

Mercury

Mercury is a toxic heavy metal that can be found in cinnabar (red sulfide) and other ores containing compounds of zinc, tin, and copper; in rocks such as limestone, sandstone, calcareous shales, and basalt; and in fossil fuels such as coal. Mercury is present in trace amounts in all environmental media. The bulk of global atmospheric mercury is elemental mercury in vapor form. From the atmosphere, mercury elements are removed through precipitation, resulting in deposition to water bodies, the soil, and vegetation. The ultimate depository of mercury is the sediment of oceans, seas, and lakes, where inorganic mercury is readily transformed into highly toxic organic methylmercury through bacterial synthesis and other enzymic and nonenzymic processes. Organic mercury rapidly accumulates in the aquatic biota and biomagnifies upward through the aquatic food chain, attaining its highest concentrations in fish, especially in large predatory species, where it often exceeds 2.0 micrograms per gram ($\mu\text{g/g}$), and in such species as dolphins, reaching 10 $\mu\text{g/g}$. Average levels of 0.07–0.17 $\mu\text{g/g}$ mercury are found in fish, largely (over 70%) in the form of organic methylmercury (OECD 1974).

Atmospheric mercury concentrations range from a few nanograms per cubic meter (ng/m^3) to 0.05 micrograms per cubic meter ($\mu\text{g/m}^3$), averaging 0.002 $\mu\text{g/m}^3$. Near stationary sources such as mines, however, concentrations may reach 0.6–1.5 $\mu\text{g/m}^3$ (WHO 1987). Typical concentrations of mercury in water bodies range from below 0.001 to 0.003 micrograms per liter ($\mu\text{g/l}$); see Fan (1987). Normal levels in soil range from 0.05 to 0.08 $\mu\text{g/g}$. Mercury tends to bond strongly to particulate matter in fresh water, largely in inorganic mercuric form. Mercury concentrations in soil normally do not exceed 0.1 $\mu\text{g/g}$. Total human daily intake of all

forms of mercury from all sources has been estimated at between 5 and 80 μg (Fan 1987).

Sources and Uses

The natural emissions of mercury, mainly a result of the degassing of the Earth's crust and evaporation from water bodies, are two to four times larger than those from anthropogenic sources (Hutchinson and Meema 1987). About half of the atmospheric mercury generated by anthropogenic sources can be attributed to fossil fuel combustion (EPRI 1991). Emissions from fossil fuel combustion vary according to the mercury content of the fuel (Watson 1979).¹ Mercury levels in coal tend to be one to four orders of magnitude greater than those in fuel oil and natural gas. Waste incineration and the mining and smelting of ores are also important contributors to anthropogenic air pollution. Additional sources include mercury-cell chlor-alkali production and coke ovens. The accumulation, processing, and incineration of mercury-containing waste (for example, batteries and various industrial wastes such as scrubber sludge) contribute to mercury contamination of all environmental media.

The main use of mercury has been as a cathode in the electrolysis of sodium chloride solution to produce caustic soda, which is used by various industries. The mercury-cell chlor-alkali industry has been the largest anthropogenic discharger of mercury to water bodies. The use of liquid metallic mercury in the extraction of gold also contributes to the contamination of rivers.

The use of mercury in caustic soda production is being gradually phased out and replaced with membrane technology. The agricultural use of organic mercury in pesticides and fungicides has been banned in many countries to prevent human exposure. Agricultural applications are

of particular concern because of the extreme toxicity of the mercury compounds used, the limited control over dispersed use and exposure, and the potential for misuse that could contribute to direct poisoning through the diet. Uses of mercury in electric switches, batteries, thermal sensing instruments, cosmetics, pharmaceuticals and dental preparations have been similarly decreasing.

Health Impacts of Exposure

The main human health hazard of mercury has been associated with exposure to highly toxic organic methylmercury through food, primarily through the ingestion of aquatic organisms, mainly fish. Methylmercury in the human diet is almost completely absorbed into the bloodstream and distributed to all tissues, the main accumulation taking place in the brain, liver, and kidneys.

Methylmercury poisoning affects the central nervous system and the areas associated with the sensory, visual, auditory, and coordinating functions. Increasing doses result in paresthesia, ataxia, visual changes, dysarthria, hearing defects, loss of speech, coma, and death. The effects of methylmercury poisoning are, in most cases, irreversible because of the destruction of neuronal cells. Methylmercury shows significant and efficient transplacental transfer and contributes to severe disruptions in the development of the child's brain. Thus, prenatal life is more sensitive to methylmercury exposure than adult life. Not enough evidence exists, however, to establish a no-observed-effect or a dose-response function. According to WHO (1990), daily intake of 3–7 micrograms per kilogram ($\mu\text{g}/\text{kg}$) body weight can be connected to an incidence of paresthesia of about 5%. Human intake of mercury through drinking water is generally low, representing only a fraction of the amount of methylmercury intake through diet (WHO 1987). The main form of mercury in drinking water is inorganic mercuric mercury with low (7–10%) absorption rates (WHO 1991) and very low penetration rates to the brain and fetus. The lethal oral dose of metallic and other inorganic mercury compounds for humans is estimated at 1–4 grams (USEPA 1980).

Atmospheric mercury, largely in vapor form, poses a less significant health risk to the general

population than exposure to more toxic organic mercury compounds through the diet. About 80% of inhaled vapor is retained and absorbed in the bloodstream. In addition to direct exposure, the indirect impacts of atmospheric mercury on human health through deposition in lakes and rivers are of concern.

Ambient Standards and Guidelines

Ambient standards and guidelines for mercury in the environment are aimed at protecting human health and aquatic life. Ambient criteria for waterborne mercury concentrations attempt to take into account the complex effects of bioaccumulation of mercury and average dietary habits, using calculations of mercury concentrations in edible fish species. However, the possibility of deposition and accumulation makes it difficult to establish guide values that allow for postdeposition impacts. Table 1 presents EU, USEPA, and WHO reference standards and guidelines for ambient levels of mercury.

Conclusion

Because of the indirect route of the primary human exposure, the multiple and indirect sources of exposure, varying dietary habits of exposed population groups, and inadequate understanding of the accumulation, transformation, and complex effects of bioaccumulation of mercury in the environment, ambient standards and guidelines for individual environmental media are only a starting point for a comprehensive pollution management approach that considers the multiple sources of exposure, special dietary habits, and site-specific conditions.

Recommendations

Stationary sources that contribute to the increase of mercury in the environment should not exceed the mercury emissions referred to in the relevant industry section of this *Handbook*. These emissions are normally achievable through good industrial practices.

In addition, the impacts of new sources on ambient concentrations of mercury should be considered. When the use of certain fuels results in mercury emissions that contribute to a significant

Table 1. Reference Standards and Guidelines for Ambient Levels of Mercury

Medium	EU limit values	EU guide values	USEPA standard	WHO guide values
Water (micrograms per liter)				
Fresh water	1 ^a	0.5 ^a	0.19	
Estuary coastal water			0.11	
Marine water			0.14	
Drinking water	1 ^a	0.5 ^a	2	1
Air (micrograms per cubic meter)				— ^b

a. Arithmetic mean of results obtained over a year. EU, 1992 Council Directive 76/464/EEC.

b. Annual average indoor mercury concentration guideline of 1 mg/m³ was recommended. No ambient air quality guideline was established.

Sources: Water: European Union (EU) 1992, Council Directive 76/464/EEC; USEPA 1980; WHO 1976, 1993.

increase in ambient mercury concentrations, or in areas where fish is the main dietary source from waters affected by mercury emissions, the environmental assessment should ensure that mercury emissions are properly abated, taking into consideration alternative technologies and control measures. Intermittent monitoring of the surrounding water bodies and fish should ensure that mercury concentrations do not impose an increased health threat.

Notes

1. Mercury emission coefficients have been estimated at 1,760 kilograms (kg) per 10¹⁵ British thermal unit (Btu) for oil and 7,560 kg per 10¹⁵ Btu for high-mercury utility and industrial coal. The average emission coefficient for coal was estimated to be 3,000 kg per 10¹⁵ Btu.

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