Mercury Emissions

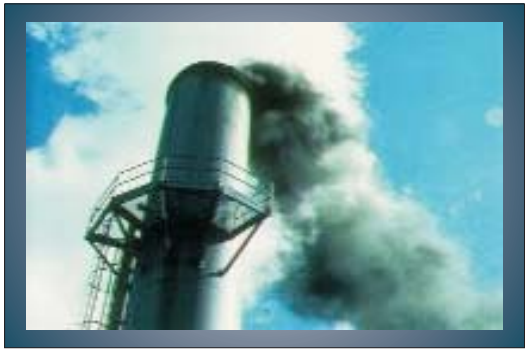
Background

Mercury is a volatile heavy metal that is toxic to humans at relatively low levels. Exposure to mercury can be due to acute and/or chronic inhalation of its toxic vapors, but more commonly comes from eating contaminated fish. Children and pregnant women are especially susceptible to health threats caused by mercury contamination, and exposure to even relatively low levels can cause permanent brain damage to the fetus, infants and young children. Fish become contaminated with mercury when it is deposited directly or indirectly into the water. Once in an aquatic ecosystem, mercury accumulates in the tissues of organisms (i.e., bioaccumulates) as methylmercury, a toxic and harmful form of mercury. Mercury-contaminated fish have been found in remote areas of the State, such as the Pinelands, as well as in industrialized areas (see "Fish Contamination" in this Environmental Trends series.) Studies have shown that reducing mercury emissions can significantly reduce contamination in nearby aquatic ecosystems.[1,2]

Sources of mercury contamination in waterbodies include air pollution that deposits mercury directly to the water (i.e., air deposition), stormwater runoff from land surfaces (which contains mercury from air deposition), and from other direct inputs to waters such as point source discharges. Mercury falls to the land in precipitation ("wet deposition") and also attached to particles and in a gaseous form that becomes adsorbed to land surfaces and foliage ("dry deposition").

New Jersey is one of 50 states that have issued consumption advisories for certain species of fish known to be contaminated with mercury. A small but significant fraction of the pregnant population already exhibits elevated levels of methylmercury in their system most likely caused by eating fish contaminated with mercury. A New Jersey study found that 13% of pregnant women tested had levels above 1 ppm (detected in hair), which is considered evidence of exposure to an unsafe level of mercury.[3]

Much of the mercury contamination in New Jersey is caused by air emissions from long-range sources, such as coal-burning power plants in China, as well as regional and local sources, such as coal-burning power plants in central and western U.S. and in-state power plants, incinerators, and industrial facilities. Mercury is also released to the air and to other media from mercury-containing waste sites, although this contribution has not been quantified. The DEP has been working to better understand the impacts of mercury exposure on human health and the environment in New Jersey, and also to better quantify and control mercury emissions. These efforts began in the early 1990s with the establishment of the first Mercury Task Force, which identified municipal solid waste (MSW) incineration as a major source of mercury air emissions and recommended stringent controls. These controls were adopted by New Jersey in 1993, reducing mercury emissions from incinerators by more than 90 percent, and were considered a model for other states and the federal government. A second Mercury Task Force was convened in 1997 with the objectives of clarifying the impacts of mercury on the State, identifying additional significant sources of mercury contamination of New Jersey's environment, and recommending control and management approaches. The second Task Force developed an extensive body of information on sources of mercury, adverse impacts of mercury contamination and various control strategies, and published its final reports in January 2002.[4] In the years since the Task Force recommendations, the DEP has taken a number of steps to further reduce mercury releases to the environment. These include:



- On July 14, 2006, DEP adopted new rules that require further reductions in mercury emissions from certain facilities.[5] The rules called for up to a 90 percent reduction by 2008 of mercury emissions from the State's 10 coal-fired boilers in power plants. The rules also required New Jersey's five MSW incinerators to reduce mercury emissions at least 95 percent below 1990 levels by January 3, 2012. The new rules also mandated a reduction of mercury emissions by 75 percent by 2010 from the State's iron and steel plants.

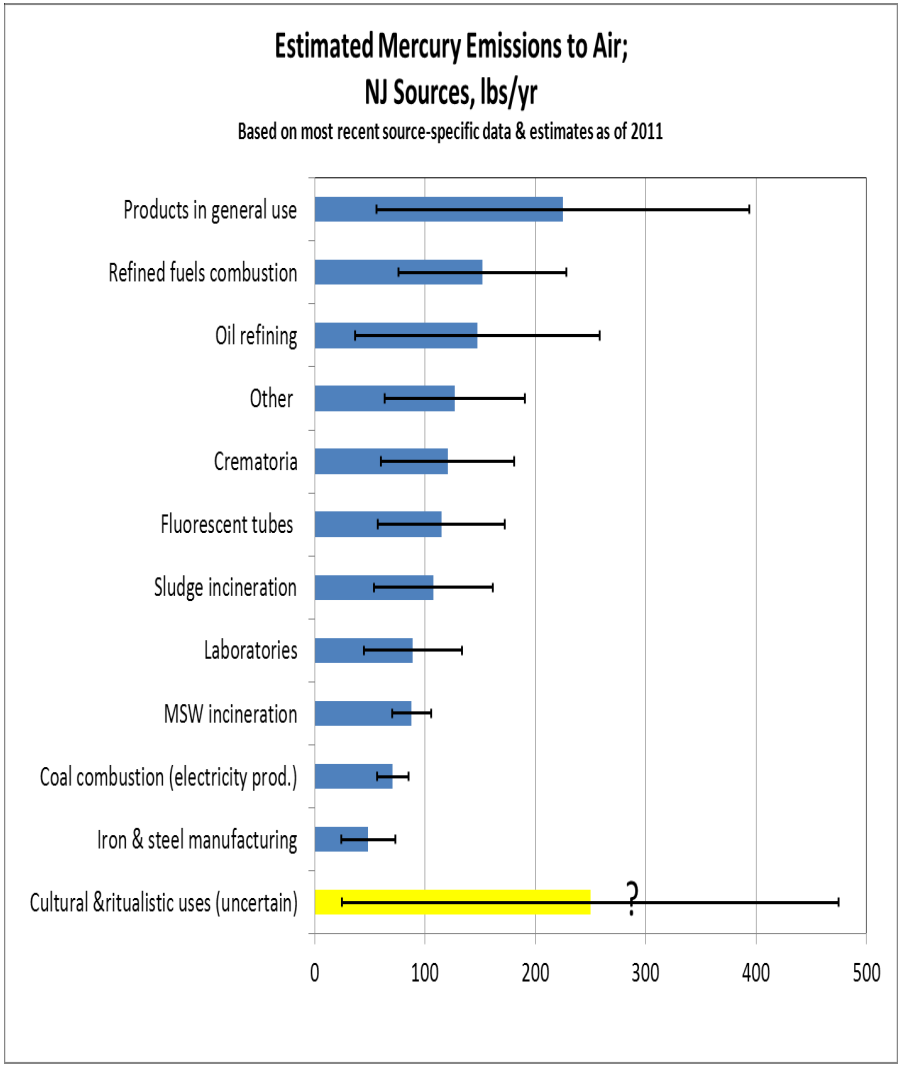
- On October 1, 2007, DEP adopted the Dental Amalgam rules, and also finalized a NJPDES Discharge to Ground Water General Permit for dental facilities that discharge to on-site septic systems. The new rules and permit were expected to significantly reduce the amount of mercury discharged to wastewater treatment plants.[6]

- In March 2005, the Mercury Switch Removal Act of 2005,[7] became effective in New Jersey. This law requires automobile manufacturers to develop and fund a plan to remove mercury switches from end-of-life vehicles and requires all scrap yards and automobile dismantlers to remove mercury switches from end-of-life vehicles before sending the auto scrap metal to iron and steel mills. The mercury would otherwise be released into the air when the vehicles are melted down and recycled. Pursuant to this law, collection of mercury switches from end-of-life vehicles is now underway. Status reports of New Jersey collection efforts, as well as those of other states, are available on-line.[8]

- The Department has developed statewide Total Maximum Daily Loads (TMDLs) for impaired watersheds where mercury fish tissue concentrations are likely to be influenced by mercury from air deposition. The TMDL was approved by the United States Environmental Protection Agency (EPA) on September 25, 2009, and was adopted into New Jersey's Water Quality Management Plans statewide in June 2010. The TMDL modeling indicates that to achieve TMDL targets, virtually all anthropogenic sources of mercury contamination must be eliminated. In addition, it shows that only 12.5% of the mercury contamination from air deposition originates from New Jersey sources. The TMDL document is available online.[9]

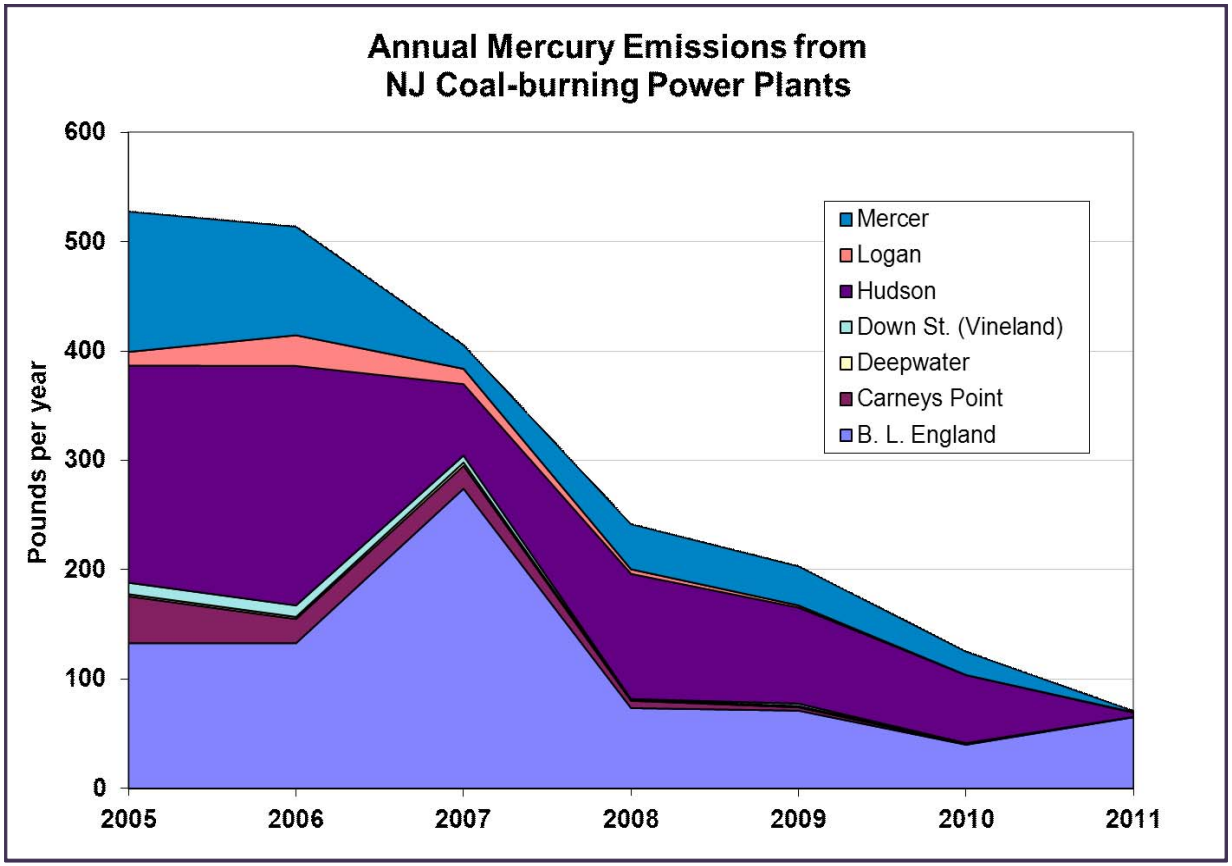
Status and Trends

The various recent actions to reduce mercury emissions at the federal and state level, especially the new DEP rules noted above, have led to dramatic mercury emissions reductions from New Jersey sources. As recently as 2006, reasonably well-characterized New Jersey air emissions sources were estimated to release a total of approximately 2600 pounds per year to the air. As of 2011, this quantity is estimated to have dropped to less than 1600 pounds per year. See the table "Estimated Mercury Emissions to Air; NJ Sources."

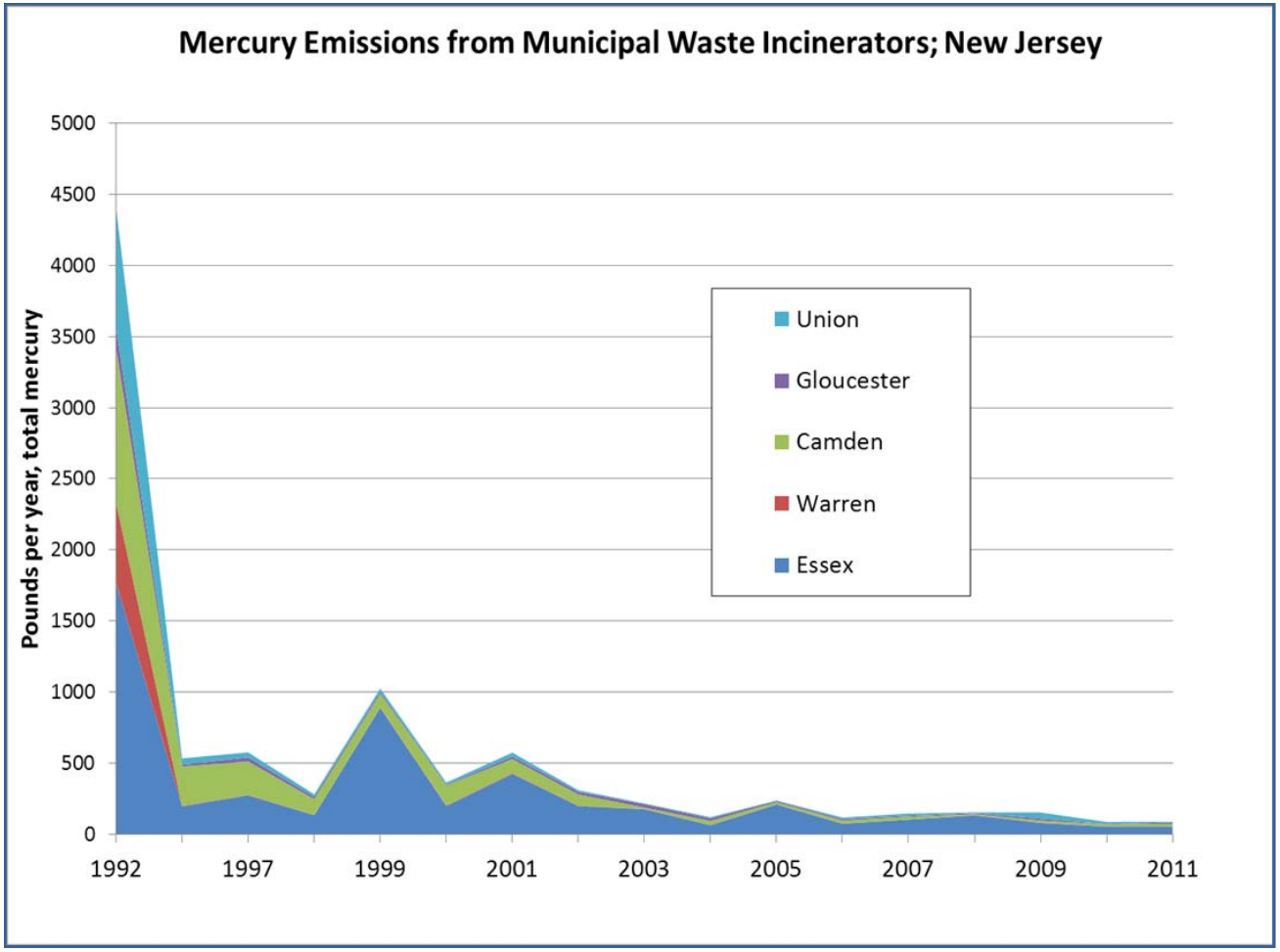


The reduction in emissions from the iron and steel manufacturing sector is dramatic. A portion of this reduction has been caused by the closing of four of the six plants. The removal of mercury-containing switches from end-of-life automobiles through the implementation of the Mercury Switch Removal Act (as noted above) has contributed. However, by far the biggest portion of the reduction is due to the success of emissions control technology using activated carbon. Through the use of this method, the emissions of one plant, Gerdau Ameristeel in Sayreville, have gone from over 900 pounds per year in 2005 to approximately 50 pounds per year in 2011. The other currently operating plant in New Jersey, Atlantic States Iron Pipe Co., of Phillipsburg, has reduced its mercury emissions from approximately 80 pounds per year in 2005 to about a pound per year in recent years.

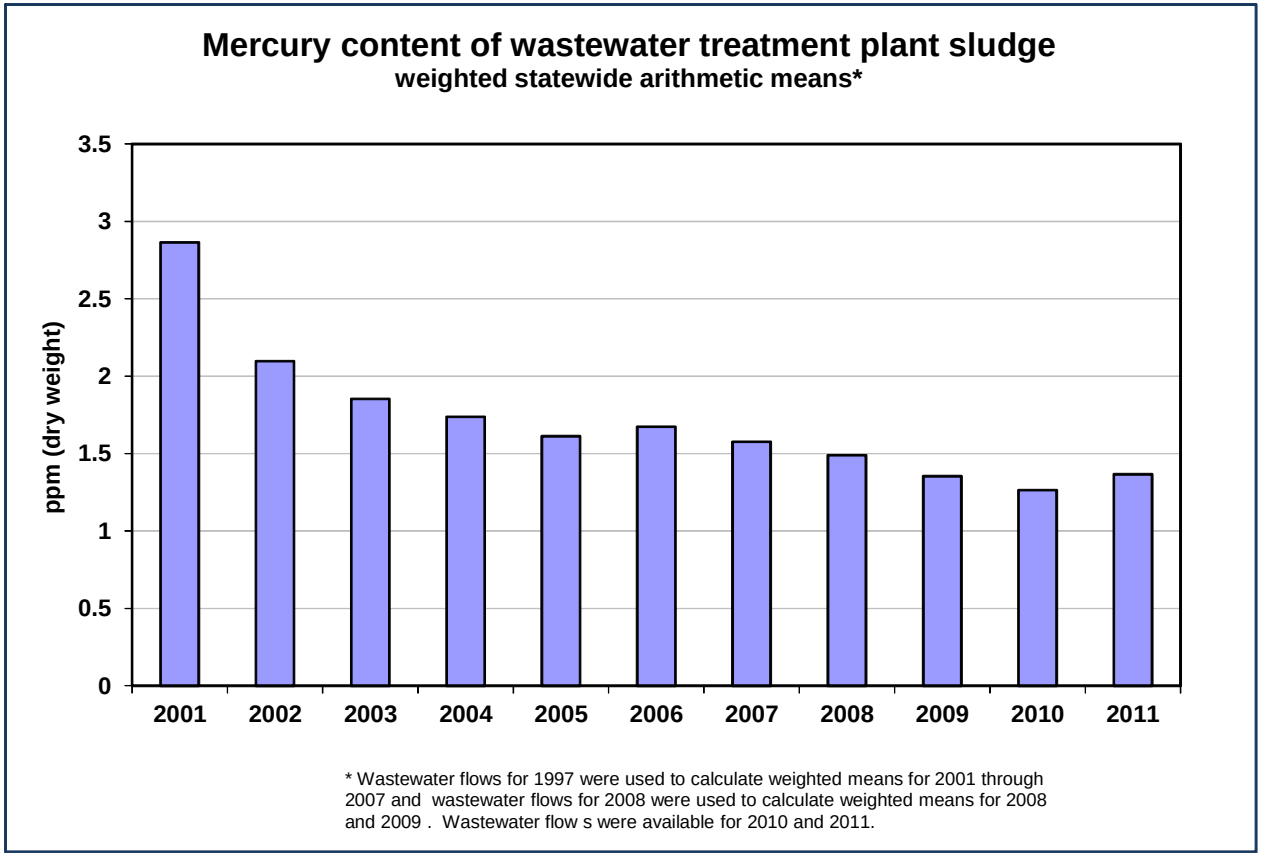
Coal-burning electricity-generating plants have also shown significant reductions through the use of stack controls using activated carbon, reducing their overall emissions from over 500 pounds per year in 2005 to less than 100 pounds per year in 2011. See the chart "Annual Mercury Emissions from NJ Coal-burning Power Plants."



The MSW incineration sector, which released over 4000 pounds of mercury to the air per year in the early 1990s, achieved major reductions by the mid-1990s also through the use of carbon injection emissions control, as well as through the removal of mercury from products such as dry cell batteries. This sector's total releases in 2011 were less than 100 pounds per year. See the chart "Mercury Emissions from Municipal Waste Incinerators; New Jersey."


Mercury Emissions from Municipal Waste Incinerators; New Jersey
Pounds per year, total mercury
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1992
1997
1999
2001
2003
2005
2007
2009
2011
Union
Gloucester
Camden
Warren
Essex

Mercury concentrations are also declining in sludge from wastewater treatment plants (see the chart "Mercury content of wastewater treatment plant sludge").[10]

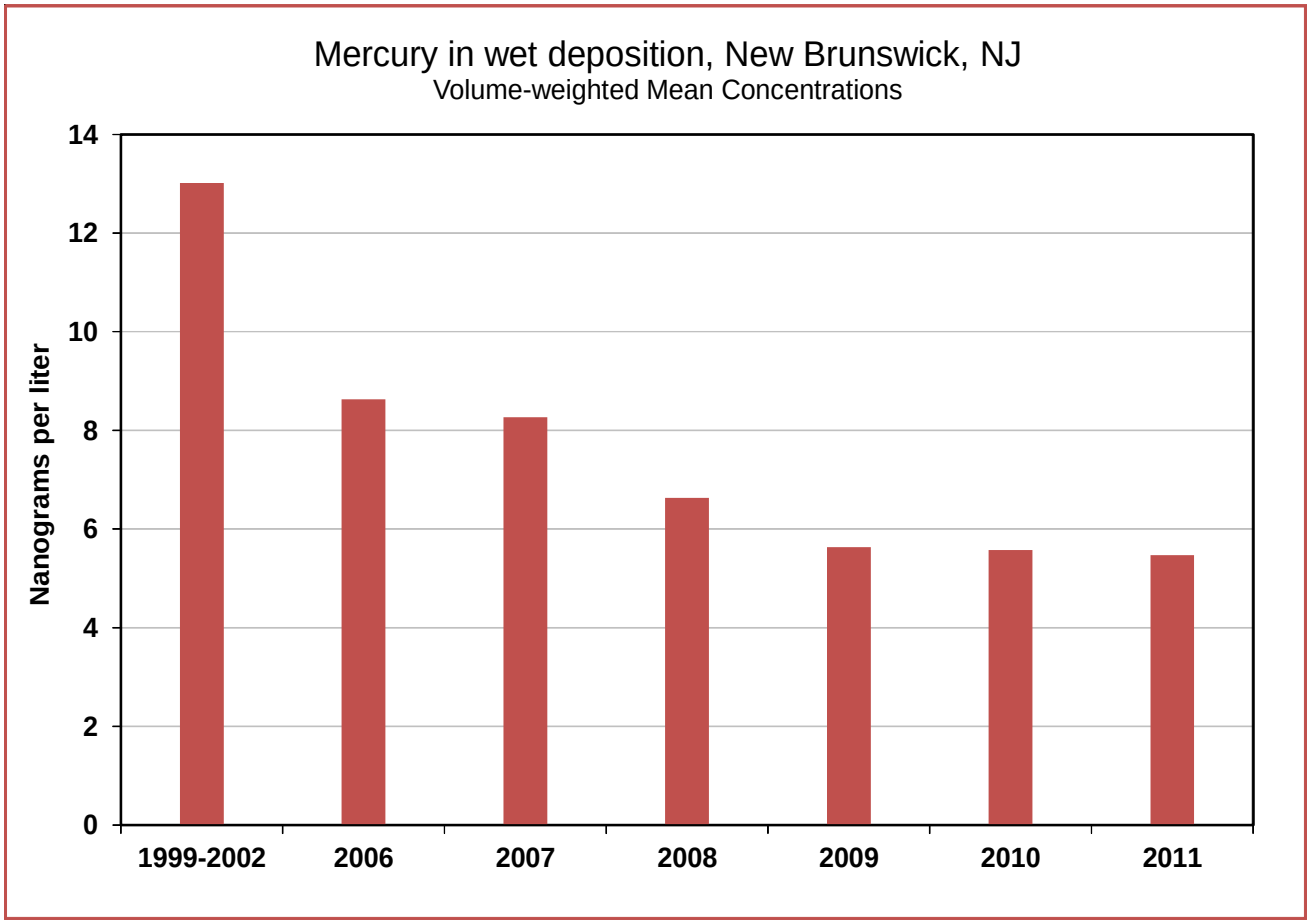


As noted above, on October 1, 2007, DEP adopted the Dental Amalgam rules, and also finalized a NJPDES Discharge to Ground Water General Permit for dental facilities that discharge to on-site septic systems. The new rules, under most circumstances, exempt a dental facility from the requirement to obtain an individual permit for its discharge to a Publicly Owned Treatment Works (POTW), if it implements best management practices (BMPs) for the handling of dental amalgam waste and installs and properly operates an amalgam separator. Dental facilities were required to implement the BMPs by October 1, 2008, and install and operate an amalgam separator by October 1, 2009.

DEP now also requires certain wastewater dischargers to report their effluent mercury concentrations. Ninety-three POTWs in New Jersey submitted baseline data on mercury concentrations in their treatment plant effluent. These samples were analyzed using the most sensitive analytical method for mercury in wastewater, Method 1631E. This baseline data will be used to determine the effectiveness of the implementation of the dental BMPs and the installation of the amalgam separators. These POTWs were required to conduct additional mercury sampling and analyses, using the same analytical method, from February 1, 2011 to July 31, 2011. These reported measurements indicate that the mercury concentration in effluent is now lower than in previous years, and has declined significantly in the last three years. In 2008 the mean statewide concentration was 9.3 ± 1.8 ng/l. By 2011, based on comparison of data from facilities that reported for both periods, the mean effluent mercury concentration had declined to 6.6 ±1.4 ng/l. The change, based on a Wilcoxon matched-pairs signed-ranks test, is extremely significant, with a one-tailed P value less than 0.0001.

Since most of the human exposure to mercury is from eating fish, it is important to estimate the primary sources of mercury contamination of waterbodies. Mercury enters the aquatic ecosystem through direct deposition from air, point source discharges of wastewater and stormwater, and indirectly from air deposition through overland flow of stormwater runoff into receiving waters. The second New Jersey Mercury Task Force reviewed data obtained through the NJ Atmospheric Deposition Network, which indicated that the

mean wet deposition mercury concentration in the State was about 12 ng/l.[11] Based on this, and the assumption that a similar or somewhat smaller quantity falls as dry deposition, the second Task Force estimated that a total of approximately 1100 pounds (500 kg) of mercury falls on the State in wet and dry deposition. More recent data collected at a new national Mercury Deposition Network site[12] funded by the DEP, show that wet deposition has been declining, and is now in the range of 6 ng/l. See the chart "Mercury in wet deposition, New Brunswick, NJ."



Most mercury entering the NJ environment via atmospheric deposition appears to become bound to soils. Recent sampling by DEP and the U.S. Geological Survey (USGS) suggests that the mean concentration in surface waters in upstream locations is in the range of 1 to 2 ng/l, and is somewhat higher in more downstream locations. A comparison of this quantity with the wet deposition and inferred dry deposition quantity noted above suggests that much of the mercury that is deposited on land remains sequestered in soils. Concentrations of dissolved mercury, and the amount of mercury adsorbed to particles, both appear to be higher during high flow conditions, suggesting that storm events lead to higher mercury inputs to waterbodies.

Outlook and Implications

The DEP has drafted a Mercury Reduction Action Plan that suggests ways to make additional progress in controlling mercury, and is considering how best to implement the Plan or portions thereof. The Plan can be accessed at http://www.state.nj.us/dep/dsr/.

The DEP continues to promote awareness of the risks of mercury through fish advisories and other outreach efforts, such as the "Fish Smart Eat Smart NJ" (FishSmartEatSmartNJ.org) educational campaign,[13] and continues to support mercury research. The DEP expects to continue tracking reductions in mercury releases and discharges and to report reductions in levels of mercury in the environment.

More Information

A variety of mercury-related information is available at the DEP's mercury web site, www.state.nj.us/dep/dsr/mercury/. The second Mercury Task Force report can be found at www.state.nj.us/dep/dsr/mercury_task_force.htm.

References

[1] Atkeson, Thomas D., Curtis D. Pollman and Donald M. Axelrad. 2005. Recent trends in mercury emissions, deposition, and biota in the Florida Everglades: a monitoring and modeling analysis. In: *Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes, Human Exposure Around the World*, N. Pirrone and K. Mahaffey (Editors), Springer Publisher, Norwell, MA, USA. Chapter-26, pp. 637-656.

[2] MADEP (Massachusetts Department of Environmental Protection), 2006, Massachusetts Fish Tissue Mercury Studies: Long-Term Monitoring Results, 1999-2004. Office of Research and Standards, Boston, MA.

[3] Stern, Alan, Michael Gochfeld, Clifford Weisel, and Joanna Burger, 2001, Mecury and Methylmercury Exposure in the New Jersey Pregnant Population, *Archives of Environmental Health, 56*, pp. 4-10.

[4] DEP, 2002, New Jersey Mercury Task Force, Volumes I, II, and III, http://www.nj.gov/dep/dsr/mercury_task_force.htm

[5] N.J.A.C. Subchapter 27. Control and Prohibition of Mercury Emissions, http://www.nj.gov/dep/aqm/Sub27.doc

[6] The new regulations were published in the October 1, 2007 *New Jersey Register* at 39 N.J.R. 4117(a) and can be found under N.J.A.C. 7:14A-21.12. See http://www.nj.gov/dep/dwq/Dental_Amalgam_Overview.htm

[7] P.L. 2005, c.054 (A2482 1R), available at http://www.njleg.state.nj.us/2004/Bills/PL05/54_.HTM

[8] See http://www.eqonline.com/services/elvs-mercury-switch-recovery-program.asp

[9] See http://www.nj.gov/dep/watershedmgt/DOCS/TMDL/tmdl_mercury_061509.pdf

[10] Data on mercury content of sludge were analyzed by finding mean sludge concentration for sludge reported by each facility, weighting that concentration by the flow of that facility, and then determining statewide weighted average.

[11] New Jersey Atmospheric Deposition Network (NJADN) Final Report, 2005, http://www.state.nj.us/dep/dsr/njadn/

[12] See the National Mercury Deposition Network website at http://nadp.sws.uiuc.edu/mdn/

[13] See Fish Smart Eat Smart NJ educational campaign information at http://www.state.nj.us/dep/dsr/njmainfish.htm