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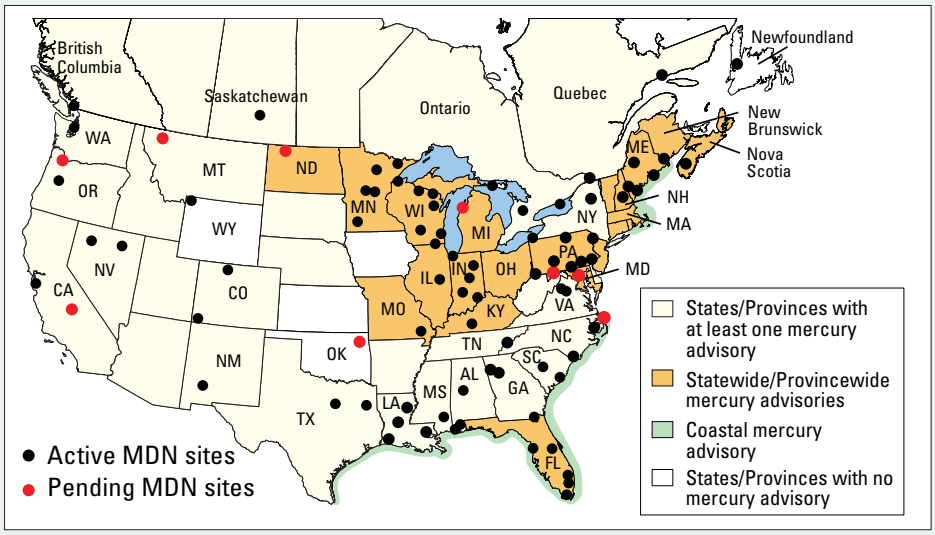
Expanding the Mercury Deposition Network in Virginia and the U.S. Mid-Atlantic Region

Mercury in the Environment

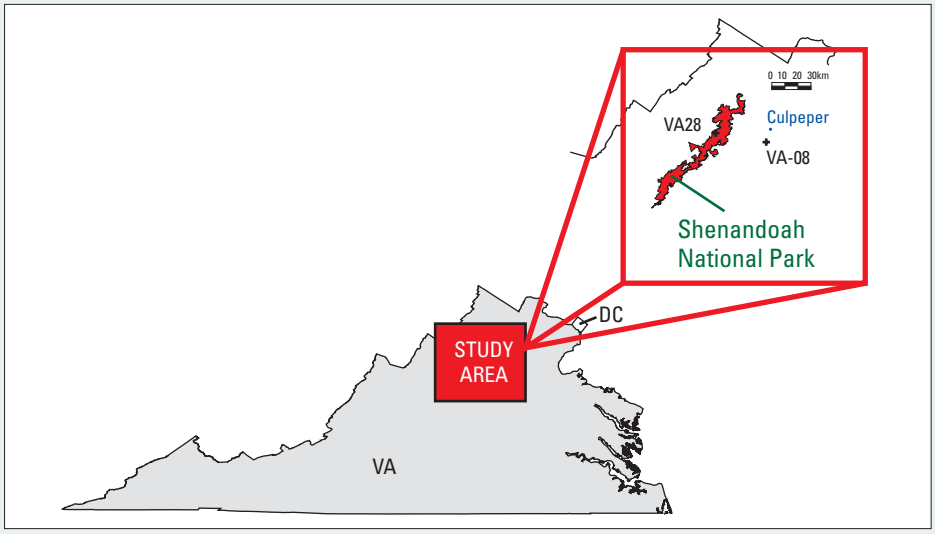
Mercury is a toxic metal having known detrimental health effects on the central nervous system. Mercury in the environment is derived from natural sources (such as volcanic eruptions) and from human activities (such as combustion of fossil fuels, metal processing, and some mining activities). Mercury added to the atmosphere by these sources may circulate globally or may be deposited locally, depending on its chemical form. Levels of mercury present in the air and in precipitation (rain and snow) generally do not pose a direct threat to humans; however, mercury derived from the atmosphere is thought to be a primary source of mercury in fish. Fish consumption is the main avenue for human exposure to mercury in the United States, and fish consumption advisories for mercury now account for more than three-quarters of all State fish consumption advisories (fig. 1).

Monitoring atmospheric mercury deposition provides estimates of the amount of mercury added to lakes, rivers, estuaries, and wetlands. In an aquatic environment, a portion of the mercury may be converted by bacteria to organic forms (for example, methylmercury) that can be taken up by organisms.



A

Figure 1*A*. Map showing distribution of operating Mercury Deposition Network (MDN) stations, pending sites, and fish consumption advisories as of 2003. Prior to 2003, there were no operating MDN sites in Delaware, Maryland, Virginia, or West Virginia. Map compiled by National Atmospheric Deposition Program - Mercury Deposition Network (http://nadp.sws.uiuc.edu/mdn), with data from U.S. Environmental Protection Agency National Listing of Fish and Wildlife Advisories (http://oaspub.epa.gov/nlfwa/nlfwa.bld_qry?p_type=advmap&p_loc=on).



B

Figure 1*B*. Location map showing the sites of MDN stations in northern Virginia. Stations VA–08, near Culpeper (latitude 38.42; longitude –78.10), and VA–28, at Big Meadows (latitude 38.52; longitude –78.44), are about 100 and 130 kilometers southwest of Washington, D.C., respectively.

Figure 2. Views of MDN sites VA–08 , Culpeper (top), and VA–28, Shenandoah National Park-Big Meadows (bottom). Each station consists of a recording rain gauge (cylinders) and a precipitation collector (boxes). Mercury sample is collected through a glass funnel exposed when a moisture sensor activates the lid covering the sample chimneys at the left side of the collector. Top photograph by Allan Kolker, USGS; bottom photograph from National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=MDN&id=VA28).

Levels of methylmercury in the tissues of organisms increase upward in the food chain; that is, there are higher concentrations at increasingly higher levels in the chain. This bioaccumulation poses a potential hazard to humans and long-lived wildlife.

The Mercury Deposition Network

The Mercury Deposition Network (MDN) of the National Atmospheric Deposition Program (NADP) was started in the mid-1990s to meet the need for information on rates of mercury deposition from precipitation in North America (information on the NADP is available on the Web at http://nadp.sws.uiuc.edu). The goal of the MDN is to develop a national database of weekly mercury data to determine spatial and seasonal trends in mercury wet deposition (that is, mercury deposited from the atmosphere via rain, sleet, and snow). Mercury deposition under dry conditions, which accounts for a portion of the mercury deposited from the atmosphere, is not measured by the MDN. Most MDN stations are in the eastern third of the United States, where predicted levels of mercury deposition are greatest due to prevailing weather conditions and the number of coal-fired power-generating stations, a significant source of atmospheric mercury, in the Midwest, the mid-Atlantic States, and the Southeast.

The MDN in the U.S. Mid-Atlantic Region

In autumn 2002, two MDN stations began operation in Virginia (fig. 1), helping to fill a significant gap in the network in the mid-Atlantic region. Station VA–08, located southwest of Culpeper, Va., at an elevation of 163 meters, is operated jointly by the U.S. Geological Survey and George Mason University (fig. 2). Station VA–28, located at Big Meadows in Shenandoah National Park, at an elevation of 1,074 meters, is operated by the National Park Service. These sites greatly improve MDN coverage immediately west of the Washington, D.C., metropolitan area. The proximity of the Culpeper and Big Meadows sites

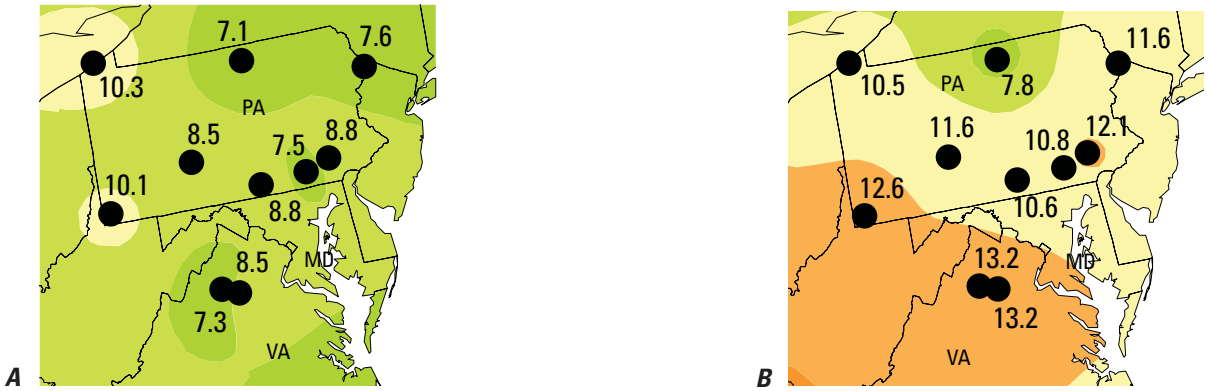


Figure 3. MDN results for 2003 for U.S. mid-Atlantic stations (black dots), including two stations in Virginia. *A*, Average yearly mercury concentration, weighted by volume, in nanograms per liter (1 nanogram equals 10^{-9} grams). *B*, Total mercury deposition for the year, in micrograms per square meter. Each site also showed seasonal variation in mercury concentrations, with the highest values occurring in the summer months. Variation in total mercury deposition mainly reflects differences in precipitation for the year. Color bands indicate contoured 2003 results. Maps from National Atmospheric Deposition Program - Mercury Deposition Network (http://nadp.sws.uiuc.edu/mdn/).

Figure 4. Satellite view of Hurricane Isabel, September 18, 2003, 11:50 a.m. From NASA Terra satellite, http://science.nasa.gov/headlines/y2003/18sep_isabel.htm.

to each other (31 kilometers) is among the closest in the MDN, allowing comparisons of local mercury deposition at different elevations. Station VA–28 is also used to monitor potential mercury exposure by wildlife in Shenandoah National Park.

Annual MDN results for 2003 (fig. 3) showed a gradual southward increase in mercury deposition across the mid-Atlantic region. These results are consistent with the high levels of mercury deposition that occur in the southeastern States. A longer period of observation, however, is needed to assess nationwide patterns and differences among MDN sites in the region.

Most MDN sites also show seasonal variations, with increases in mercury concentration and total deposition in the warm weather months. For the year 2003, mercury concentrations were higher at Culpeper (lower elevation) than at Big Meadows (higher elevation). Because precipitation was greater at Big Meadows, however, total mercury deposition at both sites was nearly the same. Additional yearly results will soon be available as data for 2004 and for three new MDN stations in Virginia and Maryland—VA–98 (Harcum; lower Chesapeake Bay), MD–08 (Piney Reservoir; Garrett County, western Maryland), and MD–99 (Beltsville; suburban Washington, D.C.)—are finalized.

Generally, weekly MDN samples cannot be linked to specific weather events. For samples taken the week ending September 22, 2003, however, most mid-Atlantic MDN sites showed unusually low mercury concentrations. These samples consisted predominantly of precipitation from Hurricane Isabel, which came ashore along the North Carolina coast and followed a path northward through the region (figs. 4, 5). Mercury concentrations in precipitation from Hurricane Isabel were much below average for that time of year (fig. 6), consistent with the depletion of mercury from the atmosphere by the heavy rain and the origin of the storm far from anthropogenic mercury sources.

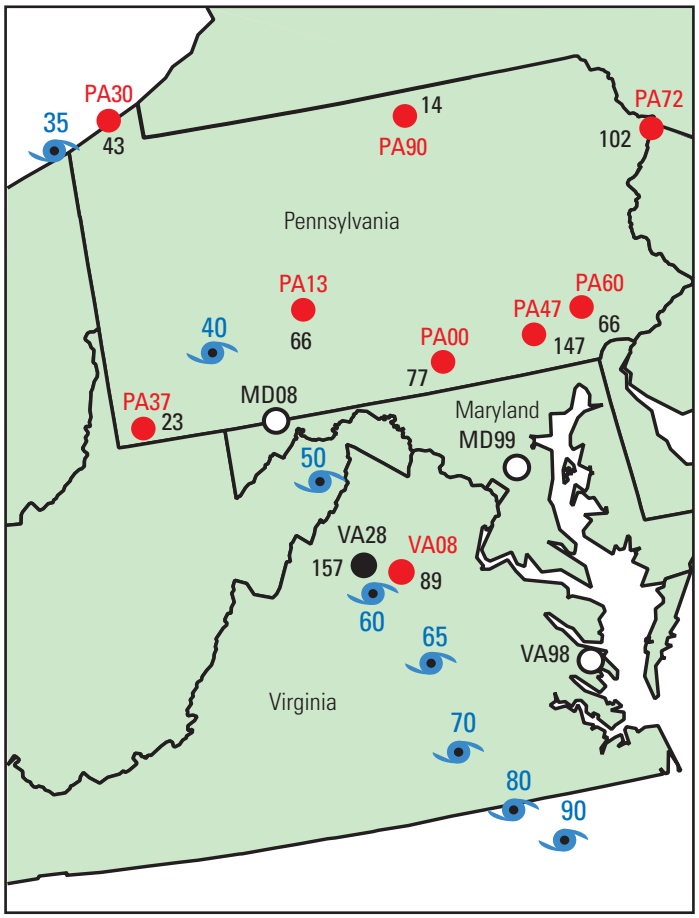


Figure 5. Map showing locations of U.S. mid-Atlantic MDN sites active in 2003 (solid symbols) and sites used to calculate average mercury concentrations (red symbols; see fig. 6 for concentration data) for the weeks leading up to and following Hurricane Isabel (September 18–19, 2003). Precipitation amounts (black numbers; in centimeters) are shown for the week ending September 23, 2003, as are the path (hurricane symbols) and wind speed (blue numbers; in mph) of the hurricane. Open symbols indicate MDN sites added after September 2003. Black symbol for MDN site VA–28 indicates that this site was excluded from the mercury concentration averages shown in figure 6 due to loss of power, which resulted in shutdown of the station during the hurricane. Storm track for Hurricane Isabel is plotted from information available at http://hurricane.csc.noaa.gov/hurricanes/. Modified from Kolker, Allan, Mose, D.G., and Spitzer, Shane, 2004, Filling a gap: MDN stations VA–08 (Culpeper) and VA–28 (Shenandoah National Park–Big Meadows) in Virginia [abs.]: National Atmospheric Deposition Program (NADP), 2004 Scientific Symposium, Halifax, Nova Scotia, Canada, 2004.

The Need for Measuring Mercury Deposition

Recent work (for example, see http://www.umanitoba.ca/institutes/fisheries/METAALICUS.html) suggests that new mercury added to the environment by atmospheric deposition is more prone to become methylmercury than mercury already present in sediments. It is therefore very important to quantify

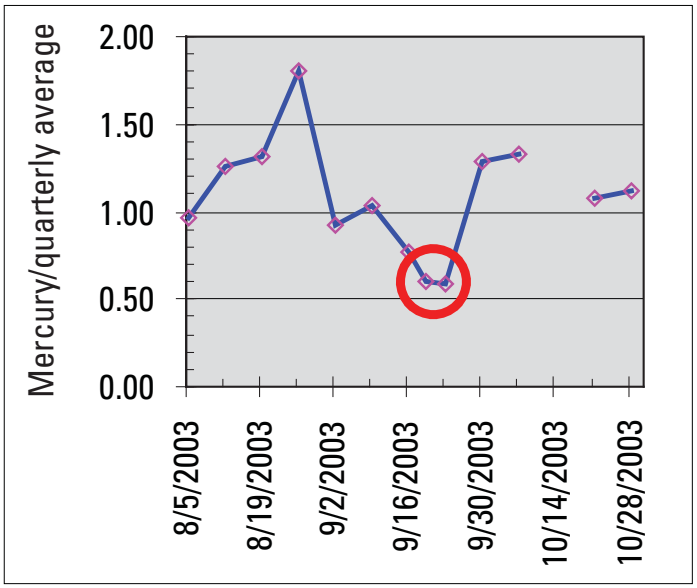


Figure 6. Mercury concentration averages of nine U.S. mid-Atlantic MDN stations affected by Hurricane Isabel, normalized to quarterly averages for the respective stations for the period shown. Plot shows a pronounced mercury concentration low for the first samples taken after the hurricane (red circle). Results for site VA–28 (Shenandoah National Park) are excluded due to site operation problems resulting from the hurricane. Modified from Kolker, Allan, Mose, D.G., and Spitzer, Shane, 2004, Filling a gap: MDN stations VA–08 (Culpeper) and VA–28 (Shenandoah National Park–Big Meadows) in Virginia [abs.]: National Atmospheric Deposition Program (NADP), 2004 Scientific Symposium, Halifax, Nova Scotia, Canada, 2004.

the amount of mercury deposited each year from atmospheric sources.

Currently, coal-fired powerplants are the largest industrial source of U.S. mercury emissions. The U.S. Environmental Protection Agency (USEPA) has approved a long-term plan to cap and reduce mercury emissions from coal-fired power-generating stations (see http://www.epa.gov/oar/mercuryrule/ for information on the USEPA Clear Air Mercury Rule). The MDN will be a primary tool for measuring the overall effectiveness of the new mercury rule. For example, the growth of the MDN has led to an increased ability to map regional patterns of mercury deposition. Documenting these patterns will help establish baseline mercury levels prior to the implementation of the USEPA plan.

The impact of the USEPA plan should be greatest in the eastern third of the United States, where the levels of mercury deposition are highest. A similar plan to limit emissions of sulfur dioxide resulted in a large decrease in deposition of sulfate (the main component of acid rain) in the East in the last decade.

Summary

The addition of new MDN stations in the mid-Atlantic region has greatly improved the ability to assess the impact of reduced mercury emissions from coal-fired powerplants in the region and in neighboring States. As the density of MDN stations increases, the network will also become more effective in defining local variations and improving yearly estimates of mercury deposited from the atmosphere to ecosystems in different regions.

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Additional Resources

Shenandoah National Park Air Monitoring Program
http://www.nps.gov/shen/SHEN_IM/m_prog_air.htm

National Park Service, Center for Urban Ecology,
Air Resources Page
http://www.nps.gov/cue/programs/air/air_resources.htm

USGS Mercury Research
http://minerals.usgs.gov/mercury/

Fish and wildlife studies, methylation, and mercury in plants and/or organisms
http://co.water.usgs.gov/trace/

Mercury cycling in watersheds and aquatic ecosystems
http://toxics.usgs.gov/about.html