Monitoring Mercury Deposition

A Key Tool to Understanding the Link between Emissions and Effects

An Introduction to the Mercury Deposition Network

The Mercury Deposition Network (MDN) is the mercury wet-deposition monitoring arm of the National Atmospheric Deposition Program (NADP). The NADP is a cooperative monitoring program comprised of federal and state agencies, academic institutions, Native American tribal governments, and private organizations.

High-quality environmental data have been collected for NADP monitoring networks since 1978. The NADP has a long history of providing consistent, accurate, quality-assured data to researchers, policymakers, and the general public.

The MDN began measuring total mercury in precipitation (wet deposition) in 1996. It now has more than 100 sites.

Automated wet-deposition collectors and precipitation gages measure mercury concentrations and wet deposition. Optional measurements include methyl mercury (MeHg) concentrations. After review and validation by the NADP Program Office, data are made available to all users.

The MDN

- Provides a nationally consistent survey of mercury wet-deposition concentrations and fluxes showing regional and international deposition patterns.
- Identifies long-term pattern changes in wet-deposition rates over time and space.
- Provides high-quality data for use in estimating wet-deposition rates locally or between sites, and for current and future mercury policy and modeling efforts.

Advantages of MDN Membership

The MDN provides high-quality data, on a continental scale, for research and decisionmaking about wet deposition of environmental mercury. This cooperative network has several advantages for members:

- Low operating costs.
- Input to decisions.
- High-quality data that undergo rigorous MDN quality assurance (QA).
- Access to all site data for comparison and research.
- Contributing to the international understanding of mercury in the environment.

Unsurpassed Quality Assurance/Service

A very important MDN component is quality assurance, and the NADP has a 26-year record of providing high-quality data. All sites follow well-defined standard operating procedures, and all laboratory analyses use state-of-the-art methods to provide the best data.

Mercury in the Environment

- *Mercury does not naturally occur as pure "quicksilver" but usually occurs as its principal ore cinnabar (HgS), one of 25 mercury-containing minerals that make up about 0.5 parts per million of the Earth's crust.*
- *Mercury is used in industry, commerce, mining, metallurgy, manufacturing, medicine, and dentistry.*
- *Human sources of atmospheric mercury include by-products of coal-fire combustion, municipal and medical incineration, mining of metals for industry, and many others.*
- *Natural sources of atmospheric mercury include outgassing from volcanoes and geothermal vents, and evaporation from naturally enriched soils, wetlands, and oceans.*
- *Atmospheric mercury concentrations can vary greatly depending on the location. Away from sources, elemental mercury is nominally 1.4 to 1.6 ng/m^3 and reactive gaseous and particulate bound mercury are nominally below 0.05 ng/m^3. Close to sources and in unique environments, concentrations can range widely.*
- *Wet deposition could be responsible for 50-90% of loading to many inland water bodies.*

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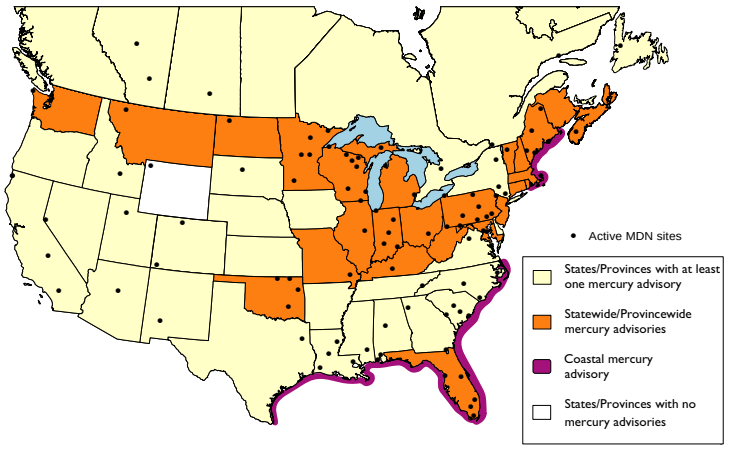
To keep sites running smoothly, the MDN provides all sampling supplies, instructions on standardized operating procedures, and an annual training course. There is a toll-free number for procedural and mechanical questions.

Weekly sampling materials arrive on site pre-cleaned and ready for use in durable containers that require minimal storage space. Members spend less than an hour a week on all MDN activities, including sample collection.

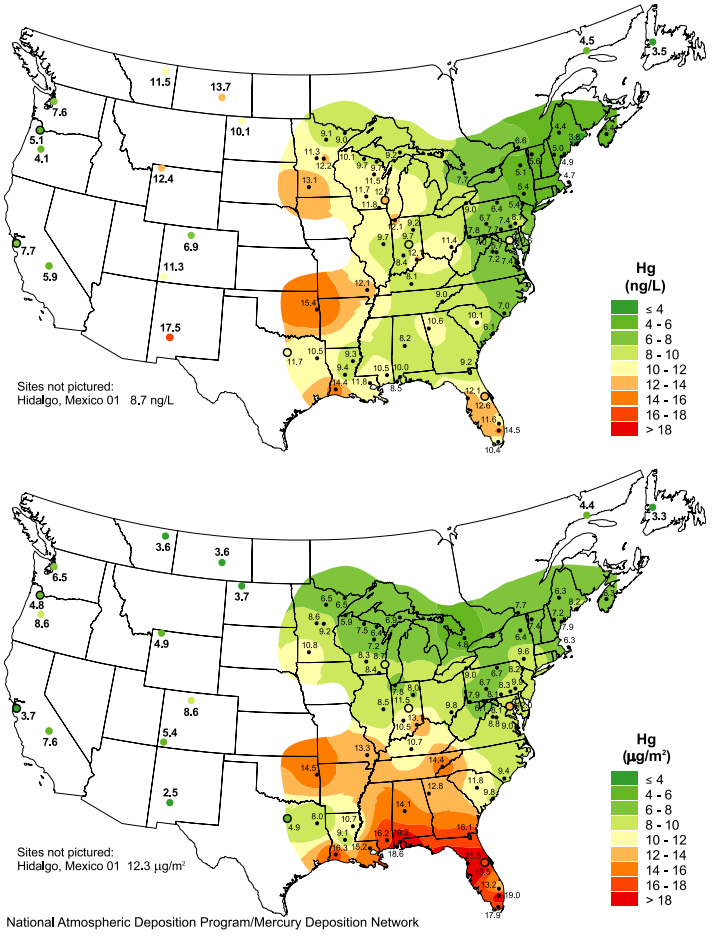
Easy Data Access/Use
Members receive all final data within six months of sample collection. Site sponsors receive preliminary data even sooner. Data provided include weekly mercury concentration and wet-deposition values (see nadp.sws.uiuc.edu).

The NADP publishes annual summary maps that facilitate data comparisons with other nearby stations or national averages for scientific studies and modeling. Upon request, the NADP provides customized databases for special analyses.

Competitive Costs
The MDN strives to keep all costs for this large and growing network affordable. Consequently, prices for supplies and services remain constant for several years, fostering long-term site operation. The NADP helps maintain/repair MDN equipment and provides technical assistance to keep monitoring costs low.



Location of operating MDN sites in 2005, and local, statewide, and provincewide fish-consumption advisories for mercury. (http://www.epa.gov/OST/fish)



Total annual average mercury concentation in rainfall in 2005 (top), and total annual mercury wet deposition in 2005 (bottom).

The Mercury Problem

For thousands of years, civilizations have found mercury to be very useful. Worldwide industrial use of mercury in mining and manufacturing processes, and emissions during power generation have mobilized and redistributed mercury in the environment.

Unfortunately, only recently has there been an appreciation of mercury's adverse health effects on wildlife and humans. Current U.S. and Canadian human health concerns do not focus on exposure to elemental mercury, but rather on exposure to very low concentrations of MeHg in fish.

Mercury Persists in the Environment

Mercury is in a class of chemicals called persistent bioaccumulative toxins. It persists in the environment for long periods by cycling back and forth between the air, water, and soil, all the while changing chemical forms.

Elemental mercury has an atmospheric lifetime of about one year, but MeHg can reside in the soils for long periods. Mercury never is removed from the environment: it just moves to other locations and

eventually ends up in soils and sediments.

Mercury Accumulates in the Food Chain

Mercury accumulates in animal and plant tissue through bioaccumulation and other complex reactions as yet unclear. Several types of bacteria incorporate inorganic mercury through chemical conversion to organic mercury compounds, largely the compound MeHg. This MeHg form is more toxic and more difficult to remove from bacterial systems than inorganic mercury. As higher organisms consume these bacteria, they also consume increasing amounts of MeHg, a cycle that repeats all the way up the food chain to fish, mammals, and humans.

Estimates suggest that MeHg can accumulate more than a million-fold in the aquatic food chain and then further accumulates in birds and mammals feeding in North American rivers, lakes, and wetlands. Of particular interest are fish and wetland-feeding species such as loons, pelicans, eagles, otters, etc.

Mercury in Humans

As humans consume fish, they also consume any MeHg in the fish. Humans bioaccumulate MeHg if they consume MeHg faster than their bodies can remove it. By consuming less MeHg-contaminated foods, concentrations in humans should decrease. This idea has led to the fish-consumption warnings for mercury.

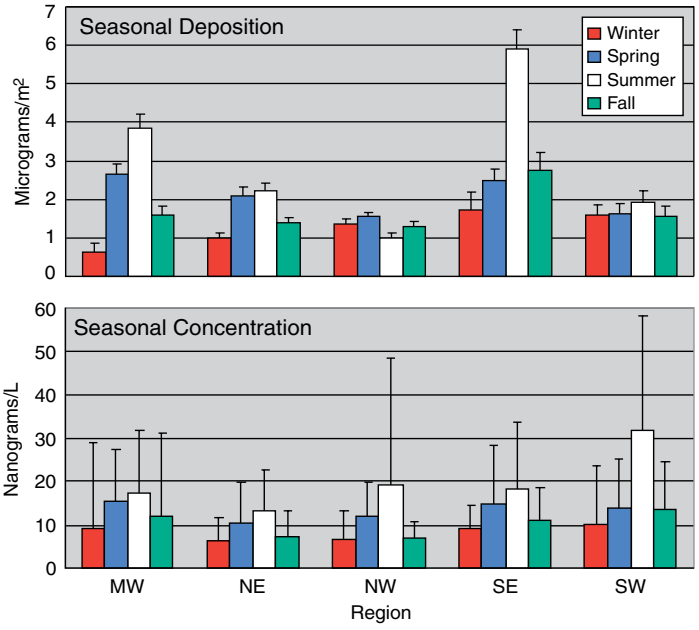
Mercury as Neurotoxin

Neurotoxicity is the most important health concern related to mercury. Any MeHg easily reaches the human bloodstream and is distributed to all tissues; it can also cross the normally protective blood-brain barrier and enter the brain. Because it readily moves through the placenta to developing fetuses, it is of particular concern to pregnant women. Low-level exposure is linked to learning disabilities in children and interferes with reproduction of fish-eating animals. The U.S. Environmental Protection Agency lists both MeHg and mercuric chloride as possible human carcinogens.

How Mercury Reaches Lakes, Rivers, and Oceans

A major contributor of mercury to inland water bodies is atmospheric deposition, both wet and dry. Wet deposition transfers atmospheric constituents to the Earth's surface in precipitation. Dry deposition is atmosphere-to-surface deposition in dry weather. These pathways lead to mercury loadings in water bodies, where mercury may be converted to MeHg and bioaccumulate through the aquatic food chain.

Estimates suggest mercury wet deposition accounts for 50-90



Mercury wet deposition and concentration by region and season with standard deviations as measured, 1997-2003.

All photos are public domain photos from various federal agencies, particularly the U.S. Fish and Wildlife Service, the National Park Service, and the National Oceanic and Atmospheric Administration.

For more information, visit the NADP website (http://nadp.sws.uiuc.edu), or contact David Gay [(217) 244-0462 or dgay@uiuc.edu] at the Program Office.

percent of the mercury load to many inland U.S. water bodies and estuaries. Elemental, divalent, and particulate mercury are all important in wet and dry deposition. Wet deposition more readily removes the latter two water-soluble forms. More than 98 percent of atmospheric mercury is the long-lived elemental form, which is transported great distances before removal.

Wet-deposition rates vary seasonally and regionally but tend to be highest in summer, except at West Coast sites. Our measurements show the highest depositions along the Gulf Coast, and somewhat less in the Midwest. Highest concentrations are in the Southwest, followed by the Midwest and South. Also, dry deposition to forest canopies may exceed wet deposition in certain ecosystems.

Scientific and regulatory communities need to know where mercury is added to specific environments, as well as the rates, concentrations, and routes. The MDN is an excellent tool to fulfill those aims.

Joining the MDN

The goal of MDN is to develop a network that adequately covers all continental ecoregions for accurate determination of wet deposition of mercury. If you are interested in joining the MDN, or just need more information, contact the NADP for an informational packet. Your completed short application will help the Program Office staff locate and evaluate your proposed monitoring site for MDN participation.

After your site is accepted, you will purchase and install equipment, and choose a site operator. Site requirements include 110-volt power and all-weather access. Site operators receive training by various methods, including on-site training, instructive videos and technical manuals. Site operators collect and ship samples every Tuesday, which require only about an hour per week. New sample glassware, field sheets, etc. automatically are shipped to the site operators.

The table shows estimated costs for a new site. Retrofitting an existing National Trends Network site costs less because both projects use the same raingage. In addition, composite or weekly MeHg analyses (within certain restrictions) are available for an added charge.

Estimated MDN Costs for Individual Sites

	Total Mercury	*Optional Methyl Mercury*
Total Mercury Analysis	$ 8,268	1950/6240[B]
Shipping	$ 1,300	0
Coordination (data mgt., QA, etc.)	$ 2,700	0
Total Annual Cost	$ 12,268	$1950/6240
Equipment[A] Costs & Installation (year 1 only)	$ 11,000	

[A] *Equipment choices available*
[B] *4-week/weekly*

The NADP Program Office is located at the Illinois State Water Survey, an affiliated agency of the University of Illinois and a Division of the Illinois Department of Natural Resources.

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The NADP is a National Research Support Project-3: A Long-Term Monitoring Program in Support of Research on the Effects of Atmospheric Chemical Deposition. More than 250 sponsors support the NADP, including private companies and other nongovernmental organizations, universities, local and state government agencies, State Agricultural Experiment Stations, national laboratories, Native American organizations, Canadian government agencies, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Tennessee Valley Authority, the U.S. Department of Agriculture-Cooperative State Research, Education, and Extension Service (under agreement no. 2002-39138-11964). Any findings or conclusions in this publication do not necessarily reflect the views of the U.S. Department of Agriculture or other sponsors.