



FOCUS NORTH

Environmental Contaminants in the Arctic

Produced by the research company Ocean Futures, Oslo for the Norwegian Atlantic Committee

What are environmental contaminants?

Environmental contaminant is a collective term for different types of hazardous chemicals and substances with the following characteristics:

They are toxic over the short or long term

Environmental contaminants often have an acute toxic effect, and may also have a more long-term, chronic effect, such as causing cancer. The toxic effect can be measured on three levels:

- Through a biochemical effect on individual cells;
- Through changing functions in the organism as a whole;
- Through ecological changes in the entire group of individuals.

Uncertainty is least around the first level of effects and greatest around the third level.

They decay slowly and are often stored in fat

Environmental contaminants can decay into non-toxic compounds in nature, but as a general rule this takes a very long time, especially when they are dissolved in water. Therefore, they can be transported long distances and will remain in natural circulation long after emissions have ceased.

In some cases, the decay products (metabolites) are more harmful than the original compound. There are also many examples of substitutes for environmental toxins in a product that can be as harmful and potent as the compound they were intended to replace.

They tend to accumulate in living organisms

Many toxins are fat-soluble, a trait that makes them difficult for organisms to break down and eliminate. Animals which prey on organisms that contain contaminants can accumulate higher

toxicity levels than the prey—a phenomenon known as biomagnification. Moreover, organisms that contain toxins often require a very long time to eliminate them.

Concentrations of toxins therefore become greater the higher up the food web one goes. Concentrations are greatest in marine food webs, because they have more links, thereby compounding the biomagnification effect.

Contaminants and commerce

Many of the toxins found in nature today are a direct result of industrial processes, combustion, or disposal of certain product groups. Industry is thus an important direct or indirect *producer* of environmental contaminants. Industrial producers have economic interests associated with the use and regulation of hazardous compounds.

Other industries are *receivers* of environmental toxins, not least the primary industries such as agriculture and fishing. These industries have economic interests for clean, safe products.

Environmental contaminants are a problem which open a space and a market for alternative processes and products that do not contain harmful substances. Here, commercial enterprise plays a key entrepreneurial role in the innovation and development of alternative, environmentally benign processes and products.

Types of contaminants in the Arctic

The most common environmental contaminants found in the Arctic are heavy metals and persistent organic pollutants (POPs). In addition are radioactive isotopes, which exhibit similar persistent, toxic characteristics. Radioactive contamination in the North is discussed separately in "Nuclear Contamination," *Focus North*, No. 1 (2006).

Heavy metals

Several metallic elements are considered heavy metals, and they can form a part of many different chemical compounds. Mercury, lead and cadmium have been most studied in the Arctic environment. These are metals that can be found in nature, but which in addition are emitted in large quantities through human activities.



Table 1 gives an overview of the sources, quantities, effects and transport pathways of selected heavy metals in the Arctic

Persistent organic pollutants (POP)

Persistent organic pollutant is a collective term for many different hazardous chemical compounds, such as organochloride insecticides, industrial chemicals, and certain by-products of combustion.

The Arctic acts in many ways as an indicator region for known and new POPs, because the mere fact that one finds a particular compound here means that the substance degrades slowly and can be transported a long distance.

Five particular compounds and compound groups have been studied in the Arctic: PCBs, DDT, dioxins and furans, HCH, and brominated flame retardants.

Table 2 gives an overview of the sources, quantities, effects and transport pathways of selected persistent organic pollutants in the Arctic.

Amounts and effects of contaminants in the Arctic

The amount and extent of pollution in the Arctic has been studied for many years, not least by the Arctic Monitoring and Assessment Programme (AMAP), which is one of the five working groups under the intergovernmental Arctic Council.

AMAP concluded that the Arctic remains one of the cleanest environments on the planet. Few toxins have been produced, used or stored here. Nevertheless, the Arctic is by no means untouched. One can find traces of hazardous compounds throughout the Arctic. They can be found in the atmosphere, in soils and sediments, in snow and ice, in saltwater and freshwater, and in plants and animals, including humans. In some areas, high concentrations of certain toxins give cause for alarm.

These concentrations are first and foremost local, but regional and circumpolar effects are also evident. Although the levels of some pollutants are slowly declining, others are clearly rising.

Heavy metals

The Russian smelter works in Norilsk and on the Kola Peninsula are large, local sources of heavy metal emissions to the Arctic. The highest measured levels in the Arctic occur in the near vicinity of these sources, as about 90 percent of the heavy metals are deposited within 200 km of the smelters. The remainder is spread and deposited throughout the Arctic.

Mercury is deposited from the atmosphere to snow in a form that makes it easily absorbed by organisms. Mercury concentrations are so high among some animals at the top of the food web, such as polar bears and Arctic gulls, that scientists anticipate harm to these animals.

**Table 1 – Heavy metals
Sources, quantities, effects and pathways to the Arctic**

	Human-based sources	Amount of human-caused emissions	Health effects	Transport pathways to the Arctic
Mercury	Combustion of hydrocarbons and waste, industrial processes, seepage from landfills. Used in fluorescent light tubes.	2240 tons emitted worldwide in 1995. Emissions from Western Europe and North America declined dramatically during past 20 years, but increased in Asia. About 150–300 tons deposited in the Arctic each year.	Acutely toxic. Can lead to chronic effects in small concentrations. Can harm kidneys and nervous system, cause foetal injury, and cause contact allergies.	Primary: atmosphere Secondary: Russian rivers
Lead	Combustion of hydrocarbons, metallurgy, seepage from landfills. Used in paints, plastics and sand-blasting.	120,000 tons emitted worldwide in 1995. Most lead that reaches the Arctic comes from Europe and Russia.	Can cause acute and chronic effects in small concentrations. Can damage nervous, immune and reproductive systems; cause foetal injury; and damage blood formation.	Primary: atmosphere and Eurasian rivers Secondary: ocean currents
Cadmium	Processing of zinc-bearing ores, burning of coal, seepage from landfills. Used in rechargeable batteries.	Estimated 3000 tons emitted worldwide in 1995, but figure is believed to be much higher. Most cadmium reaches the Arctic from North America and Asia.	Acutely toxic, especially for aquatic organisms. Can cause chronic effects in small concentrations. Can cause skeletal deformities and kidney damage. Carcinogenic.	Primary: rivers and atmosphere Secondary: ocean currents and other mechanisms

Mercury causes proven adverse health effects among humans. Areas in Canada and Greenland have higher mercury levels than the European Arctic and the Barents Sea. Nearly all the women tested in eastern Greenland had mercury levels far over recommended limits.

Lead in the atmosphere has declined dramatically, primarily due to the phase-out of leaded petrol. However, there has not been a corresponding decline of lead among plants and animals in the Arctic, suggesting they have already taken up and stored significant amounts of lead. Nevertheless, lead levels are expected to decrease across most of the Arctic with time. The exceptions are areas in the vicinity of large, local emission sources.

Cadmium levels in the Arctic show large local variations. Concentrations are lower among seabirds and seals in the Barents Sea than in Canada and Greenland. In some marine mammals, the

concentrations exceed the level expected to cause effects, but no cadmium-related effects have been proven. In general, cadmium levels are not rising in Arctic animals; however, much uncertainty is associated with mechanisms and consequences of cadmium in the Arctic.

Other heavy metals such as platinum, rhodium and palladium have also been found in the Arctic. Emissions from catalytic converters on automobiles are the likely source. More research is required before reaching any conclusions on the effects of these metals in the Arctic.

Persistent Organic Pollutants (POP)

POPs have proven adverse health effects on animals high up in the food web across most of the Arctic. Species such as polar bears, Arctic gulls, Greenland seals and char are showing weakened immune systems.

**Table 2 – Persistent Organic Pollutants
Sources, quantities, effects and pathways to the Arctic**

	Human-based sources	Amount of human-caused emissions	Health effects	Transport pathways to the Arctic
PCB poly-chlorinated biphenyl	Synthetic aromatic compound that has been used in a variety of applications, such as condensers, transformers, building materials and paints.	1.3 million tons produced globally between 1930 and 2000. Production and use now banned worldwide. Many products containing PCBs have been destroyed or disposed, though some products containing PCBs may still be found.	Acutely and chronically toxic, even in small concentrations, especially for marine organisms. Can damage reproductive, nervous and immune systems, and cause foetal damage. Carcinogenic.	Primary: atmosphere Secondary: ocean currents
DDT dichloro-diphenyl-trichloroethane	Synthetic insecticide.	About 69,000 tons produced annually from 1971–1981. Banned in much of the world since the 1980s. Still in use in several countries to control malaria (e.g., India, China)	Acutely and chronically toxic. Can damage nervous system, liver and kidneys. Carcinogenic. Can cause foetal malformations and effect reproduction.	Primary: atmosphere Secondary: ocean currents
Dioxins and furans	Can be a by-product of combustion where chlorine and carbon are present, such as in industrial processes, incinerators and fires.	Little data on the amount of human-source emissions. Global emissions of the dioxins PCDD and PCDF to the atmosphere are about 3 tons per year.	Acutely and chronically toxic. Can harm immune, hormone and nervous systems and reproduction. Carcinogenic.	Primary: atmosphere Secondary: ocean currents
HCH hexachloro-cyclohexane	Synthetic insecticide.	In use since 1943. Global use from 1948 to 1997 estimated at 10 million tons.	Can affect hormones and reproduction. Can harm enzyme and immune systems. Carcinogenic.	Primary: ocean currents
Brominated flame retardants	Found in electronic products, switches and insulation. Emission can occur through production, use, disposal or recycling of products.	Uncertain data on global emissions. According to the chemical producer BRG Townsend, global annual use is 907,000 tons.	Some compounds acutely toxic for aquatic organisms. Suspected to cause hormonal disturbances, harm nervous system and affect reproduction. Tends to bio accumulate.	Primary: atmosphere Secondary: ocean currents



Incomplete estimates make it difficult to state with certainty the quantity of POPs deposited in the Arctic each year. Some occurrences stem from local sources, such as high levels of PCBs in harbours along the coast of northern Norway. Nevertheless, long-range transport via the atmosphere, ocean currents and rivers are considered the major sources of POPs in the Arctic.

The European Arctic may receive more POPs than other parts of the Arctic. Concentration levels in the atmosphere, snow, soil, and in plants and animals have been measured at different locations in the Arctic. Measurements at Svalbard showed higher atmospheric concentrations of PCBs and brominated flame retardants, and higher snow concentrations of DDT and HCH, whereas PCB deposition was greatest on the Greenland icecap.

Similar trends are exhibited among samples taken from Arctic wildlife. Polar bears on Svalbard showed PCB levels two to six times higher than those in Alaska or Canada. Levels of brominated flame retardants, especially PBDE 47 and 99 were higher in gulls, ring seals and beluga whales at Svalbard than in the Canadian Arctic. The levels in cod liver were correspondingly higher along the coast of northern Norway than along the western coast of Alaska.

In northern Norwegian marine areas, PCBs and DDT levels are highest in the eastern part of the Barents Sea. Concentration levels decrease as one moves either east- or westward.

In general, there is a clear global trend towards declining concentrations of persistent organic pollutants. These trends follow the worldwide prohibition or phase-out of several compounds, such as PCB, DDT and HCH. Nevertheless, for some PCBs the changes are small, while for others the concentrations are increasing.

There are insufficient time-series measurements to unambiguously show the effects of global measures within the Arctic. Still, early indications are encouraging: measurements taken from seabird eggs (from 1973–1993) and polar bears (1990–1998) indicate declining PCB levels on Svalbard.

Effects on commercial activities

Environmental toxins can potentially affect commercial activities in the North several ways:

Direct and indirect effects

Public anxiety over contamination, whether real or perceived, can have serious, long-lasting effects, especially where the acceptance of food products is concerned. For example, mad cow disease devastated the British beef industry, costing €820 million per year in lost exports from 1996 to 2000, while a dioxin scare in Belgium cost its food industry €1.5 billion in 2000.

The discovery of contaminants—especially of potentially hazardous concentrations in food—typically results in measures to eliminate or limit their intake. Already today it is recommended that individuals limit intake of blubber from marine mammals, fish liver and gull eggs harvested in certain locally polluted areas of the Arctic. Such restrictions could encompass larger areas and include more species. These restrictions can limit, if not eliminate, the basis for certain commercial activities in the affected area.

Pollutants can in this way indirectly affect commercial activities in the Arctic, especially activities based on living resources. Clean seas are thus imperative to maintain consumer confidence in Norway's seafood exports, worth €3.4 billion in 2004.

Contamination also affects human settlement patterns. It is unattractive to live and work in a contaminated area. The discovery of contaminants could directly affect human settlement, leading to a shortage in skilled labour for commercial activities in the vicinity.

Regulation of polluting activities

Activities which lead to the production and emission of pollutants could be restricted or prohibited. There are a number of international agreements which forbid or limit production of many pollutants. Some of the agreements are also adaptive, so that they can address new pollutants as appropriate.

If a new persistent and bio-accumulating compound arises in the Arctic food web, this could have consequences for its continued industrial use. For example, the EU has forbidden the production and use of certain groups of brominated flame retardants after it was discovered that they were accumulating in the Arctic environment.

Summarized from "Environmental Contaminants in the Arctic" (9/2005), available (in Norwegian) at ocean-futures.com

