Environmental Studies
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Mercury in the Arctic

Mercury is released naturally into the environment from volcanoes and from rock weathering. Humans release mercury during mining operations but the biggest human source is coal burning.

Human sources are estimated to release 2000 tonnes of mercury each year whilst natural emissions are estimated at 3000-4000 tonnes.

Mercury exists in different forms:

- elemental mercury is a solid which often oxidizes into mercury oxide
- mercury oxide and methyl mercury (organic form) are very soluble in water. Bacteria can transform mercury into methyl mercury
* Methyl mercury is soluble in fat (liposoluble), is extremely toxic and will bioaccumulate and biomagnify

If methyl mercury is ingested or absorbed, it passes into the brain and acts as a **neurotoxin**. It also causes abnormal foetal development, kidney failure, liver damage and reduces coordination and sensitivity by inhibiting enzymes that contain sulfur.

Typical Exam Question

Outline the properties of a pollutant that increase the likelihood that it will become biomagnified (2).

Markscheme

Persistent;

Not excreted or metabolized;

Liposolubility;

For the Biologists

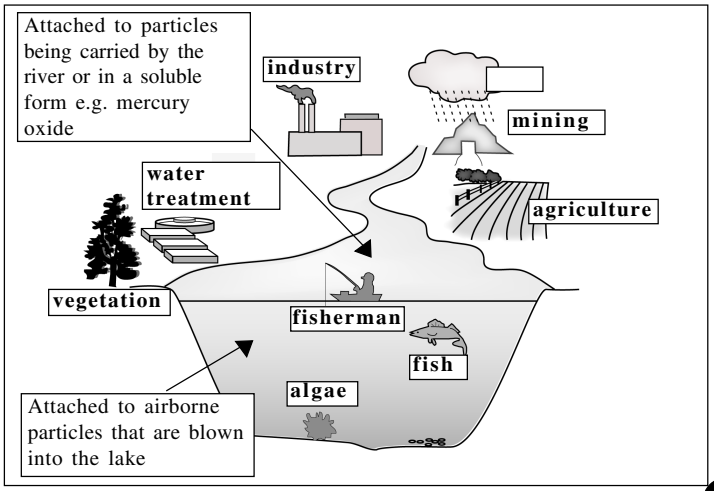
Mercury binds to sulfur-containing groups in enzymes that are away from the active site. This changes the tertiary structure of the enzyme and prevents the enzyme-substrate complex forming.

Transport of mercury

Most of the mercury that is released into the air is in the form of the element mercury. It has a residence time of 1-2 years.

Fig.1 shows how mercury could enter a freshwater lake

Fig.1 Entry of mercury into freshwater lake



How does mercury reach the Arctic?

Mercury is transported to the Arctic on air currents, and much more slowly, in rivers and ocean currents. Mercury emissions are decreasing in Europe and the US but are increasing rapidly in Asia and much of the mercury reaching the Arctic is believed to originate in Asia.

Reducing mercury emissions

Coal-burning is the largest anthropogenic source of mercury. In Europe and the US several approaches have succeeded in reducing the amount of mercury that has been emitted:

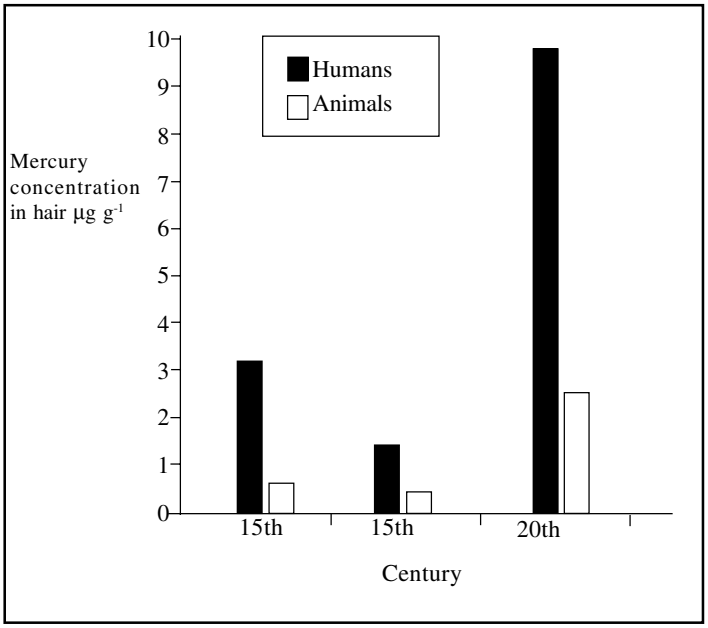
- Burning higher rank coal but with similar or lower mercury content
- Chemically cleaning the coal before combustion
- Removing mercury from combustion gases using activated carbon or sodium tetrasulfide that turn the gaseous mercury into a solid that can be removed by electrostatic precipitators
- Using catalysts that oxidize elemental mercury which can then be removed by limestone flue gas desulfurisation

Biomagnification

Recent research suggests that, over the last 150 years, the levels of mercury in marine animals such as polar bears, beluga, ringed seals and birds of prey have increased enormously. This is a result of biomagnification.

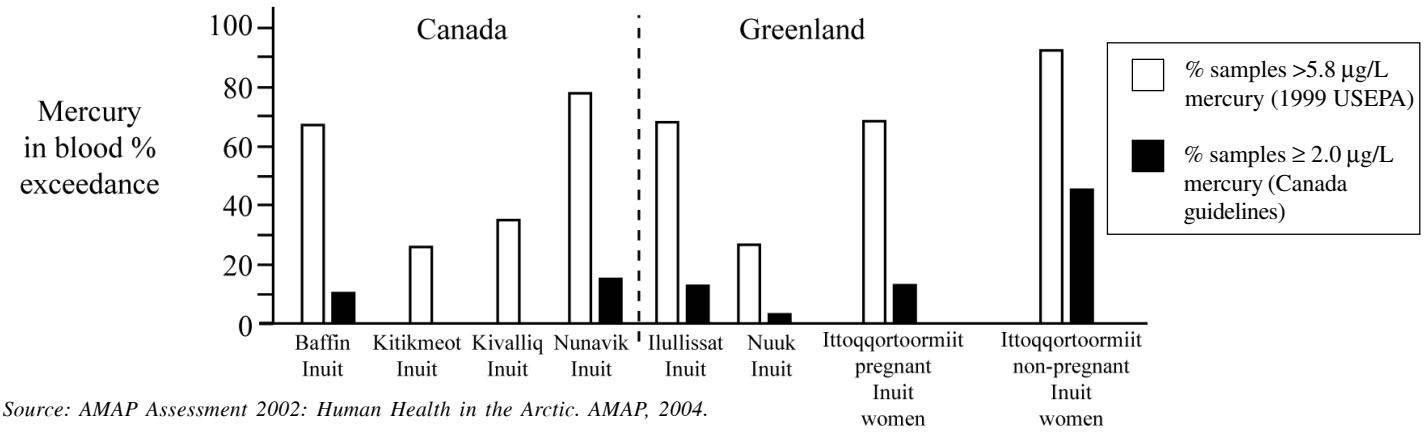
Mercury levels are increasing in humans too. Fig. 2 shows how mercury levels in human and animal hair have increased since the 15th century.

Fig. 2 Mercury levels in human and animal hair in Greenland



A significant proportion of Inuit women of child-bearing age from northeast Canada and Greenland have mercury levels that exceed WHO weekly intake limits (Fig.3). Such communities still eat a traditional diet rich in freshwater fish and marine mammals that have accumulated methyl mercury.

Fig. 3 Percentage of samples exceeding U.S. EPA and Health Canada mercury guidelines



Source: AMAP Assessment 2002: Human Health in the Arctic. AMAP, 2004.

Inorganic forms of mercury are being converted into the much more toxic organic forms in seabed and lake sediments and wetlands where oxygen levels are low.

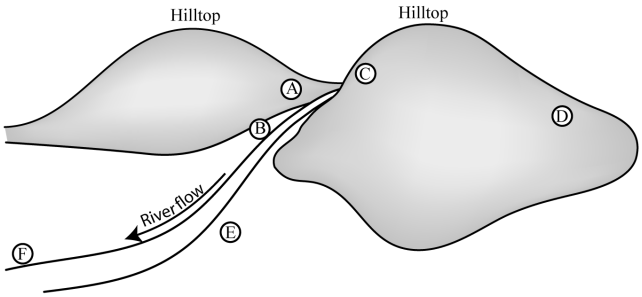
Effect of climate change

Some factors will increases the availability of organic mercury in the Arctic whilst other factors may reduce it – scientists are trying to work out which factors may dominate.

If the Arctic warms the ice-free period will last longer. More gaseous mercury may then be able to escape. But large amounts of mercury are stored in sediments, glaciers and permafrost which will release mercury if they warm up and melt. As with so many other aspects of global climate change, it is difficult to predict what the overall effect will be on mercury in the Arctic.

Practice Questions

1. The diagram shows an old mercury sulfide mine. Between 1884 and 1967 mercury sulfide was mined, crushed and heated at the mine to extract elemental mercury. Scientists analysed mercury levels in four soil samples taken from each of five sites, A-E. The table shows the results.



Site A: original 1884 processing plant
Site B: processing plant established in 1948

	Mercury concentration /µg (10^{-6}g)					
Sample no.	Site A	Site B	Site C	Site D	Site E	Site F
1	1540	940	3.1	0.4	12.6	7.8
2	1890	620	6.7	1.2	14.9	5.4
3	1145	102	4.0	0.7	10.5	2.5
4		176	5.8	0.9	15.5	3.8
Mean	1646	459	4.9		13.3	4.8

(a) Calculate the missing values (2).
(b) How did the scientists try to improve the accuracy of their data? (1)
(c) Suggest reasons for each of the following:
(i) The low concentrations of mercury at site D (2)
(ii) Mercury concentrations at site E were higher than those at site F (2).

2. (a) Some communities eat fish as a staple food. Suggest why eating large predatory fish such as tuna may be more of a health hazard than eating the same amount of smaller non-predatory fish species (2)
(b) Suggest how the characteristics of a water body influence the severity of a mercury pollution discharge (4)

Markschemes

1. (a) 2009; 0.8;
(b) By taking repeat samples at each site;
(c) (i) D is above the mine so transport must have been airborne;
Mercury and its compounds are heavy may have settled close to the mine;
(ii) Waterborne transport;
Mercury would settle out in sediment;

2. (a) concentration of mercury increases along the food chain;
predatory fish will contain high concentrations than non-predatory fish;
(b) volume of water body;
influences dilution;
currents;
influence dispersal;
presence of living organisms;
influence amount of harm/death/ contribute to biodegradation/ may influence rate of methylation;
temperature;
influences rate of chemical reaction/biodegradation;
existing pollution ref to synergism;
pH influences rate of reaction/solubility;

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