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The Problem of Mercury

In the U.S. more of our surface waters are impaired for fishing due to mercury contamination than for any other toxic contaminant (U.S. EPA). Fish consumption is most often the route of human exposure to toxic contaminants, and the U.S. Food and Drug Administration (FDA) routinely issues guidelines to states on levels that warrant closures of fishing waters to recreational and commercial fishing. Currently, thirty-nine states have mercury fish advisories, which likely impact both sport fishers and subsistence fishers (USGS). Other counties around the world, including our neighbor to the north-Canada, and several European countries also issue fish consumption warnings due to elevated levels of mercury in fish. The form of mercury found in fish is Methyl mercury (MeHg), which is a neurotoxin. Those most at risk for brain and nervous system damage are children and unborn babies of mothers who eat mercury contaminated fish during pregnancy. Subsistence fishermen, such as many Native American Tribes, are particularly affected by these bans on consumption of mercury-contaminated fish because of the problems associated with alternative foods. There are numerous Alaskan tribes that depend on fish and wildlife for their source of food. Recent research has revealed that the Arctic ecosystem may be particularly at risk due to unusual meteorological conditions and atmospheric chemistry observed there that lends itself to greater deposition of mercury to the surface of the frozen ecosystem.

Today the dominant source of fish contamination is believed to be emissions to the atmosphere from fossil-fuel burning power plants (primarily coal-fired), municipal waste incinerators, and other industrial sources. Some forms of the emitted mercury compounds (e.g. mercuric chloride) directly deposit to water bodies, or to the watershed where they runoff to the adjacent lakes and streams. To date we have a limited data set for the emissions of Hg in its various forms from the major emissions source types.

It should be noted here that in parts of the U.S. significant amounts of mercury reach surface and ground water due to indirect inputs such as urban runoff and leaching from mines and waste disposal sites. Elevated mercury concentrations have also been measured in the influent of municipal wastewater treatment facilities in urban areas that might accept discharges of industrial wastewaters as well as domestic waste.

Natural emissions of mercury to the atmosphere from abandoned mine tailings and from natural geological materials are also significant in parts of the western U.S. Understanding the magnitude of these natural emission sources is made more difficult due to the observation that previously deposited mercury can also undergo chemical transformations that convert it back to the elemental form that readily leaves the earth's surface (land and water) to re-enter the global background of mercury. The rate at which mercury is re-emitted from the surface varies with the type of surface, forest vs. farm field for example. Research to understand the factors that influence the rate of surface emission is ongoing and will meet a critical data need for the development of emissions inventories needed for sounds environmental management of impaired ecosystems.

After it enters the environment, biological and chemical processes in the soil, surface waters, and sediments can transform mercury into methyl mercury (MeHg), the most toxic form of Hg, which can be taken up by plants and animals. The levels of MeHg tend to build up or bioaccumulate in organisms on up through the food chain. While mercury can transform from one chemical form to another, it does not degrade or disappear like some other persistent organic pollutants.

Mercury and Acid Deposition

The problems of acid rain and mercury contamination are closely linked. Research has revealed that the levels of Hg in fish tissue tend to be higher in more acidic water bodies. The same

sensitive ecosystems that have been the recipient of acidic compounds from the burning of fossil fuels also receive elevated concentrations of mercury and other toxic trace elements. With the Vice President's announcement of an energy policy that continues to focus heavily on fossil fuels, there is some urgency to understand the linkage between atmospheric emissions from these sources and the risks to humans and the environment. Research aimed at understanding the sources and cycling of mercury in the environment will also help us in understanding the fate and risks from the other 15 "pollutants of concern" identified in the *Third Report to Congress* of the Great Waters Program. Since the atmospheric fate and transport of mercury is so inter-twined with the chemistry of atmospheric acids and ozone, federal agencies should aim to develop integrated high-temporal and spatial monitoring sub-networks in select ecosystems that have comparable aquatic and biological monitoring.

Environmental Monitoring

The importance of high quality monitoring data for development of sound environmental policy can not be understated. At present, the proper balance of long-term atmospheric deposition monitoring sites and integrated process level research sites does not exist. While there are currently several national monitoring networks for acid deposition *(NADPINTN,* CASNet, AIRMON) as well as the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) for assessment of the National Ambient Air Quality Standards, there is not a national effort to properly assess the trends in ambient mercury or the dry deposition of mercury, which can equal the deposition of mercury deposited by precipitation. Several states have initiated weekly mercury monitoring as part of the NADP sub-network referred to as the Mercury Deposition Network (MDN). However, the spatial coverage at present is not adequate to assess emissions trends or to assess the efficacy of reduction programs. The highest deposition (wet and dry) is found in and downwind of our large urban areas where there are, at present, few monitoring sites. Support from the federal government will be required to improve the spatial coverage as well as to improve the quality of the monitoring equipment presently being utilized. Current efforts by the U.S. EPA and USGS need to be expanded to allow for a continued improvement of monitoring networks and utilization of modem technological breakthroughs in microelectronics that are now becoming more widespread. Improvements in monitoring methods will also be required for attainment of the goals of the bi-national (U.S.–Canada) and tri-national (U.S.–Canada-Mexico) environmental programs and action plans.

Source Attribution

The question of whether one can determine the source or source types contributing the Hg in a particular water body or in the fish in a particular lake is one asked often. Monitoring conducted for source allocation would require the use of short-duration measurement techniques that are now available as well as event-based wet and dry deposition methods. The use of proper techniques and complete chemical and elemental characterization of the deposition samples allows the estimation of the contribution of mercury from the major sources (See Dvonch et al. 1999, ES&T for more details). Detailed measurements that are needed for determining source-receptor relationships can also be used to better understand the basic processes that are controlling the fate of mercury emissions from various sources in different regions of the U.S.

A well-defined network of monitoring sites together with the chemical and elemental characterization would allow for regional and national assessments of the major sources contributing to the mercury deposition. This network would provide the needed data to track changes in mercury deposition and assess the efficacy of regulatory programs. Funding for the development and implementation of this type of network would also need to include both wet and dry deposition measurements. In addition, the enhanced deposition data would allow linkage to whole ecosystem studies tracking changes in the biological and physical environment.