Mercury Contamination of Aquatic Ecosystems

Fact Sheet FS-216-95

U.S. Department of the Interior–U.S. Geological Survey

Introduction

Mercury has been well known as an environmental pollutant for several decades. As early as the 1950's it was established that emissions of mercury to the environment could have serious effects on human health. These early studies demonstrated that fish and other wildlife from various ecosystems commonly attain mercury levels of toxicological concern when directly affected by mercury-containing emissions from human-related activities. Human health concerns arise when fish and wildlife from these ecosystems are consumed by humans.

During the past decade, a new trend has emerged with regard to mercury pollution. Investigations initiated in the late 1980's in the northern-tier states of the U.S., Canada, and Nordic countries found that fish, mainly from nutrient-poor lakes and often in very remote areas, commonly have high levels of mercury. More recent fish sampling surveys in other regions of the U.S. have shown widespread mercury contamination in streams, wetlands, reservoirs, and lakes. To date, 33 states have issued fish consumption advisories because of mercury contamination (fig. 1). These continental to global scale occurrences of mercury contamination cannot be linked to individual emissions of mercury, but instead are due to widespread air pollution. When scientists measure mercury levels in air and surface water, however, the observed levels are extraordinarily low (fig. 2). In fact, scientists have to take extreme precautions to avoid direct contact with water samples or sample containers, to avert sample contamination (fig. 3). Herein lies an apparent discrepancy: Why do fish from some remote areas have elevated mercury concentrations, when contamination levels in the environment are so low?

How does mercury become a toxicological problem?

Like many environmental contaminants, mercury undergoes bioaccumulation. Bioaccumulation is the process by which organisms (including humans) can take up contaminants more rapidly than their bodies can eliminate them, thus the amount of mercury in their body accumulates over time. If for a period of time an organism does not ingest mercury, its body burden of mercury will decline. If, however, an organism continually ingests mercury, its body burden can reach toxic levels. The rate of increase or decline in body burden is specific to each organism. For humans, about half the body burden of mercury can be eliminated in 70 days if no mercury is ingested during that time. Biomagnification is the incremental increase in concentration of a contaminant at each level of a food chain (fig. 4). This phenomenon occurs because the food source for organisms higher on the food chain is progressively more concentrated in mercury and other contaminants, thus magnifying bioaccumulation rates at the top of the food chain. The bioaccumulation effect is generally compounded the longer an organism lives, so that larger predatory game fish will likely have the highest mercury levels. Adding to this problem is the fact that mercury concentrates in the muscle tissue of fish. So, unlike organic contaminants (for example PCBs and dioxins) which concentrate in the skin and fat, mercury cannot be filleted or cooked out of consumable game fish.

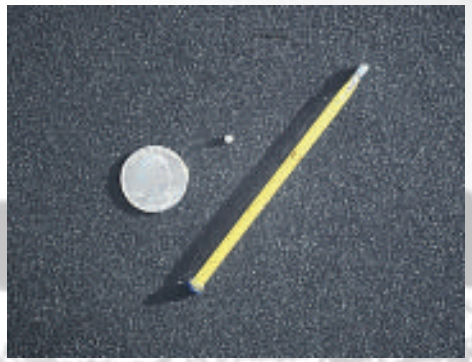

Figure 2. *The droplet of mercury shown in this slide is about 1 gram; the same amount that is in a standard mercury thermometer and the total amount that is deposited annually on a lake in northern Wisconsin with a surface area of 27 acres.*

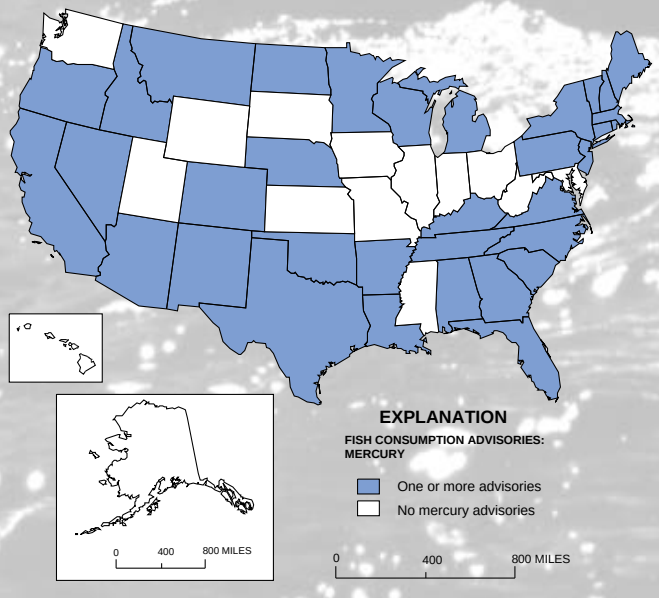

Figure 1. *States with at least one fish consumption advisory for mercury. Source: USEPA Fish Consumption Data Base*

Figure 3. *Because there is actually very little mercury in most natural waters, scientists have to use extreme measures when sampling for mercury to avoid sample contamination from their hands and clothing. This entails the use of lint-free suits, plastic gloves, hoods, and stringently cleaned sampling equipment.*

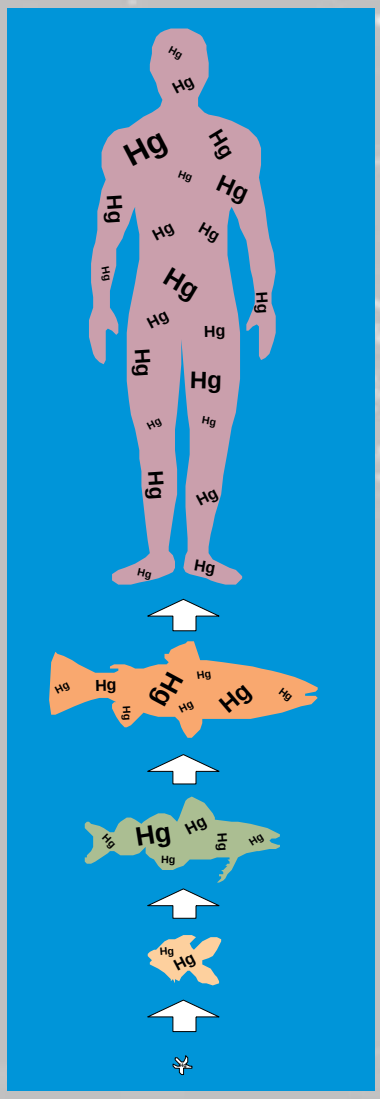

Figure 4. *Mercury (Hg) biomagnifies from the bottom to the top of the food chain. Even at very low input rates to aquatic ecosystems that are remote from point sources, biomagnification effects can result in mercury levels of toxicological concern.*

What are the human health effects of mercury toxicity?

Humans generally uptake mercury in two ways: (1) as methylmercury (CH_3Hg^+) from fish consumption, or (2) by breathing vaporous mercury (Hg^0) emitted from various sources such as metallic mercury, dental amalgams, and ambient air. Our bodies are much more adapted for reducing the potential toxicity effects from vaporous mercury, so health effects from this source are relatively rare. Methylmercury, on the other hand, affects the central nervous system, and in severe cases irreversibly damages areas of the brain (fig. 5). The most well documented cases of severe methylmercury poisoning are from Minamata Bay, Japan in 1956 (industrial release of methylmercury) and in Iraq in 1971 (wheat treated with a methylmercury fungicide). In each case, hundreds of people died, and thousands were affected, many with permanent damage. In milder cases of mercury poisoning, adults complain of reductions in motor skills and dulled senses of touch, taste, and sight. These milder effects are generally reversible if exposure to mercury is halted. Unborn children are at greatest risk from low-level exposure to methylmercury. Recent research suggests that prenatal effects occur at intake levels 5-10 times lower than that of adults. If these results are confirmed, a substantial fraction of unborn children would be at risk.

Mercury Cycling in the Environment

Mercury can take a myriad of pathways through the environment. Figure 6 shows a schematic drawing of mercury cycling in an aquatic ecosystem. With the exception of isolated cases of known point sources, the ultimate source of mercury to most aquatic ecosystems is deposition from the atmosphere, primarily associated with rainfall. As depicted in this figure, atmospheric deposition contains the three principal forms of mercury, although the majority is as inorganic mercury (Hg^{2+}, ionic mercury). Once in surface water, mercury enters a complex cycle in which one form can be converted to another. It can be brought to the sediments by parti-

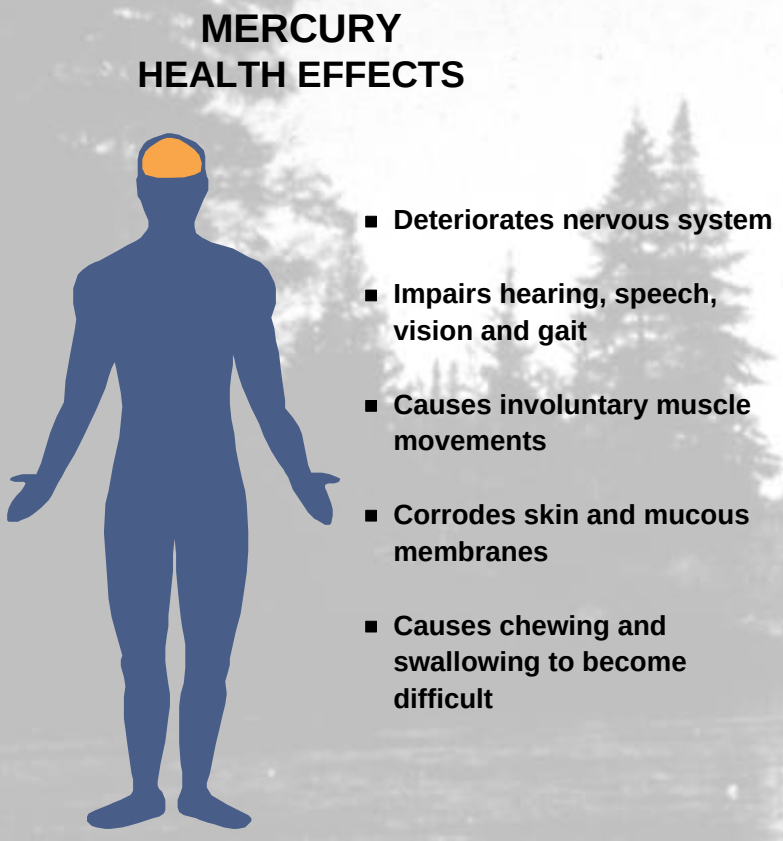

Figure 5. *All forms of mercury are toxic to humans, but methylmercury is especially of concern because our bodies have a less well developed defense mechanism against this toxin. Effects on the nervous system are the most prevalent in humans.*