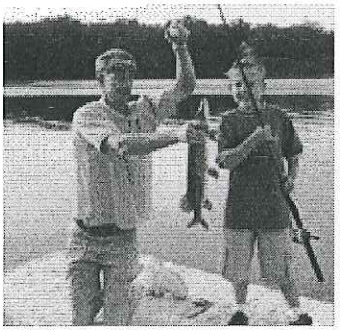
U.S. Geological Survey

Mercury in the Environment

Fact Sheet 146-00 (October 2000)

Mercury is a highly toxic element that is found both naturally and as an introduced contaminant in the environment. Although its potential for toxicity in highly contaminated areas such as Minamata Bay, Japan, in the 1950's and 1960's, is well documented, research has shown that mercury can be a threat to the health of people and wildlife in many environments that are not obviously polluted. The risk is determined by the likelihood of exposure, the form of mercury present (some forms are more toxic than others), and the geochemical and ecological factors that influence how mercury moves and changes form in the environment.

Toxic Effects



Eating contaminated fish and wildlife exposes people and fish-eating wildlife to the most toxic form of mercury, methylmercury.

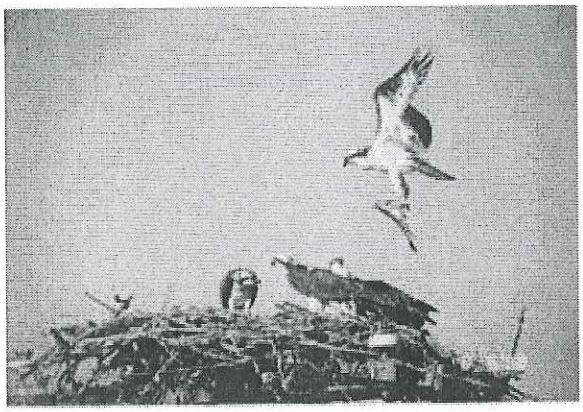
The toxic effects of mercury depend on its chemical form and the route of exposure. Methylmercury [CH_3Hg] is the most toxic form. It affects the immune system, alters genetic and enzyme systems, and damages the nervous system, including coordination and the senses of touch, taste, and sight. Methylmercury is particularly damaging to developing embryos, which are five to ten times more sensitive than adults. Exposure to methylmercury is usually by ingestion, and it is absorbed more readily and excreted more slowly than other forms of mercury. Elemental mercury, Hg(0), the form released from broken thermometers, causes tremors, gingivitis, and excitability when vapors are inhaled over a long period of time. Although it is less toxic than methylmercury, elemental mercury may be found in higher concentrations in environments such as gold mine sites, where it has been used to extract gold. If elemental mercury is ingested, it is absorbed relatively slowly and may pass through the digestive system without causing damage. Ingestion of other common forms of mercury, such as the salt $HgCl_2$, which damages the gastrointestinal tract and causes kidney failure, is unlikely from environmental sources.

Risk to People

People are exposed to methylmercury almost entirely by eating contaminated fish and wildlife that are at the top of aquatic foodchains. The National Research Council, in its 2000 report on the toxicological effects of methylmercury, pointed out that the population at highest risk is the offspring of women who consume large amounts of fish and seafood. The report went on to estimate that more than 60,000 children are born each year at risk for adverse neurodevelopmental effects due to in utero exposure to methylmercury. In its 1997 Mercury Study Report to Congress, the U.S. Environmental Protection Agency concluded that mercury also may pose a risk to some adults and wildlife populations that consume large amounts of fish that is contaminated by mercury.

How can I avoid consuming mercury in fish?

Options for avoiding the mercury in mercury-contaminated fish are more limited than for fish contaminated with PCBs, dioxins and other organic contaminants. Younger fish tend to have lower concentrations of mercury than older, larger fish within the same waterbody. Mercury concentrates in the muscle tissue of fish. So, unlike PCBs, dioxins and other organic contaminants that concentrate in the skin and fat, mercury cannot be filleted or cooked out of consumable game fish.



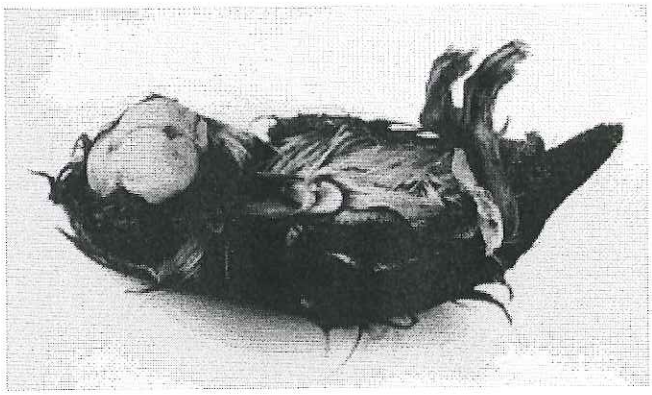
Fish-eating birds in certain parts of the United States may ingest large amounts of methylmercury in their diet.

Risk to Wildlife

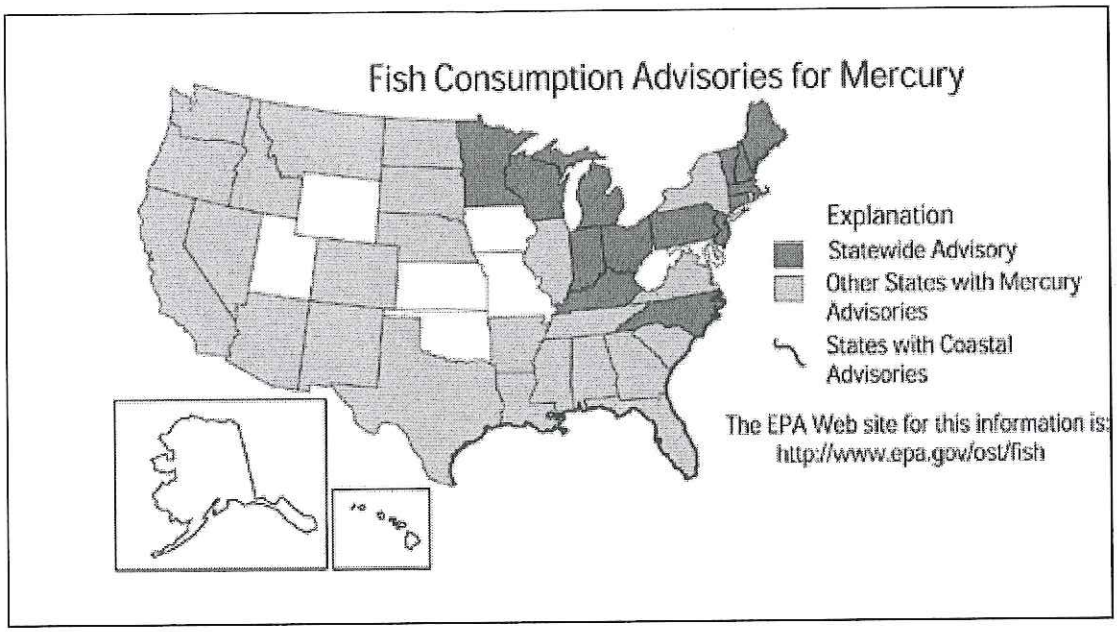
In several areas of the United States, concentrations of mercury in fish and wildlife are high enough to be a risk to wildlife. It is difficult to prove cause and effect in field studies, however, because other factors that may contribute to the biological effect under study (for example, reproductive success) are often impossible to control. Scientists have discovered toxic effects in the field at concentrations of mercury that are toxic in the lab, and controlled lab studies have found toxic effects at concentrations that are common in certain environments. In studies in Wisconsin, reductions in loon chick production has been found in lakes where mercury concentrations in eggs exceed concentrations that are toxic in laboratory studies. At dietary mercury concentrations that are typical of parts of the Everglades, the behavior of juvenile great egrets can be affected. Studies with mallards, great egrets, and other aquatic birds have shown that protective enzymes are less effective following exposure to mercury. Analyses of such biochemical indicators indicate that mercury is adversely affecting diving ducks from the San Francisco Bay, herons and egrets from the Carson River, Nevada, and heron embryos from colonies along the Mississippi River. Finally, other contaminants also affect the toxicity of mercury. Methylmercury can be more harmful to bird embryos when selenium, another potentially toxic element, is present in the diet.

Fish Advisories

The steadily increasing number and geographic extent of State advisories against the consumption of fish because of mercury contamination has raised the awareness of the widespread nature of the mercury hazard. Fish consumption advisories for methylmercury now account for more than three-quarters of all fish consumption advisories in the United States. Forty States have issued advisories for methylmercury on selected water-bodies and 13 states have statewide advisories for some or all sportfish from rivers or lakes. Coastal areas along the Gulf of Mexico, Maine, and the Atlantic Ocean from Florida through North Carolina are under advisories for methylmercury for certain fish.



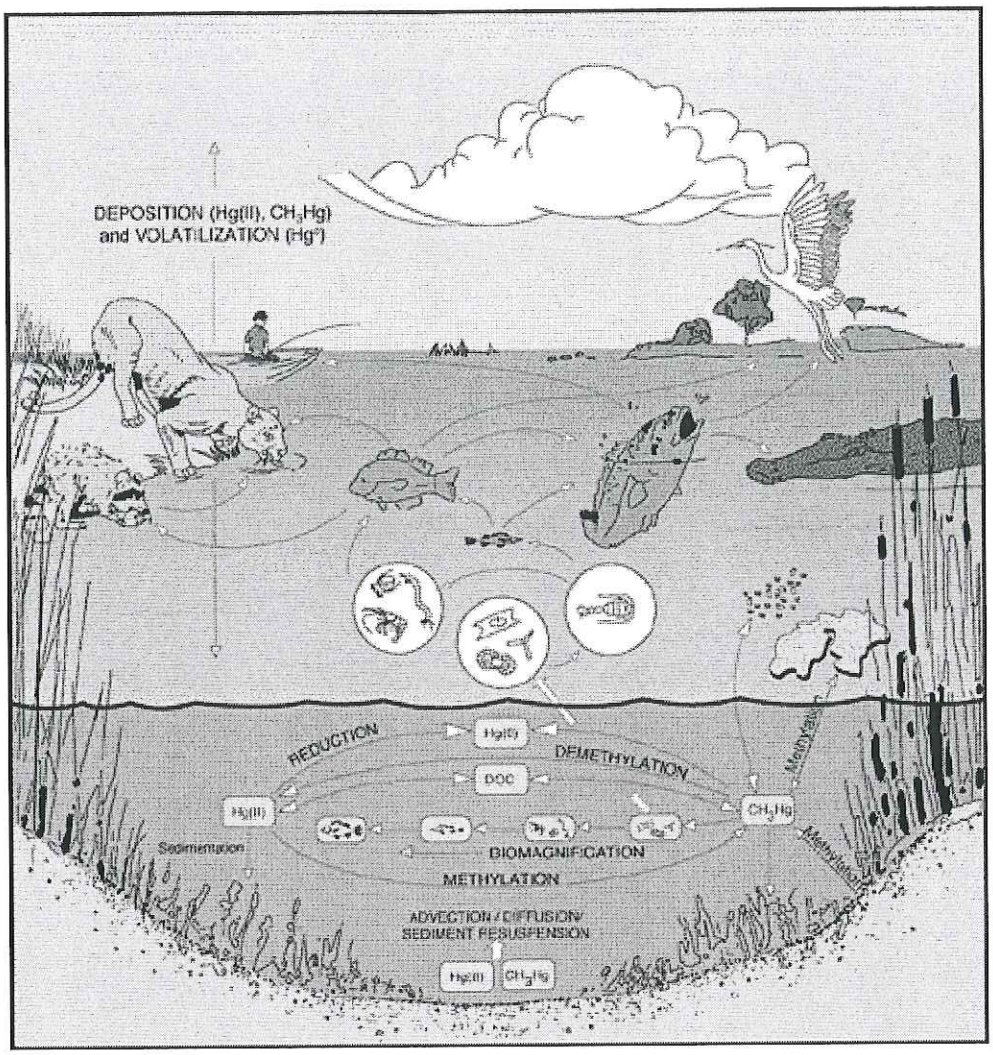
Mercury can cause deformities in developing animals.



Mercury concentrations are high enough to trigger fish consumption advisories in many States.

Sources of Mercury

Alkali and metal processing, incineration of coal, and medical and other waste, and mining of gold and mercury contribute greatly to mercury concentrations in some areas, but atmospheric deposition is the dominant source of mercury over most of the landscape. Once in the atmosphere, mercury is widely disseminated and can circulate for years, accounting for its wide-spread distribution. Natural sources of atmospheric mercury include volcanoes, geologic deposits of mercury, and volatilization from the ocean. Although all rocks, sediments, water, and soils naturally contain small but varying amounts of mercury, scientists have found some local mineral occurrences and thermal springs that are naturally high in mercury.



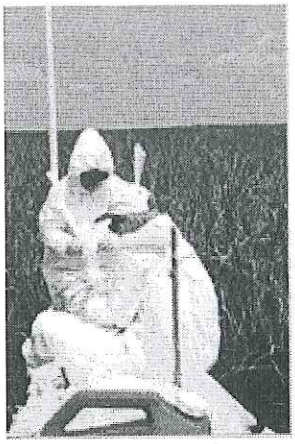
What factors affect the methylation?

Methylation is a product of complex processes that move and transform mercury. Atmospheric deposition contains the three principal forms of mercury, although inorganic divalent mercury (HgII) is the dominant form. Once in surface water, mercury enters a complex cycle in which one form can be converted to another. Mercury attached to particles can settle onto the sediments where it can diffuse into the water column, be resuspended, be buried by other sediments, or be methylated. Methylmercury can enter the food chain, or it can be released back to the atmosphere by volatilization.

The concentration of dissolved organic carbon (DOC) and pH have a strong effect on the ultimate fate of mercury in an ecosystem. Studies have shown that for the same species of fish taken from the same region, increasing the acidity of the water (decreasing pH) and/or the DOC content generally results in higher mercury levels in fish, an indicator of greater net methylation. Higher acidity and DOC levels enhance the mobility of mercury in the environment, thus making it more likely to enter the food chain.

Mercury and methylmercury exposure to sunlight (specifically ultra-violet light) has an overall detoxifying effect. Sunlight can break down methylmercury to Hg(II) or Hg(0), which can leave the aquatic environment and reenter the atmosphere as a gas.

Environments Where Methylmercury is a Problem



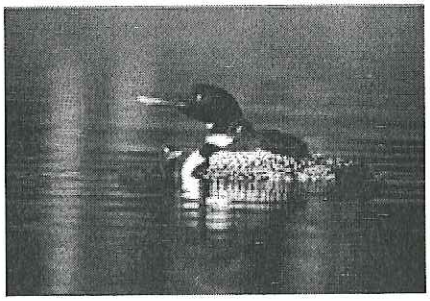
Sampling mercury in water requires extra care to avoid cross contamination because concentrations in water are so low.

Although mercury is a globally dispersed contaminant, it is not a problem everywhere. Aside from grossly polluted environments, mercury is normally a problem only where the rate of natural formation of methylmercury from inorganic mercury is greater than the reverse reaction. Methylmercury is the only form of mercury that accumulates appreciably in fish. Environments that are known to favor the production of methylmercury include certain types of wetlands, dilute low-pH lakes in Northeast and Northcentral United States, parts of the Florida Everglades, newly flooded reservoirs, and coastal wetlands, particularly along the Gulf of Mexico, Atlantic Ocean, and San Francisco Bay.

How does mercury enter the food chain?

The exact mechanisms by which mercury enters the food chain remain largely unknown and may vary among ecosystems. Certain bacteria play an important early role. Bacteria that process sulfate (SO_4=) in the environment take up mercury in its inorganic form and convert it to methylmercury through metabolic processes. The conversion of inorganic mercury to methylmercury is important because its toxicity is greater and because organisms require considerably longer to eliminate methylmercury. These methylmercury-containing bacteria may be consumed by the next higher level in the food chain, or the bacteria may excrete the methylmercury to the water where it can quickly adsorb to plankton, which are also consumed by the next level in the food chain. Because animals accumulate methylmercury faster than they eliminate it, animals consume higher concentrations of mercury at each successive level of the food chain. Small environmental concentrations of methylmercury can thus readily accumulate to potentially harmful concentrations in fish, fish-eating wildlife and people. Even at very low atmospheric deposition rates in locations remote from point sources, mercury biomagnification can result in toxic effects in consumers at the top of these aquatic food chains.

Mercury Contamination - Past, Present, and Future



Loons are especially vulnerable to methyl-mercury because a high percentage of their diet is fish. (©Copyright Woode Hagge; used with permission.)

In highly polluted areas where mercury has accumulated through industrial or mining activities, natural processes may bury, dilute, or erode the mercury deposits, resulting in declines in concentration. In many relatively pristine areas, however, mercury concentrations have actually increased because atmospheric deposition has increased. For instance, concentrations of mercury in feathers of fish-eating seabirds from the northeastern Atlantic Ocean have steadily increased for more than a century. In North American sediment cores, sediments deposited since industrialization have mercury concentrations about 3-5 times those found in older sediments. Some sites may have become methylmercury hot spots inadvertently through human activities. Lake acidification, addition of substances like sulfur that stimulate methylation, and mobilization of mercury in soils in newly flooded reservoirs or constructed wetlands have been shown to increase the likelihood that mercury will become a problem in fish. Although scientists from USGS and elsewhere are beginning to unravel the complex interactions between mercury and the environment, a lack of information on the sources, behavior, and effects of mercury in the environment has impeded identification of effective management responses to the Nation's growing mercury problem.

Information

For more information on USGS research on mercury, visit usgs.gov/mercury. For information on USGS products and services, visit the USGS home page at www.usgs.gov or ask.usgs.gov, or call 1-888- ASK-USGS, or use the Ask USGS fax service, which is available 24 hours a day at 703-648-4888.

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