmospheric mercury is present in elemental form, reactive forms of mercury have greater local impact on the environment and are of significant concern. Recent studies have indicated significant increases in total mercury concentrations in snow deposited during MDEs, and its transformation to reactive species that are accumulating in the Arctic snowpack at rates higher than are currently measured along the highly industrialized east coast of the U.S.

#### *Biomagnification in Arctic food chains increases the potential threat from metals*

Various processes remove contaminants from the atmosphere, oceans and rivers and make them available to plants and animals. Food chains are the major biological



Yearly nickel deposition to snow on the Kola Peninsula.

pathways for selective uptake, transfer, and sometimes magnification of contaminants by Arctic plants and animals, many of which are subsequently consumed by Arctic peoples.

In several marine mammals, geographical differences in, e.g., cadmium and mercury contamination may be explained by differences in geology, diet, and growth processes related to temperature. Biomagnification of metals is often very selective, e.g., there is no indication that lead and selenium levels increase in higher trophic levels although cadmium and mercury clearly do.

There is considerable variability among species in their exposure and response to different contaminants, and their rate of recovery from the effects of exposure. The most exposed animals to many contaminants are those high in the food webs, such as marine mammals, including polar bears, and birds of prey, but also some fish species.

Cadmium seems to bioaccumulate with age, to levels that may be high enough to cause kidney damage in some terrestrial and marine birds and mammals. Mercury seems to be increasing in marine mammals. It is biomagnified but its effects may be suppressed by selenium.

Industries on the Kola Peninsula and Norilsk emit a wide spectrum of major local pollutants, including metals, resulting in strong spatial gradients along atmospheric, terrestrial, riverine and marine pathways. Effects can be locally catastrophic and subregionally damaging, e.g., areas adjacent to nickel smelters.

#### Human exposure to metals

Several groups of people in the Arctic are highly exposed to environmental contaminants. Contaminants derived from long-range transport or local sources accumulate in animals that are used as traditional foods, often at levels exceeding those in foods from outside of the Arctic.

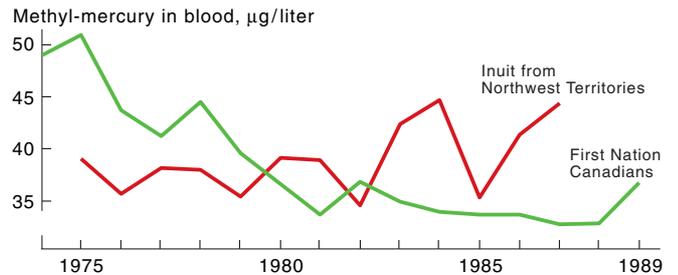
Some of the most exposed groups include Inuit in North Greenland and Inuit and Cree in the eastern Canadian Arctic. A dietary survey of eastern Canadian Inuit shows that 29 percent of the women have daily intakes of mercury that exceed WHO tolerable daily intake recommendations.

Both cadmium and mercury tend to accumulate in marine food webs. Methyl-mercury is efficiently taken up following consumption and poses the main potential risk.

Variation in human exposure depends on a combination of 1) varying environmental concentrations of contaminants, 2) local physical and biological pathways

which make the contaminants available, and 3) the local dietary habits of the people. Other life-style factors also play an important role in exposure to heavy metals and in exacerbating their effects. For example, smoking is a major source of exposure to cadmium.

Because the periods of fetal development and development in children during the early years of life are those associated with the highest vulnerability to toxic substances, contaminant intakes by pregnant women and children are of greatest concern.



Time trend of methyl-mercury concentrations in blood from Inuit in Northwest Territories and First Nation Canadians.

Methyl-mercury can be transferred to the fetus and to breast-fed children, and in certain areas levels are high enough to indicate a need for public health measures. Preliminary results indicate that the average umbilical cord blood levels of methyl-mercury are two- to ten-fold higher in newborns in the Arctic region than in newborns from regions farther south. Although mercury intakes can be high, selenium levels in Arctic traditional diets are also elevated and it is possible that selenium might reduce the risks associated with these mercury intakes.

#### Advice concerning human exposure

The goal of public health actions should be to reduce exposure to contaminants, especially by pregnant women and children, throughout the population. In indigenous communities in particular, this should be done without threatening the social, cultural, spiritual, and physical well-being that is connected to collecting, sharing, and consuming traditional foods.

Traditional foods have known nutritional value and there is as yet little conclusive scientific evidence directly linking effects in adults to the levels of exposure that have been observed in the Arctic. Therefore it is not always clear what public health measures should be taken to reduce the exposure of populations who rely on traditional foods. Consequently, it is recommended that consumption of traditional food continue, with recognition that there is a need for dietary advice to Arctic peoples so they can make informed choices concerning the foods they eat.

For certain geographic areas, current dietary exposures to methyl-mercury and to cadmium are high enough to indicate a need for public health measures.

#### Arctic Council

Web site: [www.arctic-council.org](http://www.arctic-council.org)

AMAP, P.O. Box 8100 Dep., N-0032 Oslo.

Telephone: +47 23 24 16 35. Fax: +47 22 67 67 06.

E-mail: [amap@amap.no](mailto:amap@amap.no)

Web site: [www.amap.no](http://www.amap.no)

Printed with financial support from the Danish Cooperation for Environment in the Arctic (Dancea)

