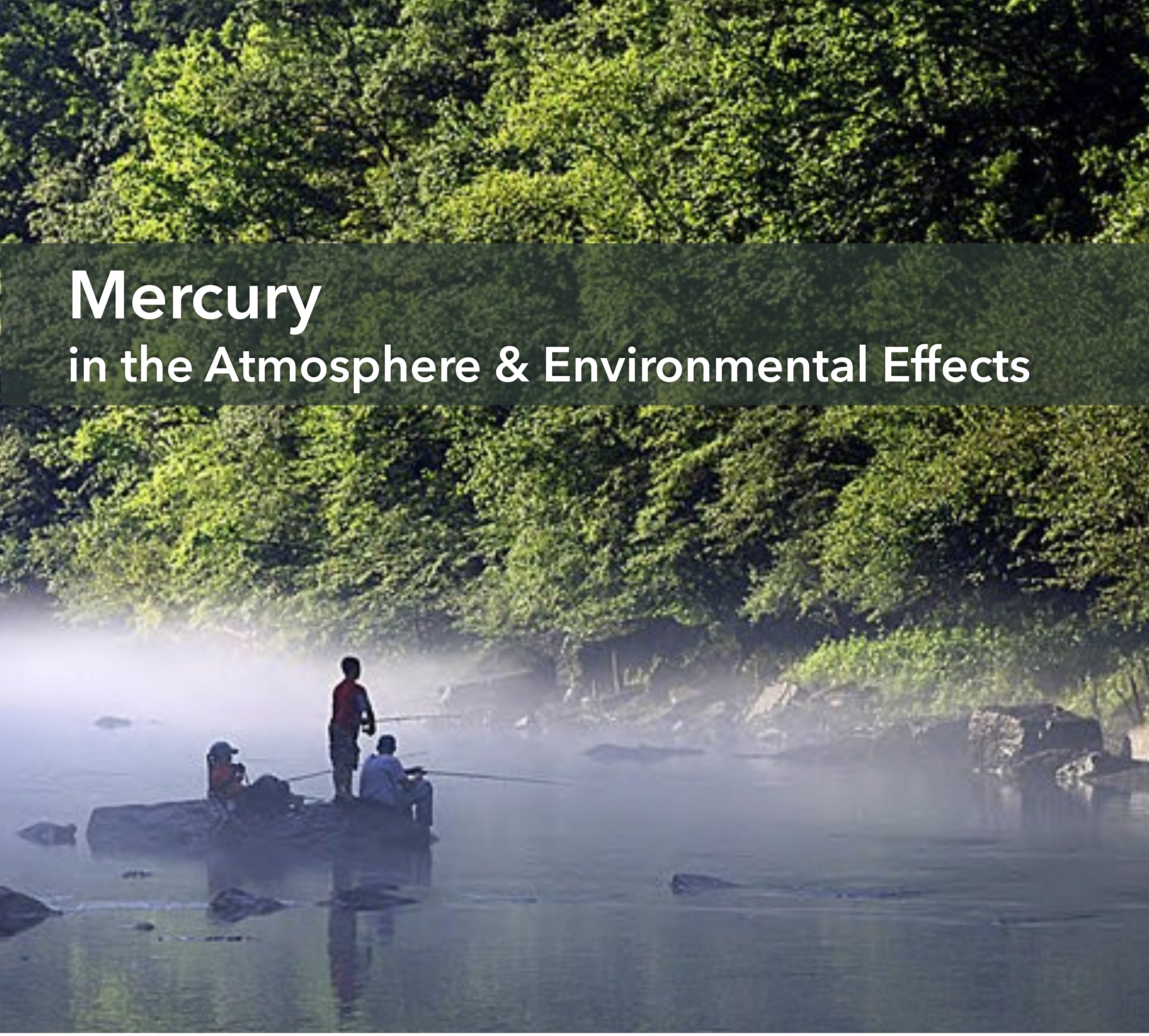


Mercury
in the Atmosphere & Environmental Effects

National Atmospheric Deposition Program

Executive Summary

Mercury in the Environment is a Concern

Mercury is a potent neurotoxin and a common contaminant in ecosystems throughout the world. Within ecosystems, natural processes convert inorganic mercury to methylmercury—a highly toxic form that is readily magnified to high concentrations in food webs. Toxic mercury exposure occurs primarily through the consumption of estuarine and marine fish, threatening the heath of both humans and wildlife. In the U.S. and in many regions of the world, the consumption of contaminated fish from freshwater lakes and streams also presents a health risk.

Human Activities are a Major Source of Mercury to the Environment

Mercury is a naturally occurring element, yet industrial activities, such as power generation from coal-burning power plants, release mercury to the atmosphere where it can be transported and deposited locally, regionally, and globally.

Atmospheric Deposition is a Main Input of Mercury to Ecosystems

Atmospheric mercury deposits as rain, snow, gas, particles, and litterfall back to the earth's surface where the fraction not soon emitted back to the atmosphere resides in soils, the oceans, freshwaters, and vegetation. Because atmospheric deposition is the primary source of mercury to many ecosystems, long-term deposition monitoring is an important step in documenting how the mercury cycle varies across the globe and how it is changing over time. Tracking atmospheric mercury deposition provides important information about the success of polices and management actions designed to reduce mercury emissions.

The National Atmospheric Deposition Program has a Robust Mercury Monitoring Capability

The National Atmospheric Deposition Program (NADP) operates three long-term networks that measure mercury. The Mercury Deposition Network (MDN) measures mercury in precipitation, the Atmospheric Mercury Network (AMNet) measures mercury gases and particles in the atmosphere and the Mercury Litterfall Network measures mercury inputs to ecosystems from leaves and needles as they fall to the ground. NADP is considering new opportunities to expand mercury monitoring. Innovative tools to measure and assess atmospheric mercury, including recent scientific advancements in simple, cost-effective techniques are very promising network applications. Often collocated with other long-term monitoring networks, NADP offers an exemplary platform for monitoring and research on which to add new capabilities.

Comprehensive Long-term Monitoring Information is Needed

In addition to monitoring atmospheric mercury concentrations and atmospheric deposition, comprehensive long-term mercury monitoring focused on watershed cycling and biological effects would allow scientists and managers to better assess mercury in the environment, linking changes in emissions and deposition with ecosystem effects and responses. Monitoring could provide answers to critical environmental policy and resource management questions, such as:

- Are mercury emissions and deposition to the environment changing as a result of implemented policies and programs?
- Are further reductions in emissions necessary to reduce methylmercury contamination of fish to acceptable levels?
- How and at what time scales are ecosystems responding to changes in mercury pollution?
- Have fish tissue concentrations changed sufficiently to revise fish consumption advisories?

Mercury in the environment is a concern

References to the neurological effects of mercury exposure date back to the 1800s when mercury was a common material used in the production of felt hats, prompting the term “mad as a hatter” to enter the vernacular. These effects were made famous by the Mad Hatter character in Lewis Carroll’s 1865 masterpiece Alice in Wonderland. However, environmental concerns regarding mercury contamination were not widespread until the tragedy in Minamata Bay, Japan in the late 1950s, when mercury waste from a petrochemical plant entered the bay, poisoning the fish and shellfish and subsequently the residents who relied upon and consumed the local catch. Since then, extensive research has been conducted to understand the distribution, cycling, and accumulation of mercury in the environment. Past studies have shown that mercury is a potent neurotoxin, a common contaminant in aquatic ecosystems throughout the world, and a significant threat to the health of both humans and wildlife.

The human health risks from exposure to methylmercury—a highly toxic form that readily magnifies to high concentrations in food webs—have been widely documented. These include damage to the brain and nervous system, impaired fetal and infant growth, impacts to kidneys and possible contributions to cardiovascular disease. Mercury not only threatens human health, it adversely affects fish and wildlife. Mercury impairs fish and wildlife feeding and predator avoidance behavior, and reproduction – ultimately affecting populations.

Methylmercury is often the form of greatest concern because of its high bioavailability and toxicity. Diet is the primary route of methylmercury exposure for most animals, and top predators tend to have the highest levels because of methylmercury’s propensity to concentrate in tissues and biomagnify through food webs.

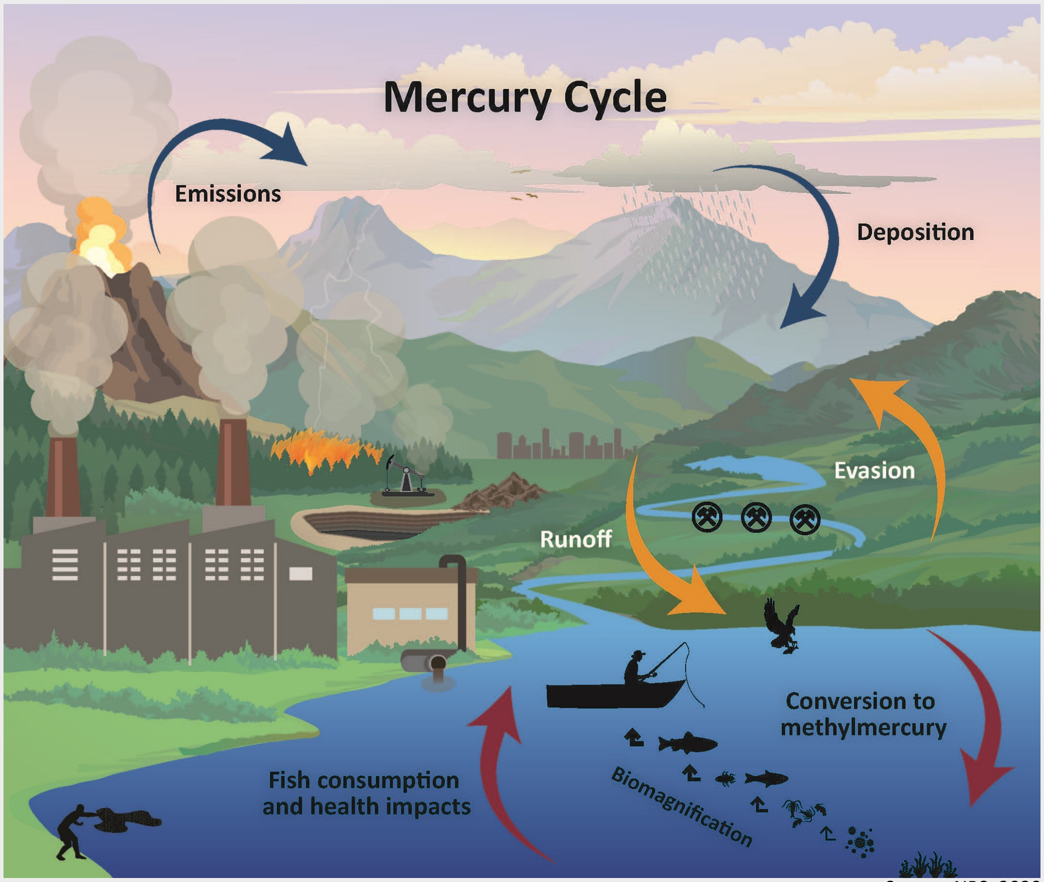
Exposure to toxic levels of mercury largely occurs through consumption of fish. More than 90% of methylmercury exposure from fish consumption in the U.S. and in many regions of the world comes from estuarine and marine fish. The consumption of mercury-contaminated fish from freshwater lakes and streams also presents a risk. Methylmercury concentrations in fish and wildlife in the U.S. now routinely exceed dietary thresholds known to harm people and wildlife. Methylmercury contamination has adversely affected the benefits derived from fishery resources in many of the nation’s inland and coastal waters.

Mercury is the leading cause of fish consumption advisories in North America; nearly half of all lakes in the U.S. contain fish with mercury concentrations of concern, as do approximately one-quarter of all the nation’s streams.

Mercury Cycling in the Environment

Mercury in the environment exists in elemental, inorganic and organic forms; however, the risks associated with each are not equivalent. Most mercury in the air, soils, and water occurs in the elemental or inorganic forms. This mercury may be transported by water movement from the soil to nearby streams and lakes and converted to methylmercury. Methylmercury is formed under certain environmental conditions by naturally-occurring microbes. Thus, exposure to methylmercury is generally associated with conditions favoring methylmercury production, such as moderately elevated levels of dissolved organic carbon and sulfate, than with loading or concentrations of inorganic mercury.

Monitoring of total mercury in atmospheric deposition provides only part of the information necessary to understand the health risks that mercury poses to humans and wildlife. Because methylmercury is the form that bioaccumulates, biomagnifies, and may result in toxicity to living organisms, measuring and tracking methylmercury throughout ecosystems is necessary to fully inform health risks. Monitoring atmospheric mercury deposition is a first step in understanding ecosystem source inputs, but additional information such as the controls on methylation rates and biomonitoring of mercury in living organisms are also needed to estimate health risks and the severity of concern in a given setting.



Source: NPS, 2020

A simplified mercury cycle shows how mercury enters and cycles through ecosystems, biomagnifies in food webs, and bioaccumulates in fish and wildlife.

Effects on fish, wildlife, and humans

Mercury exposure can elicit a range of toxicological effects in animals, impairing many organ and physiological systems. However, mercury's toxicity depends on its chemical form and route of exposure. Methylmercury is often the form of greatest concern because of its high bioavailability and toxicity. In contrast, elemental mercury is the liquid metallic form common in thermometers and used in artisanal gold mining operations. The most serious exposure risk is associated with volatilization at ambient temperatures. Inorganic mercury (e.g. mercury chloride) is commonly associated with industrial activities or can be found in association with legacy mercury mining operations. Inorganic mercury is less bioavailable than methylmercury and is more rapidly eliminated from the body.

Methylmercury and elemental mercury readily pass the blood-brain barrier where they can induce serious neurotoxicity. As such, high levels of exposure can result in loss of coordination, impaired cognitive ability, and even mortality. More commonly, at environmentally relevant exposures, the effects of methylmercury are more subtle. Fetuses and the young tend to be the most sensitive life stages to methylmercury toxicity, and impaired learning and lifelong cognitive deficits may result.

Wildlife and fish are also sensitive to methylmercury exposure, and studies have shown that methylmercury can reduce their ability to evade predators or successfully capture prey. Additionally, methylmercury alters the function of the neuroendocrine system, resulting in hormone imbalances that impair breeding behavior and may ultimately reduce reproductive success. In contrast, neurologic effects of inorganic mercury are less common, and it primarily causes kidney toxicity. All three forms of mercury also affect immune function. Mercury exposure both increases susceptibility to disease by suppressing the innate immune response, and also interferes with acquired immune responses, leading to various auto-immune disorders.

Photo: David Schmeltz

Because the developing brain is particularly sensitive to methylmercury, young children, women of childbearing age, and developing fetuses are among the most vulnerable.

Where does mercury originate?

Mercury is a trace element found in the Earth's crust. It can be emitted to the atmosphere from many different sources, including human activities, the re-emission of previously deposited mercury to land and water, and natural geology.

Human activities

For thousands of years, humans have extracted mercury for numerous medical, cultural, and industrial uses, processes, and products. However, it was the onset of the industrial revolution two centuries ago that greatly accelerated mercury emissions to the environment. As a highly volatile chemical element, mercury is released to the atmosphere from human activities which heat, combust or break apart rocks. Coal combustion for energy production, mining of metal ores, cement production, and waste incineration have profoundly impacted the amount of mercury mobilized into the environment. Human activities have increased the pool of mercury in the atmosphere by 3 to 5 fold relative to the pre-industrial period, by which time humans had already increased background atmospheric concentrations by several-fold relative to natural levels.

Today, human activities account for 30% of the total mercury emitted to the atmosphere worldwide each year; however, this statistic only represents present day, "primary" emissions and doesn't account for the legacy or re-emitted mercury emissions, a majority of which originated from human activities, but have been delayed by incorporation into soils and the oceans. In effect, the anthropogenic contribution to total mercury emissions is actually much greater when considering both primary and secondary emissions.

Recent scientific studies suggest that global anthropogenic mercury emissions may be either leveling-off or increasing. Regionally, mercury emissions in North America and Europe continue to decline whereas mercury emissions in East, Southeast, and South Asia are increasing, and account for more than 50% of global emissions.

Artisanal and small-scale gold mining

Artisanal and small-scale gold mining (ASGM) is the primary source of human-caused mercury emissions worldwide, as it is relatively inexpensive and easy to implement. In ASGM, miners often use mercury in an unregulated manner, without proper ventilation, and with little to no filtration of emissions to extract gold from rocks and sediments. ASGM occurs in 70 countries, primarily in South America, Sub-Saharan Africa, and East and Southeast Asia, typically in areas where economic opportunities are limited.

Photo: CINCIA

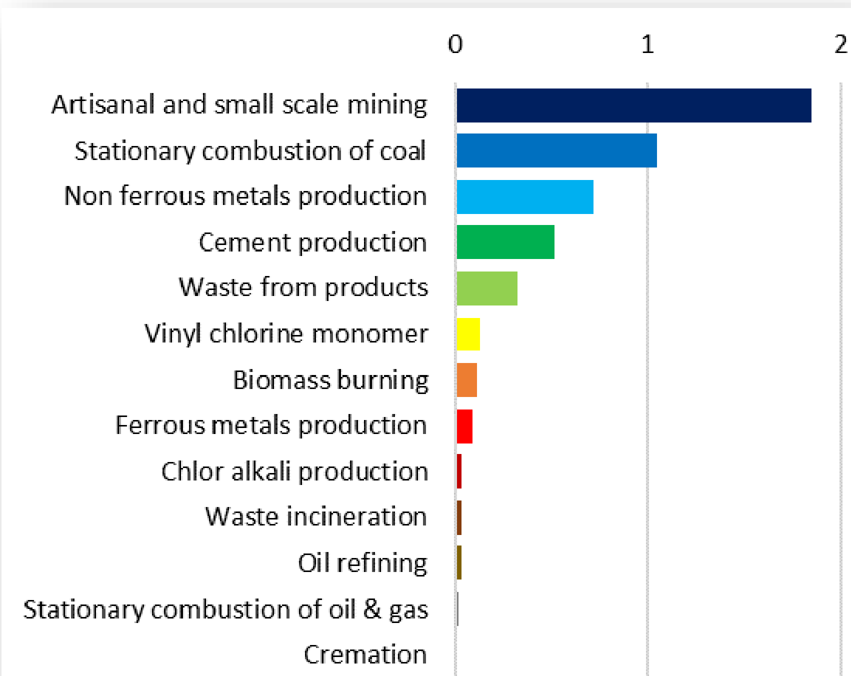
A miner at work.

Coal combustion

After ASGM, the combustion of coal for power production is the single largest anthropogenic source of mercury emissions to the atmosphere, representing 21% of the global anthropogenic mercury emitted annually. The mercury content in coal varies widely. During combustion, coal burned in very large volumes emits mercury as a pollutant biproduct.

Mercury emitted to the atmosphere may be transported over different distances, depending on its form and other factors before depositing to land and water. Despite a growing number of countries moving away from coal, combustion of coal for power generation and industrial purposes continues to increase, especially in Asia. However, scientists have noted that since about 2010, the increasing trends in mercury emissions have slowed appreciably due to the widespread use of advanced mercury control systems at coal burning power plants in East Asia. Increases in the application of emission controls, including widely available mercury-specific control technologies, together with

Global Mercury Emissions by Sector (million lbs), 2015



Source: UNEP

Artisanal and small-scale gold mining, coal combustion, production of nonferrous metals, and cement production account for 85% of the primary anthropogenic mercury emitted globally each year.

A Change in the Air

U.S. Anthropogenic Mercury Emissions Over Time

In the U.S., coal-burning power plants, medical waste incinerators, and municipal waste combustors made up approximately two-thirds of the U.S. mercury emissions inventory in 1990. Medical waste incinerators and municipal waste combustors subject to emissions standards for years have reduced their mercury emissions by more than 95%. Similarly, standards established for power plants have led to a reduction in mercury emissions by more than 90% from this sector. In 2020, monitored mercury emissions from power plants reporting under the Mercury and Air Toxics Standards (MATS) program were 2.6 tons, 91% below 2010 emissions.

Most of the human-generated point sources of reactive and particle-bound mercury, including coal-burning power plants are located in the Eastern U.S. Atmospheric modeling studies have suggested domestic sources contribute more than half of the total mercury deposited to the region. In the western U.S., the estimated contribution of domestic anthropogenic sources to mercury deposition is much smaller. For both regions, the remaining deposition is driven by regional and global natural emissions, current international anthropogenic emissions, and legacy mercury.

In the U.S., recent declines in mercury emissions correspond with decreases in atmospheric concentrations of gaseous mercury and wet mercury concentrations particularly in the eastern U.S. As the U.S. continues to ratchet down mercury emissions from domestic sources, mercury emitted from sources outside the U.S. may become a bigger portion of the contributions to U.S. mercury deposition. This is consistent with the effects of rising mercury emissions from sources in East Asia and the influence of long-range transport.

U.S. Mercury Emissions (tons) 1990-2017

Source Category	1990	2005	2008	2011	2014	2017
Coal-burning Power Plants	58.8	52.2	29.4	26.8	22.9	4.4
Medical Waste Incinerators	51	0.2	0.1	0.1	0.02	0.003
Municipal Waste Combustors	57.2	2.3	1.3	1	0.6	0.4
Industrial, Commercial/Institutional Boilers & Process Heaters	14.4	6.4	4.2	3.6	3.2	2.5
Chlorine Production	10	3.1	1.3	0.5	0.1	0.1
Electric Arc Furnaces	7.5	7	4.8	5.4	5	4.7
Hazardous Waste Incinerators	6.6	3.2	1.3	0.7	0.8	1
Total (all categories, including sources not shown)	246	105	61	56	52	33

Source: EPA National Emissions Inventory Technical Support Document, 2017

Re-emissions of mercury

Mercury residing in soils, surface waters, and vegetation and orginating from past emissions can be emitted back to the air through evasion. This includes inorganic and organic forms of mercury which can be converted to elemental mercury and volatilized back into the atmosphere. Mercury may be deposited and re-emitted many times as it cycles through the environment. Re-emitted mercury originates from both natural sources and human activities; however, by the time the mercury is re-emitted, it’s difficult to identity its origin. Nonetheless, human activities have increased the environmental burden of mercury, resulting in higher levels of re-emission.

Wildfires are a growing concern

Wildfires are a significant source of mercury worldwide. Mercury released from fires can have global, regional, and local impacts. Wildfires emit both gaseous elemental and particulate mercury, which can travel long distances before returning to the earth’s surface as atmospheric deposition.

Scientists have shown that climate change is a key factor that increases the risk and extent of wildfires. Warming temperatures predicted for the boreal forests covering vast expanses of Alaska, the U.S., Canada, and Russia, may mean more frequent, high-intensity wildfires, which could release the vast mercury pools stored in the peat and permafrost in large pulses to the atmosphere.

Natural sources

The largest natural source of mercury to the atmosphere is volcanic eruptions which generate heat, volatilize crustal mercury, and emit mercury to the air. Other natural processes such as the weathering of mercury-containing rocks happen continuously, causing mercury emissions to the air and releases to lakes and rivers. Natural sources emit almost exclusively gaseous elemental mercury. Natural sources account for 15% +/- 5% of the primary mercury emitted annually to the air.

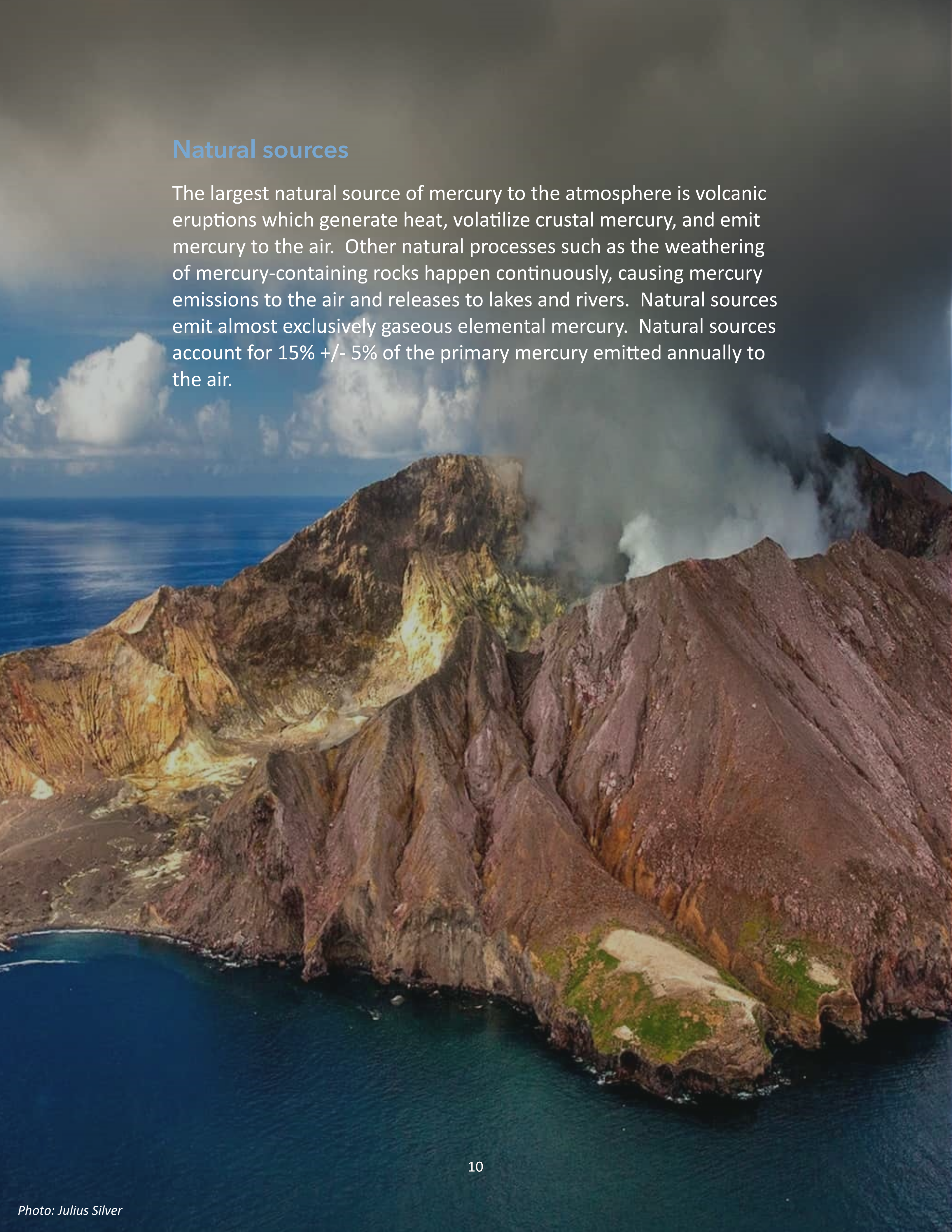


Photo: Julius Silver

Monitoring mercury deposition: a critical step

Atmospheric deposition is the principal source of mercury to many aquatic and terrestrial ecosystems across the globe.

Mercury in the atmosphere is found in gaseous and particulate forms: gaseous elemental (GEM), gaseous oxidized (GOM), and particle-bound (PBM). Emissions of gaseous elemental mercury can reside in the atmosphere for a year or more and may be transported globally before taken up by plants or soils, or transformed in the atmosphere into reactive forms. The extensive residence time not only facilitates long-range transport, it also promotes the delivery of mercury to remote locations across the world. In contrast, emissions of oxidized and particle-bound mercury are reactive, water-soluble, and therefore can deposit rapidly, contributing to local and regional impacts.

Atmospheric mercury deposits as rain, snow, gas, particles, and litterfall back to the earth's surface where the fraction not soon emitted back to the atmosphere resides in soils, the oceans, freshwaters, and vegetation. Indeed, atmospheric mercury deposition is the principal means by which mercury enters ecosystems that are not directly impacted by human activities such as mining. Because atmospheric deposition is the primary source of mercury to many ecosystems and in many geographic locations, long-term monitoring of deposition is critical to documenting how the mercury cycle varies across the globe and how it is changing over time.

Tracking atmospheric mercury deposition in precipitation, litterfall, and in dry forms provides important information about the success of polices designed to limit mercury emissions to the atmosphere such as the U.S. Clean Air Act or the Minamata Convention. Differences in atmospheric mercury deposition rates across geographic regions can also help explain mercury concentration patterns in soils, surface waters, and biota. Models that simulate the mercury cycle require measurements of atmospheric mercury deposition to make accurate predictions of how concentrations may change under different policies and as a result of future climate change. Networks such as NADP that promote long-term monitoring provide an opportunity to measure atmospheric mercury deposition at a location and to connect and compare that location with others throughout the nation and across the globe.

NADP/MDN station NY20, Huntington Wildlife Forest, NY
Photo: NADP

How does NADP monitor mercury?

The National Atmospheric Deposition Program operates three networks that monitor mercury. The Mercury Deposition Network (MDN) measures mercury in precipitation, the Atmospheric Mercury Network (AMNet) measures mercury in the atmosphere and the Mercury Litterfall Network measures mercury inputs to ecosystems from fallen leaves and other plant material.

The MDN measures total mercury concentrations in precipitation and precipitation amount, which allows calculation of wet deposition of mercury. The network began in 1996 and currently has ~85 sites throughout North America. A handful of sites also measure methylmercury, the form of mercury that accumulates in biota, and represents a small fraction of total mercury in precipitation. An MDN site consists of an approved precipitation collector and a weighing-bucket rain gage. The automated collector opens only during precipitation events and is designed specifically to preserve mercury. Using clean techniques, site operators collect samples every week and ship them to the Mercury Analytical Laboratory at the Wisconsin State Laboratory of Hygiene in Madison, Wisconsin. Standard operating procedures are followed in the field and the lab to ensure MDN data comparability and representativeness across the network.

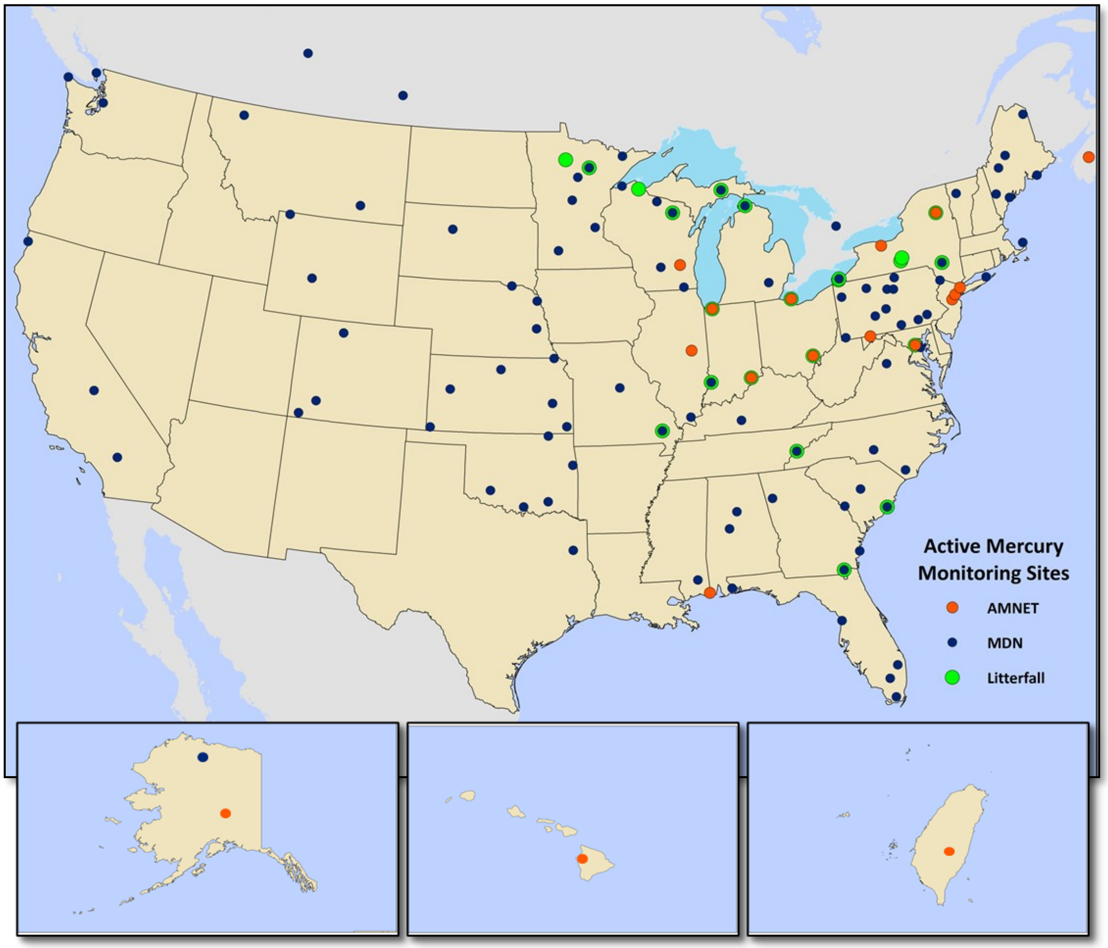
The AMNet measures atmospheric mercury fractions using automated, continuous measurement systems to understand their contribution to dry and total mercury deposition. Measurements are made following standardized methods, with quality-assured data archived in an online database. AMNet measurements are made continuously (five minute and two-hour averages). Data are qualified and averaged to one-hour (gaseous elemental mercury, GEM) and two-hour values (gaseous oxidized mercury, GOM, and particulate bound mercury, $PBM_{2.5}$).

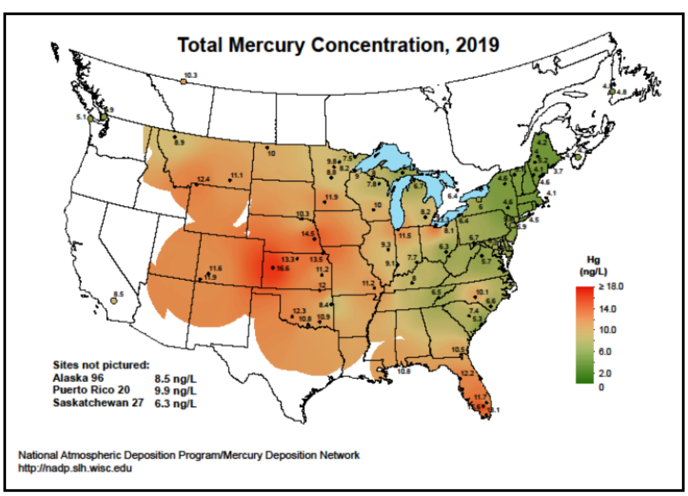
As a complement to MDN and AMNet, the Mercury Litterfall Network measures a substantial component of atmospheric mercury deposition to forested landscapes. Total mercury and methylmercury concentrations are determined in annual composite samples of litterfall from passive collectors in forest study plots, primarily near MDN and AMNet sites.

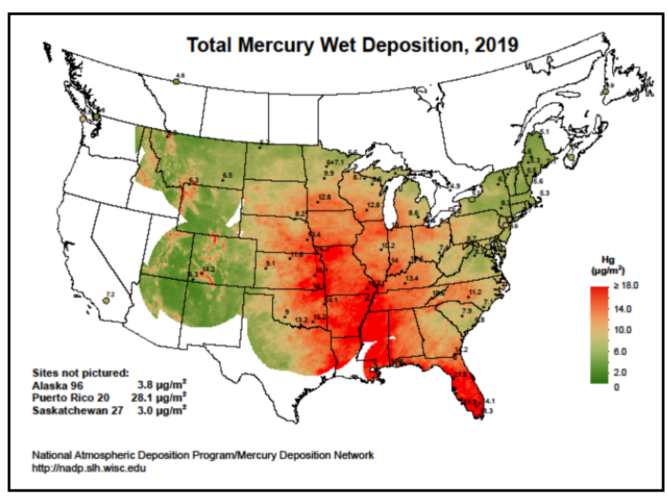
Data from these networks are used to assess (1) atmospheric inputs of mercury to sensitive aquatic and terrestrial ecosystems, (2) long-term trends of atmospheric mercury concentrations and deposition, (3) mercury emission reduction strategies, and to provide data for atmospheric mercury model development and validation. Data are available to download from the NADP website (http://nadp.slh.wisc.edu).

In addition, NADP's mercury science committee—MELD—provides an ongoing forum for the technical exchange of information and collaboration on issues relevant to the deposition of atmospheric mercury and its effects on the environment. MELD recently launched an effort to evaluate passive and low-cost active methods to measure atmospheric mercury concentrations in a network configuration. This has led to a new NADP initiative to establish a network of gaseous mercury measurements to address mercury data gaps in under-monitored areas, including in underserved communities impacted by mercury and other pollution. More information on MELD may be found at http://nadp.slh.wisc.edu/committees/meld/.

NADP Mercury Monitoring Networks







The spatial variability in precipitation-weighted mean concentration and wet deposition of total mercury across the U.S. in 2019.

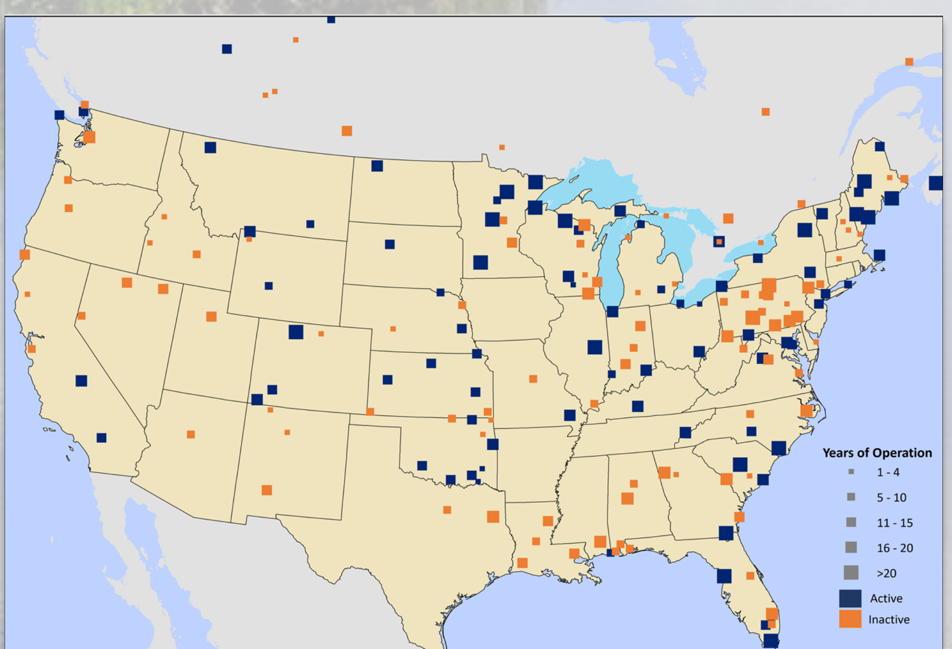
The importance of long-term mercury monitoring

Long-term environmental monitoring is critical to inform policy decisions and to track the effectiveness of pollution reduction strategies.

Long-term environmental monitoring serves an array of stakeholder interests. Environmental policy makers and natural resources managers in federal, state, local and tribal agencies need monitoring to design, implement, and evaluate effective policies and programs. Scientists need monitoring to better understand how pollutants like mercury move through ecological systems and impact the environment and public health; and the public needs monitoring to understand the state of our nation’s environment and natural resources.

To determine the effectiveness of environmental policy, environmental program implementation, or a natural resource management strategy, agencies must be able to track and assess environmental trends and conditions in response to actions. Accountability is a critical component in the implementation of environmental policy or natural resource management actions. The “chain of accountability” links information such as emission trends data with data from monitoring programs. Combining these links enables program implementers to determine whether actions translate into ecological response (e.g., changes in mercury deposition necessary to protect fish and other aquatic organisms) and enables assessment of the effectiveness of policies, programs, and management actions in meeting ecosystem protection goals.

However, while monitoring data demonstrate environmental response, program implementers and resource managers often have difficulty in assessing the implications of these trends. What do these trends imply for environmental protection? Are emission reductions sufficient? Answering such assessment questions constitute a critical role and opportunity for scientific inquiry and synthesis in the policy process. Equally important, policy and management actions provide an opportunity for exploring basic issues regarding the cycling and impact of mercury in the environment, such as increased understanding of ecological system response to changes in pollutant loading. At present, scientists must rely on limited information to understand and quantify the critical linkages between mercury emissions, environmental response, and potential human health concerns.   A comprehensive, long-term mercury monitoring program would contribute much needed information to address mercury problems in areas of the U.S. where insufficient knowledge currently exists.



The Longevity of NADP/MDN

MDN is a mature network made-up of long-term sites making it an important tool for assessing spatial and temporal trends. Of the active sites, 80% have been operating for 10 or more years and a quarter have been operating for 20 years.

Glossary

Artisanal and small-scale gold mining (ASGM)
A process in which miners add liquid elemental mercury to extract gold from soil or sediment.

Atmospheric deposition
The process whereby airborne particles and gases are deposited on the earth's surface by wet deposition (precipitation), dry deposition (processes such as settling, impaction, and adsorption), and litterfall (through plant material).

Bioaccumulation
The gradual accumulation of substances, such as pesticides, or other chemicals in an organism. Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost by catabolism and excretion.

Biomagnification

Increased concentration of mercury in the tissues of organisms at successively higher trophic levels of a food web.

Dry deposition
Atmospheric deposition that occurs when particles settle to a surface, collide with and attach to a surface, or when gases stick to a surface through adsorption.

Litterfall deposition

Atmospheric deposition that occurs when plant materials such as leaves, needles, twigs, and bark are deposited from vegetation to the earth's surface.

Mercury cycling
Transfer of mercury across environmental compartments such as the atmosphere, soils, water, sediment, and biota which may be accompanied by changes in the chemical form of mercury.

Mercury evasion
Gaseous mercury re-emitted to the atmosphere from the earth's surface.

Mercury speciation
Different chemical forms of mercury in air, soil, water, and biota, including elemental mercury (Hg^0), gaseous oxdized mercury (GOM), particulate mercury (PBM), and methylmercury ($MeHg^+$), that exhibit differing behavior in the environment.

Methylmercury (MeHg)
An organic compound of mercury, and typically used to identify a class of methylated compounds (including ionic methylmercury CH_3Hg^+, dimethylmercury, CH_3HgCH_3, ethyl methyl mercury $CH_3CH_2HgCH_3$, etc.).

Persistent, bioaccumulative, toxic substances (PBTs)
A class of compounds that have high resistance to degradation from abiotic and biotic factors, have high mobility in the environment, and have high toxicity to biological systems.

Total deposition
The total amount of a chemical constituent that is deposited to earth's surface via wet and dry deposition processes.

Wet deposition
Atmospheric deposition that occurs when rain, snow, or fog carries gases, particles and dissolved materials to the earth's surface.

Resources

The National Atmospheric Deposition Program (NADP) offers mercury data and other data products free of charge. Example NADP products include:

- MDN mercury precipitation concentration and wet deposition data and maps
- AMNet mercury air concentration data
- NTN precipitation chemistry data
- Color isopleth maps of precipitation concentrations and wet deposition
- Site photos and information
- Standard Operating Procedures (SOPs)
- Quality assurance data and other information

For more information, visit the NADP internet site at http://nadp.slh.wisc.edu or contact the NADP Program Office:

NADP Program Office

Wisconsin State Laboratory of Hygiene

465 Henry Mall

Madison Wisconsin 53706

E-mail: nadp@slh.wisc.edu

Other web resources

Asia Pacific Mercury Monitoring Network (APMMN): www.apmmn.org

Chesapeake Bay Program: www.chesapeakebay.net

Dragonfly Mercury Project: https://wim.usgs.gov/geonarrative/dmp/

Global Observation System for Mercury: http://www.gos4m.org/

Minamata Convention on Mercury: https://www.mercuryconvention.org/

National Atmospheric Deposition Program: nadp.slh.wisc.edu

National Oceanic and Atmospheric Administration AIRMoN Dry Deposition Program: http://www.atdd. noaa.gov/

National Park Service Air Resources Division: https://www.nps.gov/orgs/1971/index.htm

US Environmental Protection Agency Clean Air Status & Trends Network: www.epa.gov/castnet

US Environmental Protection Agency National Emissions Inventory: http://www3.epa.gov/ttn/chief/net/2011inventory.html

US Geological Survey Acid Rain, Atmospheric Deposition, and Precipitation Chemistry: https://www.usgs.gov/water-resources/national-water-quality-program/national-atmospheric-deposition-program-nadp

National Atmospheric Deposition Program

The NADP is the 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 non-governmental organizations, universities, local and state government agencies, State Agricultural Experiment Stations, national laboratories, Native American organizations, Canadian government agencies, the U.S. Geological Survey, the U.S. Environmental Protection Agency, the National Park Service, National Oceanic and Atmospheric Administration, the U.S. Fish & Wildlife Service, the Bureau of Land Management, the U.S. Department of Agriculture - Forest Service, and the U.S. Department of Agriculture - National Institute of Food and Agriculture under agreement no. 2018-39133-28690. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the program sponsors or the University of Wisconsin-Madison.

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