STATE OF NEW MEXICO
ENVIRONMENT DEPARTMENT
SURFACE WATER QUALITY BUREAU
Harold Runnels Building, N2050
1190 S. St. Francis Drive
Santa Fe, New Mexico USA 87502-6110
Telephone (505) 827-0187
Fax (505) 827-0160
www.nmenv.state.nm.us/swqb

BILL RICHARDSON
GOVERNOR

RON CURRY
SECRETARY

A White Paper on MERCURY in New Mexico

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Introduction

The first fish consumption advisory for mercury in New Mexico was developed for Elephant Butte Reservoir in the late 1970s. Since then some degree of consumption advisory has been issued for 26 lakes and reservoirs and five river segments. Although a few of these advisories indicate that the tested fish were free of mercury at levels of concern, most of the waterbodies listed are shown to contain fish which should be eaten with caution, or not at all.

State/EPA mercury screening survey

In 1995 and 1996 staff of the Surface Water Quality Bureau (SWQB) conducted a screening survey for mercury covering over 2,000 miles of New Mexico's water ways. Analyses were provided, free of charge, by EPA s Environmental Monitoring Systems Laboratory (EMSL) in Cincinnati, Ohio. EMSL was able to provide a minimum detection limit of 0.7 ng/L (0.7 parts per trillion). Using ultra-clean sample handling protocols developed by SWQB staff, over two hundred stations were sampled before the EMSL project lost its funding and was terminated. This study is the most comprehensive evaluation of mercury levels in New Mexico's waters ever conducted.

The Surface Water Quality Bureau has been given the use of the analytical equipment used in the State/EMSL mercury screening survey. This equipment now resides at the Scientific Laboratory Division of the New Mexico Department of Health (SLD). Staff of the SLD are currently developing a small clean room to provide a suitable laboratory environment for the analysis of mercury at low parts per trillion levels.

Survey results

The data from that study show that, with some notable exceptions, mercury levels in our rivers and streams are very low. The average concentration of mercury in New Mexico's waters is less than 2.5 ng/L (Range: 0.0 ng/L to 500.0 ng/L). No water sample drawn from any major waterway in New Mexico has been found to contain mercury at a level that could pose any degree of direct risk to humans or wildlife. While much work remains to be done, to date it appears that in all but one instance where mercury was found to exceed the current state chronic criterion of 12 ng/L (parts per trillion) its occurrence can be attributed to either mining activity or storm water runoff from Los Alamos National Laboratories (Up to >3,400 ng/L). The single exception appears to be related to a coal seam in San Juan County.

Fish tissue mercury concentrations

Despite the extremely low concentrations of mercury in the State's waters, levels in the tissues of certain fish, (usually large, predatory species), can still exceed the FDA action limit of 1.0 part per million, an increase over background of six orders of magnitude. It is this tendency of mercury to biomagnify as it is passed up the food chain that generates concern. Fish are about ten times as tolerant of mercury than are humans. This is possible because they have evolved an efficient strategy for sequestering mercury away from vital organs: they store it in muscle tissue - the portion we eat.

The form of mercury found in fish

Virtually all of the mercury found in the edible portion of a fish has combined with a simple organic molecule, methane, to form methylmercury, one of the most toxic substances known. The process of methylation has been shown to be bacterially mediated. Methylmercury usually comprises only about three percent to twenty percent of the total mercury present in the water column.

Mercury toxicity

Once methylmercury enters the human body it is very difficult to remove. If the input continues over time, the concentration of mercury in tissue can rise to potentially dangerous levels. The toxic effects of methylmercury can impact very basic cellular functions, causing a wide range of symptoms. Researchers are still working to understand the complex nature of mercury toxicity. Much of the damage done to a victim of mercury intoxication is permanent, persisting even after the body burden has returned to background levels. Moreover, if the tissues of a pregnant or breastfeeding woman are contaminated with mercury, a disproportionate amount of that mercury is passed to the baby, where it attacks the developing nervous system. A child exposed to mercury in this way may be irreparably harmed.

Mercury hazards to wildlife

Humans are not the only population at risk. Wildlife exposed to mercury via their diet may be subject to reproductive failure, immune system impairment, behavioral aberrations, motor dysfunctions, or even direct toxicity. Most at risk are those animals at upper trophic levels that feed on fish, or on other animals that feed on fish. The US Fish and Wildlife Service has attributed the death of a Florida panther, an endangered subspecies, to methyl mercury accumulated from its diet of raccoons. While little reliable information is available, there are no known instances of mercury intoxication of wildlife in New Mexico. Assessment of the impact of mercury on wildlife is difficult however, since some of the symptoms associated with chronic mercury poisoning may not be immediately apparent, resulting in reduced functionality, inappropriate breeding behavior, or early mortality by some other mechanism, e.g. impaired predator evasion.

Anthropogenic sources of mercury

The biogeochemical cycling of mercury is complex, and the potential for atmospheric transport of mercury on fine particulates or in the vapor state further complicates matters. Our industrialized society has found many uses for mercury and its compounds: colorants, antibacterial preparations, fungicides, batteries, catalytic reactors, dental amalgam, and electrical switches are only a few of the uses to which mercury has been applied. Mercury can also be found, to varying degrees, in many metalliferous ore bodies. Coal may contain relatively high quantities of mercury, which is released to the atmosphere when that coal is burned to generate electricity. While most non-essential uses of mercury have been banned or severely constrained, releases to the global environment from power generating stations and mineral extraction continue to be a refractory problem.

Atmospheric deposition of mercury

With the exception of localized mineral deposits and certain industrial settings, the greatest source of mercury to the environment is atmospheric deposition. Even though the concentration in the atmosphere is very low, our watersheds provide large catchments, and mercury is carried by runoff into waterways on fine particles of soil. These particles, easily held in suspension by the force of moving water, are eventually trapped behind dams, where they settle into the poorly oxygenated region at the bottom of the reservoir. In the anoxic sediments and hypolimnetic waters above them, sulfate reducing bacteria combine some of the inorganic mercury with methane, forming the methylmercury that biomagnifies so powerfully as it is concentrated and passed from prey to predator up the food chain.

Mercury and reservoir management

Because the methylation of mercury is primarily a biological process, the degree of bacterial activity can, within a broad range, be more important than the total mercury concentration in the generation of elevated fish tissue mercury levels. Anything that promotes the growth of bacteria will tend to increase the production of methylmercury. Reservoir management therefore, may be a significant factor in the process. While the micro-organisms involved use sulfate rather than oxygen as an electron receptor, their basic nutrient is still carbon. It has been demonstrated repeatedly that fish tissue mercury concentrations rise significantly in the impoundments that form behind new dams, and then gradually decline to an equilibrium level as the carbon provided by flooded vegetation is depleted. It follows that if the water level in a reservoir drops, allowing the growth of vegetation on the exposed littoral, that vegetation becomes a fresh source of carbon when it is flooded. With a fresh source of nutrients every time the water rises, bacterial activity, and methylmercury production, increases.

The deeper areas of a reservoir tend to stay cooler, and therefore denser, than the water above, and may become isolated during periods of warm weather. The oxygen in these deep regions is rapidly depleted, and the anoxic zone becomes available to the anaerobic bacteria that produce methylmercury. Withdrawals from this hypolimnetic zone may release methylmercury to the river below the dam.

Source attenuation strategies

In a comparison study of lake sediments in Minnesota and Alaska, researchers have documented significant reductions of mercury concentrations attributable to regional, as opposed to global, sources in the Minnesota lakes during the last ten years. This decrease in atmospherically deposited mercury is attributed to the state of Minnesota's aggressive efforts to control all sources and releases of mercury within its purview. The Minnesota Pollution Control Agency (MPCA) has combined an array of innovative programs, involving recycling, legislative action, cooperative agreements with business, municipal/regional sanitation districts, and industry, into a comprehensive mercury reduction strategy. Given the ubiquity of mercury in the environment, MPCA's plan has begun to yield positive results in a surprisingly short time. A similar program could be developed for New Mexico.

Future Directions

Environmental Protection Agency

The Office of Air and Radiation (OAR) has produced *The Mercury Study Report to Congress* which will be available soon from the National Technical Information Service for about $300.00. This document can be accessed now on the Internet.

The EPA Office of Research and Development is working to develop new methods for the analysis of mercury that will return detection limits capable of resolving the minute quantities present in the nation's waters.

The OAR projects that new emissions criteria for the control of "greenhouse" gasses and particulates will also yield significant reductions in mercury releases from combustion of wastes and coal.

Several branches of the EPA (as well as the electric power industry) are exploring technologies to remove mercury from coal prior to combustion.

At some point in the near future, EPA plans to conduct a nationwide fish tissue sampling effort to refine knowledge of the extent of mercury contamination of the nation's fisheries.

The State of New Mexico

The Surface Water Quality Bureau of the New Mexico Environment Department has acquired from EPA analytical equipment capable of resolving the minute quantities of mercury generally found in New Mexico's waters. This equipment resides at the SLD in Albuquerque. Although there are resource allocation problems associated with bringing the equipment on line, it is anticipated that it will be operational sometime this year (1998).

The Surface Water Quality Bureau is opening lines of communication with the Air Quality Bureau in hopes of establishing a cooperative effort to determine atmospheric loading of mercury to New Mexico. Analysis of weather patterns correlated with codeposited constituents may yield information about local sources of airborne mercury.

Conclusion

The concentration of mercury in all but a few small, often ephemeral, streams in New Mexico is minute; averaging less than 2.5 ng/L. At this level, there is virtually no threat to humans or wildlife from direct contact with, or ingestion of, most of the State's waters. Aside from localized areas of severe contamination, mercury in New Mexico becomes cause for concern only after biomagnification up the food chain. Consumption of large, usually predatory, fish is the primary exposure route for humans. A diet consisting primarily of fish and shellfish is the primary exposure route for wildlife.

Promulgation of a more stringent criterion for total mercury will do little or nothing to solve the problems caused by mercury in New Mexico.

Only methylated mercury tends to biomagnify; methylmercury, then, and not total mercury, is the constituent of concern. Since mercury methylation is bacterially mediated, reservoir management may be a tool for the reduction of the methylated fraction of ambient total mercury.

Regional source attenuation programs have been developed elsewhere that have produced significant results in a relatively short time. A similar program could be developed for New Mexico.

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