Division of Science, Research and Technology

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Research Project Summary

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Assessment of Historical and Current Trends in Mercury Deposition to New Jersey Aquatic Systems through Analysis of Sediment/Soil Cores - YEAR 2

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Abstract

Atmospheric deposition is an important source of mercury (Hg) to aquatic and terrestrial ecosystems and has global, regional, and local components. Deposition of mercury to waterbodies in New Jersey has resulted in elevated levels of mercury in fish across the state. Several recent studies have found elevated levels of mercury in fish sampled from many freshwater bodies including pristine lakes in remote areas. Results from the first year study showed that mercury fluxes (i.e., deposition rate) were comparable to fluxes in other parts of New Jersey and to regional atmospheric fluxes to the Great Lakes. However, the first year of this study identified Woodcliff Lake as a site of elevated mercury levels in sediments. This follow-up study included the collection of sediment cores across three sites in northeastern New Jersey to assess the importance of local sources of atmospheric mercury deposition to Woodcliff Lake and surrounding areas. The three sites sampled defined a transect across northern New Jersey between Woodcliff Lake and Mountain Lake. In addition, data from archived sediment cores at three additional sites in northern New Jersey were analyzed. The new sites were located west (upwind of Mountain Lake) of Woodcliff Lake and bracketed two possible atmospheric mercury sources related to the use of mercury fulminate in explosives, the DuPont facility in Pompton Lakes and the US Army Armament Research Development and Engineering Center in Rockaway. Dating information was obtained through radionuclide analysis of core sections. Our results indicate that on a scale of tens of kilometers, atmospheric deposition of mercury to most of northern New Jersey is comparable to other parts of the state. Possible sources of the elevated mercury fluxes to Woodcliff Lake are limited to direct inputs and local atmospheric sources.

Introduction

Consistent observations of elevated mercury concentrations in freshwater fish in all areas of New Jersey have raised questions about the sources of mercury entering aquatic systems and aquatic food chains in New Jersey. Mercury depositing in New Jersey waterbodies could originate from global sources, large-scale regional sources and/or local sources, including in-state sources. The first year of this study was designed to examine whether historic mercury deposition rates (fluxes) to waterbodies in different parts of New Jersey are different. Such differences could imply impacts from relatively local sources. The first year study utilized sediment cores collected at six sites throughout the state between September 2000 and December 2001 (Woodcliff Lake, Wawayanda Lake, Mountain Lake, Imlaystown Lake, Parvin Lake and Tuckerton marsh core). The results in NJ lakes were generally comparable to each other and to recent mercury fluxes in the Great Lakes area suggesting a large-scale regional influence (Kroenke 2003; Kroenke et al. 2002). However, the Woodcliff Lake site in northeastern NJ, had particularly elevated fluxes of mercury similar to Central Park Lake, in nearby New York City, thus raising the possibility of a local mercury source impacting a relatively large area of northeastern New Jersey. The follow-up study was conducted in lakes in northeastern New Jersey to define the potential distance scale of atmospheric sources of mercury deposition to Woodcliff Lake, and to assess the importance of two particular suspected sources.

Methods

The research approach taken in this study is similar to the previous (Year 1) study in that it is based on analyses of total mercury levels in sediment and soil core sections. The primary goal was to collect sediment cores with continuous records of particle accumulation that could be used to reconstruct the history of atmospheric Hg fluxes. By combining mercury concentration data with results from radionuclide dating of the sediment cores, historical rates of mercury deposition to sediment (fluxes) were calculated for each site. The results were then compared to Year 1 results. While the contributory sources of mercury were unknown in Woodcliff Lake, the lakes were selected in this study relative to two known sources of environmental mercury use and contamination that may have been significant sources of atmospheric mercury: the DuPont facility in Pompton Lakes and the US Army Armament Research Development and Engineering Center in Rockaway. Figure 1 shows locations of the coring sites. Criteria for selection of sites and methods for reconstructing the history of atmospheric fluxes were discussed previously (Kroenke et al. 2002). Sediment and soil cores were collected at the deepest section of Franklin Lake (Franklin Lakes, Bergen County, Watershed Management Area (WMA) 3), Splitrock Reservoir (Rockaway, Morris County, WMA 6), and Saffins Pond (Jefferson, Morris County, WMA 1). Archived sediment cores sampled in the early 1980s were analyzed from three lakes along the general east-west transect from Woodcliff Lake to Mountain Lake (Fig. 1). Core dating information was obtained through radionuclide analysis of sediment core sections as described previously (Kroenke et al. 2001). Based on the concentration of mercury in the sediments normalized for the sediment deposition rate, the mercury flux (mg/m^2/yr) was determined over time for each waterbody. The data was utilized to calculate a focus-directed yearly average of the flux of Hg in the late 20th century (early 1950s to 1980s) at each site.

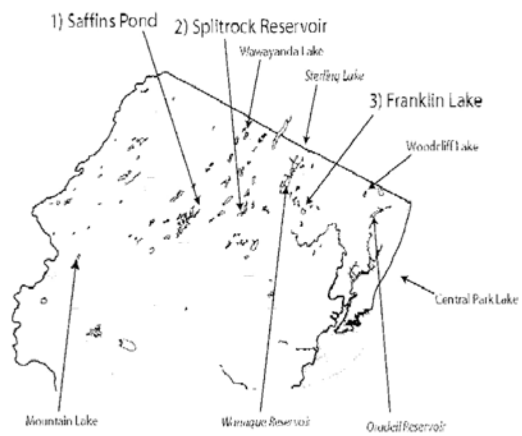

Figure 1. Sampling sites across northern New Jersey. As part of this study cores were collected at sites 1, 2, and 3. Italics indicate locations of archived cores. Cores from the remaining lakes are from previous studies.

Results

For comparison of temporal trends, mercury fluxes at the three new coring sites have been calculated as decadal averages (Table 1). For each of the sites, the periods of peak mercury flux and annual fluxes averaged over the past four to five decades are reported in Fig. 2. By comparison to other lakes, Woodcliff Lake sediments record the highest Hg fluxes of any site, strongly suggesting significant direct inputs of Hg and possibly very local atmospheric sources, with an average mercury flux rate (1950-2000) estimated at 1750 mg/m^2/year. On a regional scale, calculated atmospheric fluxes of mercury across northern New Jersey from Franklin Lake are on the order to 100 mg/m^2/yr or less with a decreasing trend over the past several decades (Fig. 2). While higher than background atmospheric fluxes reported

Table 1. Temporal Trends in Hg Fluxes to Sediments

Decade	Woodcliff Lake	Franklin Lake	Split Rock Reservoir	Saffins Pond	Mountain Lake
1990s	400	70	25	90	20
1980s	570	80	30	100	30
1970s	1900	100	40	110	50
1960s	3000	120	45	110	55
1950s	2900	110	55	100	75
1940s		75	45	70	65
Average (past 50 yrs)	1750	155	40	100	45

(Fluxes given in   g/m^2/yr normalized to xsPb-210 based focusing factor.)

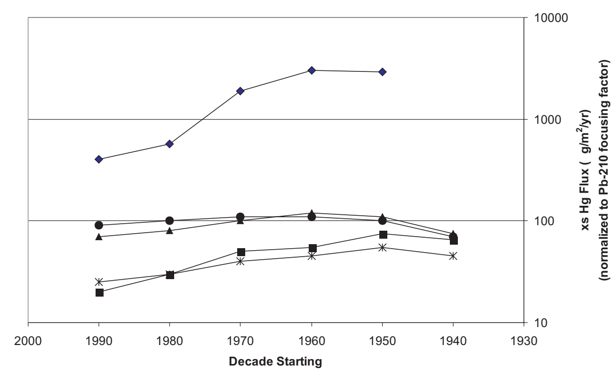

Figure 2. Decadal average mercury fluxes.

for remote areas, the fluxes in these lakes are within the range of regional fluxes reported for the Great Lakes area (Pirrone et al. 1998; Kroenke 2003; Kroenke et al. 2002). No evidence of a significant atmospheric mercury source related to fulminate of mercury explosives at the DuPont facility in Pompton Lakes (upwind of Franklin Lake) or the US Army Armament Research Development and Engineering Center in Rockaway (upwind of Splitrock Reservoir) was found. The archived core from the Wanaque Reservoir stands as the single exception to this regional picture. The high calculated average annual mercury flux for ~1950-1980 (1650 mg/m^2/yr) could be the result of uncharacterized direct inputs, possibly runoff from the site of a former iron works facility located just upstream of the reservoir. A dominant local atmospheric input from the nearby DuPont facility in Pompton Lakes appears to be ruled out by the Franklin Lake data. It should be noted, however, that these data reflect sediment levels more than twenty years old. The conditions causing the historical elevation may not be continuing. For comparison of temporal trends, Hg fluxes at the three new coring sites have been calculated as decadal averages (Fig. 2). Also included is the data for Woodcliff Lake and Mountain Lake (Table 2) described in detail in the report from the first year of the project (Kroenke et al. 2002; website (under mercury research): www.state.nj.us/dep/dsr). For each of the sites, the periods of peak Hg flux and annual fluxes averaged over the past four to five decades are reported in Table 2. Peak calculated fluxes generally occurred in the 1950s and 1960s, with the exception of Wawayanda Lake (~1920-1940) which had the lowest Hg fluxes of any site.

Table 2. Integrated Hg Fluxes at Eight Sites Across Northern NJ (East to West)

(Fluxes given in g/m^2/yr normalized to xsPb-210 based focusing factor.)

Period	Oradell Reservoir	Woodcliff Lake*	Franklin Lake	Wanaque Reservoir	Sterling Lake	Wawayanda Lake*	Splitrock Reservoir	Saffins Pond	Mountain Lake*
~1950 - 2000		1750	95			20	40	100	45
~1950 - 1980	590	2600	110	1650	70	25	45	105	60
peak (yrs)		3800 (early 1960s)	135 (early 1960s)			47 (~1920-40)	60 (early 1950s)	115 (1960s)	90 (early 1950s)

* Details of sample collection, analysis, and Hg flux estimation for Woodcliff, Wawayanda, and Mountain Lakes can be found in Kroenke et al. (2002).

Our results indicate that on a scale of tens of kilometers, atmospheric deposition of mercury to most of northern New Jersey is not anomalously high. Possible sources of the elevated mercury fluxes to Woodcliff Lake are limited to direct inputs and very local atmospheric sources.

Conclusion and Recommendations

Estimates of mercury depositional fluxes to sediments in this study can vary over about a factor of two depending on the choice of Hg background levels and sediment focusing factors, and uncertainties involving drainage basin holdup or sediment mixing. However, we are able to conclude that mercury fluxes at sites defining a transect across northern New Jersey indicate that the high fluxes previously observed at Woodcliff Lake are primarily the result of direct mercury inputs or very local atmospheric sources – within several kilometers of the site. Atmospheric fluxes of mercury to most of northern New Jersey are higher than fluxes reported for remote areas, but consistent with regional industrial atmospheric fluxes as indicated by atmospheric deposition to the Great Lakes (Pirrone et al. 1998). No evidence was found for other major sources of atmospheric mercury along this transect although the high flux calculated for the Wanaque Reservoir during the 1950s and 1960s has not been satisfactorily explained. Atmospheric fluxes of mercury at Franklin Lake, Splitrock Reservoir and Saffins Pond have decreased considerably from levels observed several decades ago. The general results of this study – mercury fluxes higher than remote areas, but consistent with regional industrial atmospheric fluxes and decreasing trends over the past several decades – are in agreement with the earlier statewide analysis.

Funding

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