Model Arctic Council

Background Guides:

Arctic Monitoring and Assessment Programme

Global Climate Change: The Environmental Consequences Bearing on the Arctic

United Nations Association in Canada
Association canadienne pour les Nations Unies

Arctic Monitoring and Assessment Programme

Global Climate Change: The Environmental Consequences Bearing on the Arctic

INTRODUCTION

Pollution in the Arctic is a complex and persistent problem which defies easy description or resolution. There are a number of serious issues facing the region each with different causes and effects and each demanding different action and remedy. Radiation, toxic chemicals, oil contamination, heavy metal poisoning and ozone depletion are the issues which will be covered in this report and are only the most serious such threats the North is facing.

The Arctic is not as isolated as it may appear. It, like every part of the world, is connected to the global ecosystem by the water and the atmosphere. Pollution from the industrialized regions in the south as well as from some of the more industrial areas within the Arctic itself can and does travel great distances from its point of origin to areas thousands of away. The prevailing currents and winds around the world push pollutants north, creating a sink of sorts for pollution.

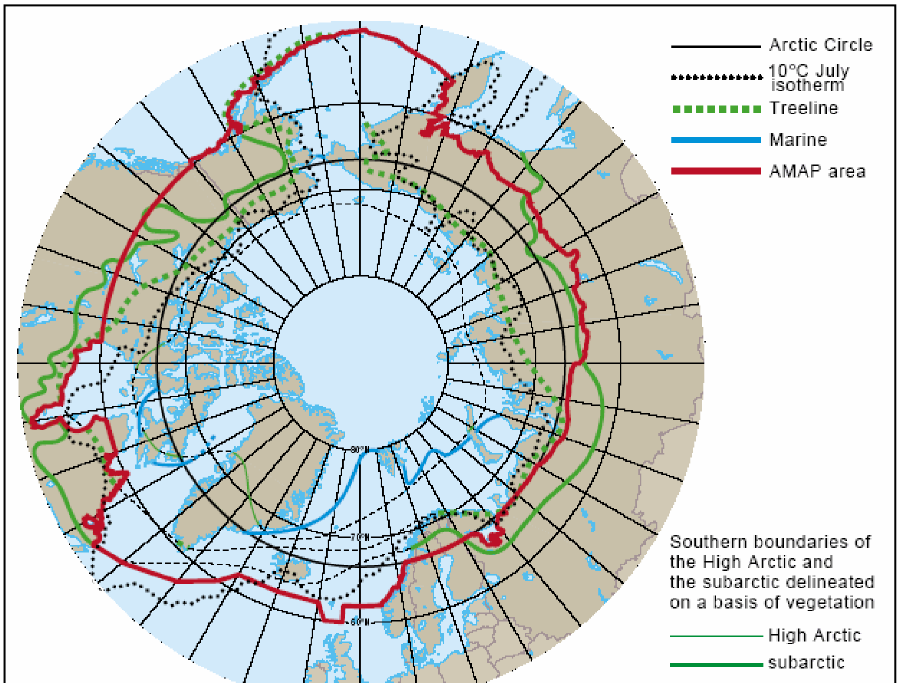
While each of these separate pollutants has their own origins, many are also connected within the broader effects of climate change. Research as to the impacts of climate change on pollution remains in its infancy and the Arctic Council is continuing its efforts to gain a clearer picture. However, there are indications that a changing environment in the Arctic would have very real consequences on the level of pollution the region might face through a series of different natural and man-made effects.

The fight to reduce or eliminate man-made pollutants from the Arctic has progressed over the past few decades to include a number of important treaties and initiatives involving a wide range of states – some of which are nowhere near the Arctic itself. The process includes academics, researchers, advisory groups and non-state actors like the Arctic Council and real achievements have been made. However there remains a great deal to be done.

THE ARCTIC MONITORING AND ASSESSMENT PROGRAMME WORKING GROUP (AMAP)

AMAP is one of the Arctic Council's six working group, each of which has a separate mandate. AMAP's task is to provid information on the status of, and threats to, the Arctic environment and to provide scientific advice on actions to be taken in order to support Arctic governments in their efforts to combat the threat of pollution.

AMAP was established in 1991 to measure pollution levels, looks for trends and to try and uncover the sources and pathways of pollutants. It also examines the impact of pollution on Arctic plants and animals (especially those used by people) and provides advice to governments and interested groups. Its field of study includes the entire circumpolar Arctic, however it also looks beyond the region to study the sources of pollutants which make their way North. The chair of the group is currently held by Canada, though it is based in Oslo, Norway where it has a permanent secretariat.



Boundaries of the Arctic.

Source:AMAP

ARCTIC POLLUTION CAUSES AND EFFECTS

Heavy Metals

Heavy metals are not necessarily pollutants, as they occur naturally in the ecosystem. Though since the industrial revolution, large quantities of man-made heavy metals have dramatically increased the concentration of these elements in the Arctic ecosystem. These rates have soared during the twentieth century with concentrations ten times higher than in preindustrial time (though with a dip during the Great Depression as industrial activity slowed).

Heavy metals are substances that bio-accumulate, which means that when they pass into animals, they stay there, immune to digestion and waste processes. When an animal is eaten (by predator or human), that hunter then consumes the contamination within its prey. Heavy metal poisoning can have a wide range of effects depending on the specific type of metal. Lead poisoning for instance can result in altered behaviour from damaged brain and nerve tissue, kidney damage and dysfunction, anaemia and intestinal dysfunction. In fish, damage is done to the gills and sense of smell creating blindness and a reduced ability to absorb nutrients through the intestine. Plants with high concentrations of mercury have shown reduced growth and heavy metals have also been proven to weaken the immune systems of birds and mammals and prevent many from reproducing.

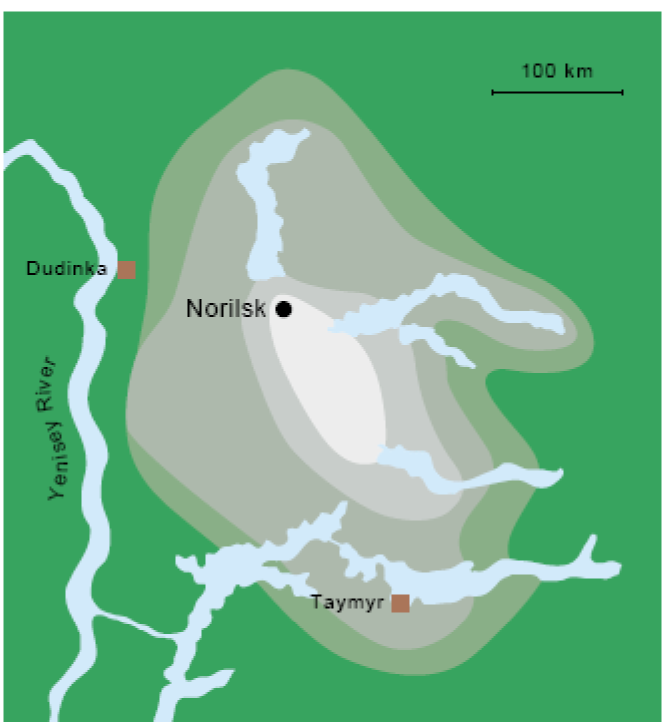
The metals raising the most concern are mercury and cadmium. They can be toxic in small quantities and are often present in surprisingly high levels. Other metals, such as nickel and copper are more of a local concern for regions near large smelting operations. Long term data is hard to come by since studies are all fairly recent, but the existing records show an increase in most parts of the Arctic. In Greenland for instance, mercury in human and seal hair has shown a three-fold increase since the 15^{th} century. In Norway, mercury in human teeth was thirteen times higher in the 1970s than in the 12^{th} century.

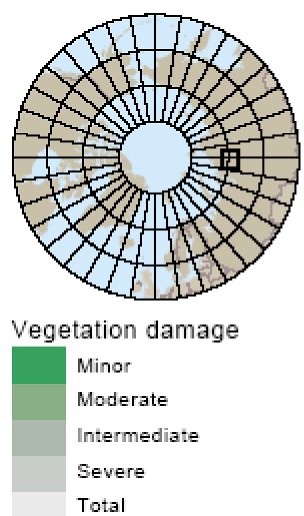
Different heavy metals have different origins. Coal burning, waste incineration and industrial processes around the world emit mercury into the atmosphere. Burning gasoline was a major produced of lead; however this has declined since gasoline is no longer uses lead in most countries. The processing of metals accounts for nearly three-quarters of global man-made cadmium emissions into the atmosphere and the burning of coal accounts for most of the remainder with some contributions from other activities, such as iron production, cement production, and burning garbage. Oil combustion was also a major source of nickel and vanadium.

Some heavy metal pollutants are produced in the Arctic though most are brought North through the atmosphere and ocean currents. The most damaging local pollution is generated in northern Siberia and the Kola Peninsula in Russia – centred on large smelter complexes. Air pollution around the Kola Peninsula facilities, for instance, is comparable with the most polluted regions of Europe and North America. Though 5 – 10% of the emissions are deposited across the High Arctic most still remain within about 200 kilometres of the source.

The impact of these facilities on the local environment is obvious. First, what is called the forest-death zone extends for up to 15-20 km around the smelters (even up to 80 km downwind at the Norilsk facility). In this zone, vegetation is dead, animals are almost entirely absent, there is little bacteria in the soil and the organic layer of soil is often absent due to fire or erosion. Beyond the forest-death zone lies the visible damage zone, which extends up to about 50 km at the Nikel and Monchegorsk facilities and up to about 200 km at Norilsk. In this zone, trees suffer defoliation, reduced growth, death of needle tips, and other problems.

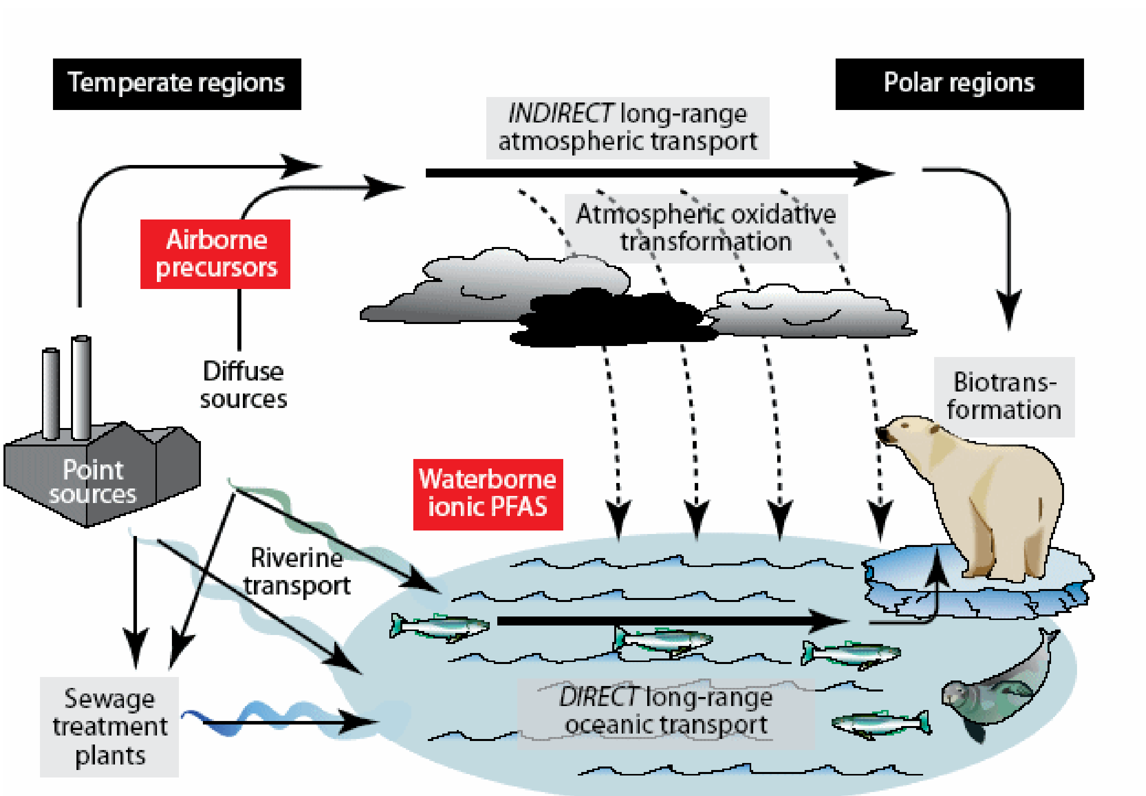
Source: AMAP SOAER (2002)





Extent of vegetation damage around Norilsk due to the combined effects of metal and acidifying substances.

Despite the damage caused by this local source, most heavy metal pollutants come to the Arctic from the South. Atmospheric transport is one of the most important pathways north. Globally, an estimated 5,000 tonnes of mercury are present in the air at any given time. In addition, water is a slower but reliable carrier. Russian rivers, for example, carry mercury released by industrial activities upstream and into the Arctic Ocean. Although their mercury concentrations are much lower than global averages, the great volume of water in the Ob, Yenisey, and Lena rivers make them regional highways for pollution. Together, the Eurasian rivers transport 10 tonnes of mercury each year to coastal estuaries and the Arctic Ocean, most of it in particulate form. Animals can also carry metals over great distances; salmon migrating from the ocean to spawn deliver mercury to lakes and rivers when they die. One study in Alaska estimated that, over the past twenty years, a total of some 15 kilograms of methylmercury has been transported by Pacific salmon to the lakes and streams of the eastern Bering Sea coast.



Source: AMAP SOAER (2002)

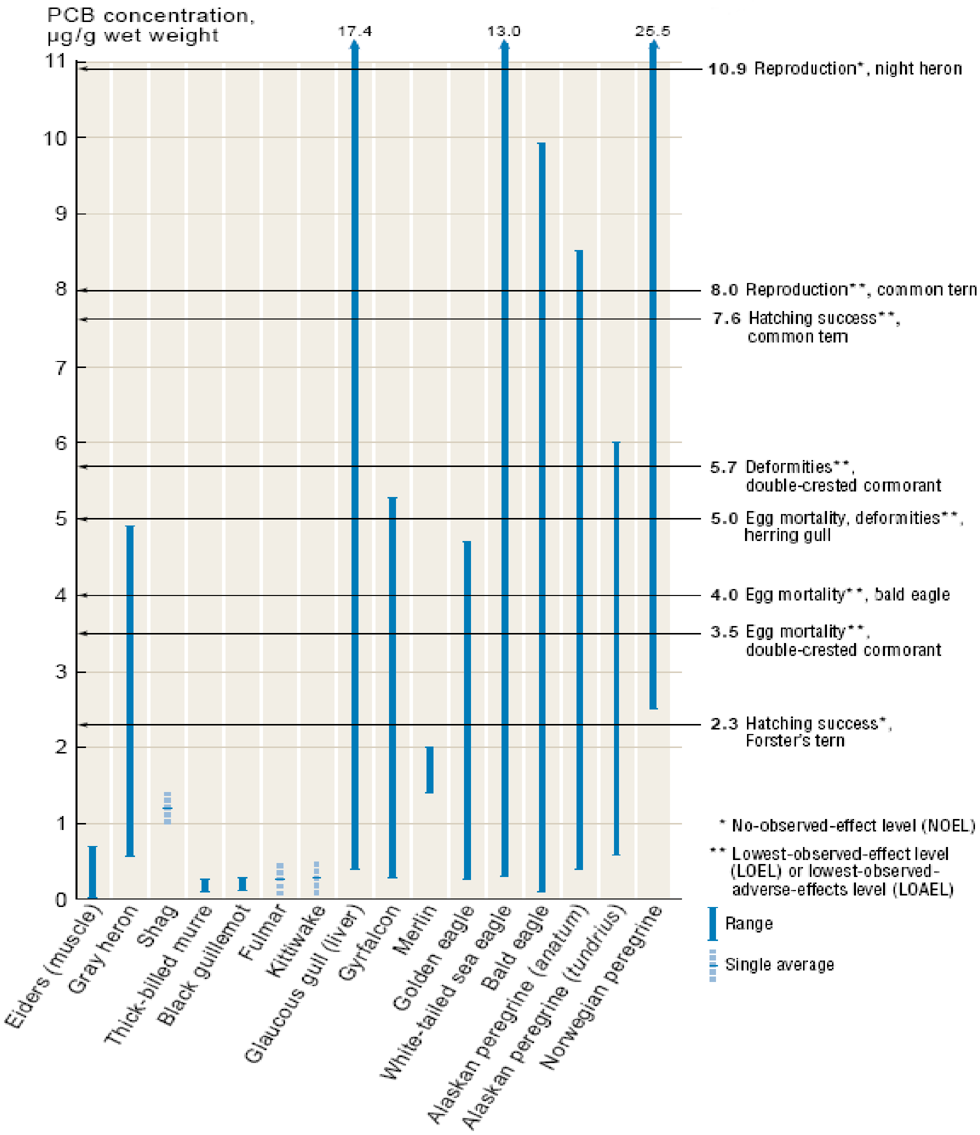
Progress has been made in reducing the level of heavy metal contamination in the Arctic over the past two decades and concentrations have generally declined since the 1970s. This was due to the adoption of clean air legislation in Europe and North America, the source of most of the pollutants. In addition, some significant steps have recently been taken internationally to address the heavy metals. The United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution adopted a Protocol on Heavy Metals in 1998 targeting mercury, lead, and cadmium.

Recent conversions to cleaner-burning power plants and the use of fuels other than coal reduced emissions significantly in Western Europe and North America during the 1980s. Industrial coal combustion now produces only half the mercury that it did at the beginning of the 1980s. Yet much of recent reductions have been offset by rising emissions in Asia, which now produces half the world's mercury emissions. The main source of Asian emissions is coal combustion to produce electricity and heat, particularly in China. Chinese emissions from sources such as small industrial and commercial furnaces, residential coal burning, and power plants are responsible for about half the Asian total, or one-quarter of global emissions

Persistent Organic Pollutants (POPs)

Persistent Organic Pollutants (POPs) is a term which covers over a dozen different chemical substances that last for a long time in the environment, bioaccumulate through the food chain, and cause damage to animals and humans. Most POPs were used as pesticides, in the industrial processes or in the production of a range of goods such as solvents or medicines. Though there are a few natural sources of POPs, most POPs are created by humans either intentionally or as byproducts.

POPs have been proven very dangerous to animal and human life in the Arctic as experiments have show effects on bone development, hormones, immune and reproductive systems. Several parts of the immune system are known to be vulnerable and the result is to reduce an animal's defence against infections. The immune system is especially vulnerable during development before and just after birth. In mammals, the period after birth coincides with exposure through milk from the mother, which can contain high levels of POPs.

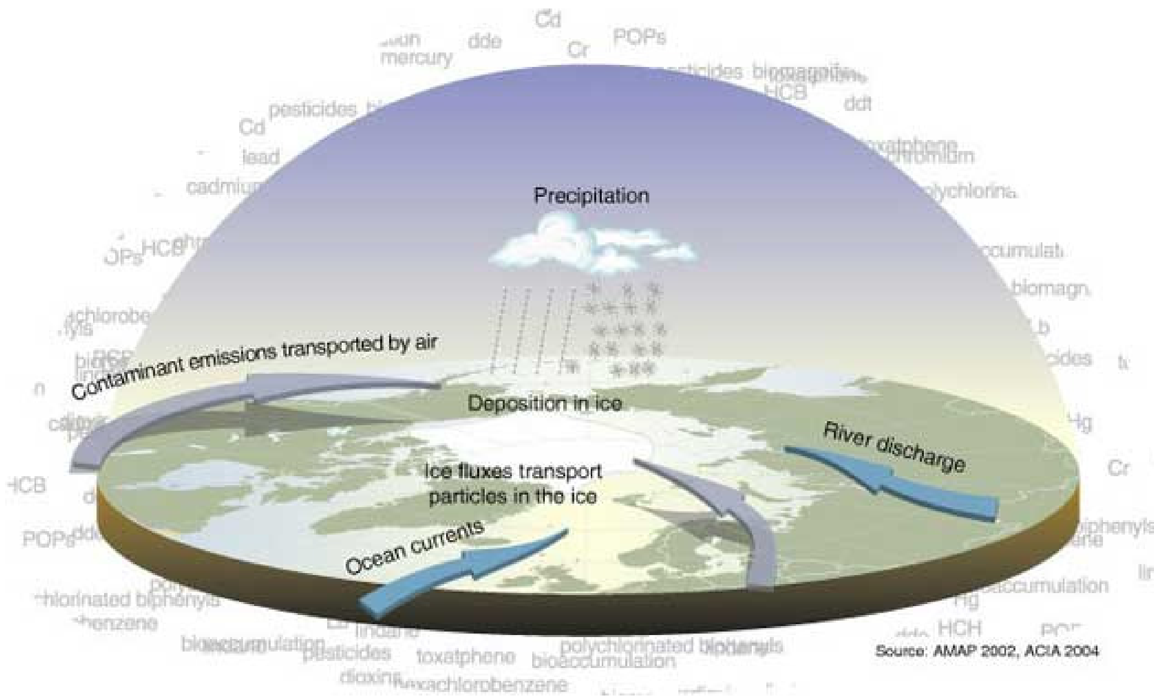


Source: AMAP SOAER (2002)

Females transfer substantial amounts of POPs to the next generation. In birds and fish, this occurs through the eggs, and in mammals, directly to the fetus through breast milk. In marine mammals, mothers' milk can have an extremely high fat content to help the young animal grow rapidly during the short summer season. In some species, such as harp seal, the transfer through milk is made worse because the female does not eat during the nursing period and POPs are further concentrated in her diminishing fat stores, including her milk.

In polar bears, there have been strong suspicions that contaminants might affect their ability to fight infections as well as their ability to reproduce. In a Canadian study, females who had lost their cubs had higher contaminant concentrations than females whose cubs survived.

Like heavy metals, a large quantity of POPs migrate to the Arctic from the industrialized south, though Arctic mineral exploration, coal mining, and heavy industry still account for a very large input. Air is the most important transporter. Under favourable weather conditions, air masses can transport contaminants from the South to the Arctic within a few days or weeks. The role of ocean currents in the migration is also extremely important, though ocean transport can take decades before POPs released in other parts of the world show up as pollution in the Arctic.



Progress in reducing POP contamination has been made over the past decades as most POPs have been banned. On a national level the bans began to be put in place in the 1970s while international conventions were signed in 1995 (The North-American Commission for Environmental cooperation initiative on the Sound Management of Chemicals), 1998 (the Convention on Long-range Transboundary Air Pollution) and 2001 (The Stockholm Convention on Persistent Organic Pollutants).

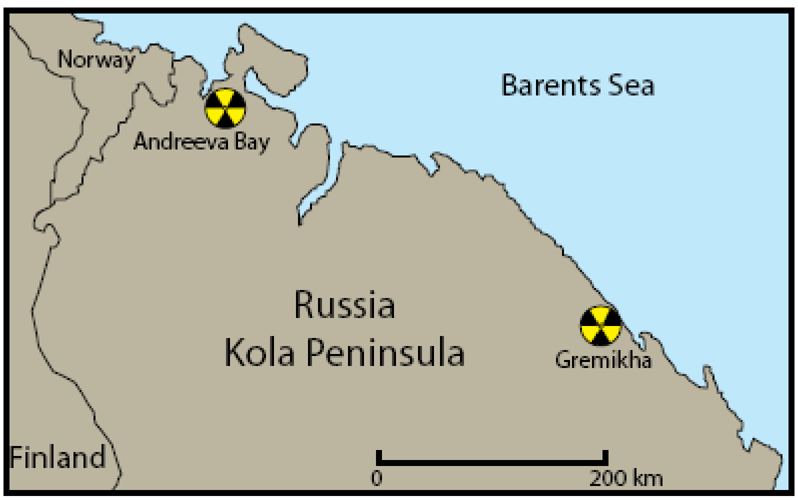
Yet not all countries have signed on to these efforts and residual POPs remain in the ecosystem. For instance, there are several signs of fresh input of the chemicals DDT in the Barents region and of toxaphene in the White Sea. This shows either that these pesticides are still used or that old stocks are leaking into the environment and thus need attention. For persistent organic pollutants that are now regulated on a global and regional basis, the situation in the Arctic is likely to improve though there are some which are still being produced such as a series of chemicals called brominated flame retardants (PBDEs).

Yet for the most part levels are decreasing. As the production and use of regulated POPs declines, new input into the environment will eventually cease. However, because of their characteristics POPs will remain in the environment for many decades as a legacy of past use.

Radiation

Radioactive contamination is a problem for the Arctic regions, in large measure because of Cold War activities and the ability of radiation to migrate from southern latitudes to the North. AMAP has concluded that the greatest radioactive contamination in the Arctic has been a result of fallout from atmospheric nuclear weapon tests conducted from the 1940s through 1980. While these tests have stopped, the legacy of the Cold War lives on in hazardous nuclear storage facilities and discarded reactors left in the region.

Ironically, the Kola Peninsula in the Soviet Arctic was the only ice-free port in the former U.S.S.R. As such, the Soviet Navy based the majority of its nuclear submarines and surface craft in Arctic bases. When these craft outlived their usefulness many were simply discarded in the Arctic waters. Until 1991, the Soviet Union dumped a number of submarine reactor compartments containing nuclear waste and part of the reactor compartment of a nuclear icebreaker. This resulted in local contamination around the dumping sites, but according to AMAP assessments, the major risks of pollution remain in the longer term, after the containment material crusts away.



In the 1960s, the Soviet Navy also developed bases at Andreeva Bay and Gremikha on the Kola Peninsula to service nuclear submarines and to store nuclear waste. They were used intensively until the late 1980s and early 1990s. Since then upkeep has fallen to dangerous levels and the facilities have started to fall apart. In 1982, failure of containment in one building at Andreeva Bay resulted in leakage of radioactive water and forced the relocation of the waste. Progress has been made in improving the buildings and the legal arrangements to manage these sites. However, much remains to be done, including transport of spent fuel and waste to safer storage sites.

Radioactive fallout from the Chernobyl disaster also continues to impact the Arctic environment –primarily in Russia and Scandinavia – after drifting north from the Ukraine. Because the Arctic region is so cold, the processes that would normally favour radioactive mobility are slower. Past fallout is thus likely to remain a source of radioactive contamination for grazing wildlife and people for years after it arrives.

Sources of contamination further south have also leaked into the global ocean current system. European reprocessing plants, which deal with spent nuclear fuel, have been releasing contaminated water which has been making its way to the Arctic. The reprocessing plants that are most relevant to the Arctic are Sellafield on the northwest coast of England and Cap de la Hague in northern France.

Air, water, and ice have proven able to carry contaminants great distances to and from the Arctic. The significance of ocean pathways in particular appears higher than once realized. For radiation it is a major route from coastal sites outside the Arctic to marine food chains in the Arctic. The contamination of the Cold War has largely stopped; the nucelar tests have been halted (by the major powers at least), the dumping has ceased and the international community is working together to assist Russia in dealing with its Cold War legacy. As of 2008, 164 old nuclear submarines of the Russian northern fleet had been defueled and dismantled and the work continues. Similar plans exist for dealing with nuclear icebreakers and their facilities, including their storage facilities.

A rusting nuclear attack submarine in Northern Russia.

Monitoring data has shown that levels of radioactivity in the Arctic environment are definitely declining. Routine releases of radionuclides to the marine environment from European reprocessing plants continue, yet they have decreased thanks to the application of new technology. Future Russian plans to construct floating nuclear power plants and the possibility of increased marine transport of radioactive material in the Arctic remain a potential concern, as does the condition of the remaining Cold War era nuclear plans in Siberia.

Arctic Haze and Acidification

Arctic haze is a kind of smog created by air pollution. It is largely composed of sulphate aerosol and particulate organic matter and carries a mess of airborne toxic contaminants such as herbicides and pesticides, heavy metals and industrial compounds. The haze blankets virtually the entire area north of 60° latitude. It builds up in the atmosphere during winter and appears in spring over large regions of the Arctic, both in North America and Eurasia. Arctic acidification on the other hand is a more local issue and of major concern only in areas with both sensitive geology and levels of acid in the ground high enough to overcome nature's natural ability to neutralize it.

In 1998 AMAP identified the smelters at Nikel, Monchegorsk, and Zapolyarnyy on the Kola Peninsula and at Norilsk in northern Siberia as the largest man-made sources of acidifying air pollutants within the Arctic. The effects produced by these facilities are discussed in more detail in the *Heavy Metals* section.

It has been determined that North America contributes relatively little (less than 4%) to the haze entering the Arctic. Two-thirds of the pollution has been found to arrive from upwind sources in the heavily industrialized nations of Eastern Europe; the remainder arrives from Western Europe. From 1979-95, Environment Canada routinely monitored the composition of the atmosphere at Alert in the Northwest Territories. Recent measurements show that the trend in increasing Arctic haze, which began accelerating in the 1950s, has stopped. Also, although the content of some of the haze pollution has remained roughly the same, concentrations of some toxic elements and heavy metals have fallen dramatically; for example, lead concentrations have declined by 55% since 1980. These declines are at least partly due to actions by Arctic rim countries and industries to control toxic releases and to eliminate lead in gasoline.

Ozone Depletion

Over the last decade, some very low ozone levels have been observed over the Arctic during the late winter and early spring. These low values have heightened concerns that human activity may be seriously impacting the Arctic stratosphere (the second major layer of Earth's atmosphere). This depletion is occurring because of the excessive amounts of chlorine, bromine, and other ozone-destroying chemicals being released into the stratosphere. Over the Polar Regions, two additional factors make ozone destruction particularly damaging in the spring.

The polar vortex is a circulation system that develops over the poles with during winter. Without sunlight and without warmer air flowing in from the South, the polar stratosphere becomes extremely cold, with temperatures falling to -80°C or lower. At these temperatures, the second factor comes into play - the formation of polar stratospheric clouds (PSCs), made up of ice, nitric acid, and sulphuric acid. In the absence of PSCs, most of the chlorine and bromine in the stratosphere is locked up in compounds that under ordinary conditions would be quite stable and therefore harmless to the ozone layer. PSCs cause these compounds to break down, however, leaving the chlorine and bromine atoms in less stable compounds. When sunlight returns in the spring, these compounds are broken apart by solar radiation, and chlorine and bromine are released.

Large increases in ultraviolet radiation at the earth's surface as a result of deep ozone depletion could be highly damaging to sensitive Arctic life forms. Reducing the amount of ozone damaging pollutants released into the atmosphere is therefore crucial. Progress has been made through the Montreal Protocol of 1987 which was intended to phase out the use of ozone-depleting chemicals and restore the ozone layer to its former healthy state. As a result, atmospheric concentrations of some ozone-depleting pollution have begun to decline and concentrations of others should follow. A substantial recovery of the Arctic's ozone strength is therefore expected by 2050. Assuming of course that the international agreements will be strictly followed and there are no surprises which scientists did not foresee.

ARCTIC POLLUTION AND CLIMATE CHANGE

The extent to which pollution of all sorts will be affected in the Arctic by climate change remains largely speculative. However it seems obvious that a changing Arctic will bring new challenges. AMAP reports have suggested that the increasing decline of sea-ice, for instance, will likely allow an increased exchange of pollution between the ocean and the atmosphere. Airborne pollution will have easier access to the Arctic Ocean and could increase, whereas other contaminants that are currently stored in the ocean water may more readily transferred from the ocean to the air. Yet this process is hard to predict. Higher temperatures will affect biological activity; for example, warmth will increase bacteria activity, which could reduce the lifespan of some pollutants since some bacteria can eat pollution. However, as Arctic ecosystems become more productive in response to warming, the accumulation of contaminants may also increase.

With climate change, Arctic glaciers – which are sinks for radioactive contaminants – are currently shrinking, and their ice, including its load of contaminants, is being released. An AMAP calculation based on the two glaciers and fjords on Svalbard shows that the inventory of radioactive contamination in glaciers can serve as a significant source for local contamination.

Climate change is also likely to affect the transport of contaminants in the marine environment. As Arctic sea routes become more accessible more potentially hazardous substances will certainly be shipped through the region. Oil shipments have begun in the Barents Sea and are likely to expand beyond to other areas as they are developed. Radionuclide transport from the European reprocessing plants to Japan through the Northern Sea Route above Russia has also already been considered.

Climate change may pose new challenges to existing nuclear facilities in Russia – particularly Andreeva Bay, Gremikha and the Bilibino power plant. Andreeva Bay has already been damaged by rapid ground freezing and thawing and it resulted in extensive contamination. The Bilibino plant is situated in a permafrost area where the thawing of that permafrost is likely to cause ground movements, which can threaten the structural stability of buildings.

Some pollutants would not only be increased by climate change but might accelerate it as well. The particles causing Arctic haze have been creating a blanket which is then trapping more heat and further increasing warming. The effect makes the Arctic two to three degrees Fahrenheit warmer during polluted, cloudy episodes than it would be if the air was clean.

Arctic ozone depletion could also be further enhanced over the next few decades as a result of climatic changes caused by increasing accumulations of greenhouse gases such as CO2 in the atmosphere. Although the build-up of these gases causes warming at the earth's surface, it also contributes to cooling in the stratosphere. Since temperatures in the Arctic stratosphere often come within a few degrees of creating ozone destroying PSCs, further cooling of the stratosphere could cause PSCs to form more frequently and increase the severity of ozone losses. Preliminary studies with atmospheric models suggest that this effect could delay a recovery of the Arctic ozone layer by a decade or more.

AMAP continues to study these questions and the interactions between the various forms of pollution being imported and generated in the Arctic and the global issue of climate change. Yet the solutions must lie with the interested stakeholders: governments, industry and people of the region.

<u>Questions to Consider</u>

1. What are the major sources of Arctic pollution?
2. How does this pollution make its way into the Arctic?
3. Over the past thirty years what has the trend been in either the reduction or increase of Arctic pollution?
4. What have been the most effective ways of controlling pollutants?
5. What political, environmental or strategic changes threaten to increase pollution in the Arctic? How?
6. How can countries far from the Arctic be convinced to control emissions which are making their way north?
7. Are the economic advantages of developing the North worth an increase in pollution?
8. Could economic development be conducted with acceptable levels of pollution?
9. How could the Arctic council expand or strengthen its influence over state policy regarding pollution?
10. Should the Arctic Council play a larger role in influencing the agendas and regulations of independent states or is that best left to individual governments?

REPORTS AND MORE DETAILED INFORMATION

The following general publications are available from the AMAP website [http://www.amap.no]

- *Arctic Pollution 2009*
- *AMAP 2009 Update on Selected Climate Issues of Concern*
- *Arctic Oil and Gas 2007*
- *Arctic Pollution 2006*
- *Arctic Pollution 2002*
- *Impacts of a Warming Arctic: Arctic Climate Impact Assessment (ACIA)(2004)*

AMAP also offers a series of scientific reports which go into far more detail on specific subjects of Arctic pollution.

- 2009 Human Health Report
- 2006 Acidification and Arctic Haze Report
- 2002 Heavy Metals Report
- 2002 Radioactivity Report
- 2002 Persistent Organic Pollutants (POPs) Report
- 2002 Influence of Global Climate on Contaminant Pathways Report
- 2002 Human Health Report