Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy

Volume 17 Article 4

2012

Monitoring Sources of Mercury in the Atmosphere

James Metcalf
George Mason University

Douglas G. Mose
George Mason University, dje42@aol.com

Chapter 3

MONITORING SOURCES OF MERCURY IN THE ATMOSPHERE

James Metcalf[1] and Douglas Mose[2§]
[1]*College of Health and Human Services,* [2]*College of Science, George Mason University, Fairfax, VA 22030*

ABSTRACT

In Virginia and most other states, rain and snow collection stations have been used to determine the concentration of mercury in precipitation. These mercury measurements are distributed by the National Atmospheric Deposition Program through the Illinois State Water Survey (http://nadp.sws.uiuc.edu). Mercury deposition data has been gathered for over a decade and may be compared to the on-line data currently reported from collection sites. Coal-burning power plants are thought to contribute most of the atmospheric mercury, and it was thought that the precipitation collections would prove this hypothesis. In Virginia, this hypothesis is supported. It has been found that the atmospheric content of mercury increases during prolonged intervals without precipitation. In this study, it was found that the atmospheric content of mercury was exceptionally low following an unusually prolonged precipitation event.

Keywords: mercury, pollution, precipitation

1. INTRODUCTION

For many years, the environmental movement has attempted with some success to limit mercury emissions from coal-fired utility power stations. The debate revolves around the cost of dealing with health problems caused by mercury versus the cost limiting mercury emissions. While the actual health costs arr not well defined, there is no doubt that coal combustion contributes to mercury deposition in aquatic ecosystems, and that fish consumption is the primary source of mercury exposure to mankind.

§ Corresponding Author: Douglas Mose, College of Science, Chemistry Department, George Mason University, Fairfax, VA, USA, 22030, 703-273-2282, dje42 @ aol.com

Coal is the compressed and dehydrated product of plant material that accumulated in an oxygen-poor environment, such as an ancient swamp. To form coal, the plant material must be the dominant part of the accumulating sediment, and must be in an area of geologically slow subsidence, where over time layers of sediment cover the plant debris, and the depth of burial is at least a kilometer. At this depth, the plant debris can be slowly warmed by the radioactivity-generated heat from deep within the planet's crust, and the compressed plant material forms coal.

Oxygen-rich stream and river water that carries sediments into an depositional environment where abundant plant debris accumulates quickly loses its dissolved oxygen content, due to plant decay. Metals in the water, including mercury, precipitate into the plant debris. The metals are not lost as the plant debris is converted into coal. If the coal is burned, as in an electricity generating facility, the metals are vaporized. If the exhaust is not treated properly, mercuty (and other metals) escape into the atmosphere around the facility. The questions raised about this "escaped mercury" include how much mercury escapes, where does it eventually reside, and what is the magnitude of the health problems caused by this mercury.

It is known that when mercury isvaporized and sent into the atmosphere, rain and snowfall wash the mercury into streams and ponds. It is converted into methyl-mercury (and other organic compounds) in the bottom-accumulated plant material that fish consume. Fish enriched in mercury are sometimes eaten by people. It is also known that methyl-mercury causes nervous system and developmental disorders in fetuses and infants (Gobeille et al., 2005). Also, in adults there is evidence that mercury-enriched fish can cause kidney disease, lung cancer, and cardiovascular disease related to chronic mercury exposure through the consumption of fish.

The National Atmospheric Deposition Program (NADP. 1995) of the U.S. Geological Survey and the U.S. Environmental Protection Agency established the Mercury Deposition Network (MDN) in 1995. The MDN consists of several hundred precipitation collection stations designed to accurately measure the concentration of mercury in precipitation in the United States and Canada.

Data from the MDN compilations show that the greatest total amount of mercury in precipitation is in the southeastern United States, probably because this area has a great amount of precipitation (close to the Gulf of Mexico). Conversely, the greatest amount of mercury precipitation during individual precipitation events is in the southwestern United States, probably because this area has small and infrequent precipitation events (Gay et al. 2006).

The national MDN database has been implemented to evaluate potential correlations between sources of mercury emissions into the atmosphere and variations in the amount of mercury in precipitation. It was anticipated that these measurements, plus an understanding of air movement in the atmosphere, could reveal areas where excess amounts of mercury emission and deposition occur.

The central Virginia MDN site is operated in the Center of Basic and Applied Science in Culpeper, Virginia by faculty and students at George Mason University in Fairfax, Virginia. Our site began providing weekly rainfall measurements and mercury collections in the fall of 2002. Culpeper is in the center of Virginia, about 200 kilometers from the nearest coal-fired electrical power stations in eastern Virginia. The other MDN site in Virginia is located in the Shenandoah National Park, west of the Culpeper MDN site and about 230 kilometers from the coal-fired stations. Data now reviewed in the following report were gathered in 2002 through 2005.

Determining if there is a significant correlation between mercury deposition by precipitation and proximity to coal-burning power plants has been a continuing effort among concerned scientists. The processes by which trace elements like mercury are incorporated into cloud droplets, and then rain, sleet, hail or snow, is well known (Walcek, 2003). At least in theory, atmospheric mercury should be deposited quickly and locally in proximity to its emission sources, which in this case are the Virginia coal-burning electrical power plants. Our study began with the anticipation that the Culpeper MDN site, being closer the eastern Virginia coal-fired stations, would regularly reveal large mercury concentrations in precipitation compared to the more distant MDN site in western Virginia.

2. METHODS

At all MDN sites, precipitation is collected over 7 day periods in glass bottles using a motorized collector that opens during intervals of precipitation (Olson and DeWild, 1999). The cumulative weekly total precipitation is recorded and an EPA-approved laboratory determines the mercury concentrations for each water sample. Each month, all the mercury concentrations are and added to the MDN database. During this interval (and today), the mercury deposition data from all the MDN sites are made available on the Internet. (NADP, 2005).

3. RESULTS

The precipitation at the MDN site in Culpeper (MDN Site Number VA-08) had an average annual mercury concentration of about 7.5 ng/L (Table 1). This

was about 10% more than the average annual mercury concentration at MDN site in the Shenandoah National Park (MDN Site Number VA-28). Since the Culpeper Site is about 10% closer to the coal-fired power stations and had about 10% more mercury in the precipitation, we regard the data as being evidence that the mercury came, at least in part, fromm the eastern Virginia coal-fired power stations.

The data also show that both the amount of precipitation and the amount of mercury in the precipitation tended to be higher in the summer and fall. We cannot present and explanation. However, it is during these seasons that higher atmospheric temperatures occur, and this could facilitate greater and faster dispersion of mercury across Virginia (Banic et al. 2005).

Fortunately for our study, during the winter quarter of 2003, Hurricane Isabel caused an unusual and brief interval of abundant precipitation and high winds. As shown in Table 1and 2, the average concentration of mercury in the precipitation was very low in this winter quarter. We believe that the brief but heavy precipitation washed most of the mercury out of the atmosphere in Virginia (Kolker et al. 2004).

Table 1. Record of Mercury Deposition at VA-08 in central Virginia

Interval	Hg Concentration (ng/L)	Precipitation Collected (cm)	Total Rain ($\mu g/m^2$)
Winter 02-03	5.7	9.2	0.5
Spring 2003	4.6	31.2	1.5
Summer 2003	10.3	42.3	4.3
Fall 2003	10.9	45.6	5.0
Winter 03-04	6.2	31.8	1.9
Spring 2004	8.8	12.0	1.0
Summer 2004	7.9	35.0	2.8
Fall 2004	7.0	37.0	2.6
Winter 04-05	4.3	31.2	1.4
Spring 2005	5.3	21.0	1.2
Summer 2005	7.9	21.9	1.8
Fall 2005	10.2	44.1	4.5
Winter 05-06	3.9	33.3	1.4

Table 2. Record of Mercury Deposition at VA-28 in western Virginia

Interval	Hg Concentration (ng/L)	Precipitation Collected (cm)	Total Rain ($\mu g/m^2$)
Winter 02-03	3.6	27.8	1.0
Spring 2003	4.4	47.1	2.0
Summer 2003	16.5	49.2	6.8
Fall 2003	9.9	64.4	4.2
Winter 03-04	4.8	39.0	1.8
Spring 2004	4.9	19.3	0.9
Summer 2004	8.4	37.9	3.2
Fall 2004	5.5	77.9	4.2
Winter 04-05	3.8	31.4	1.2
Spring 2005	4.1	24.3	1.0
Summer 2005	6.9	21.5	1.5
Fall 2005	6.9	41.7	3.1
Winter 05-06	3.4	51.5	1.1

4. CONCLUSIONS

Using the mercury data from MDN sites VA-08 in central Virginia and VA-28 in westernVirginia, it appears that the deposition of mercury in precipitation decreases as the distance to coal-fired electrical generating plants increases. It also appears when a hurricane passed through Virginia during the winter quarter of 2003, a significant amount of mercury was removed from the atmosphere, resulting in a very low precipitation of mercury in central and western Virginia.

5. REFERENCES

Banic, C., Blanchard, P., Dastoor, A., Hung, H., Steffen, A., Tordon, R., Poissant,. L., and Wiens, B., 2005, Atmospheric distribution and long-range transport of mercury. Chapter 9 of Mineralogical Association of Canada Short Course 34, Halifax, Nova Scotia, Canada, May 14-15, 2005. Parsons, M.B., Percival, J.B., eds., Mercury- Its Sources, Measurements, Cycles and Effects, p. 157-177.

Gay, D., Prestbo, E., Brunette, R., and Sweet, C., 2006, Wet deposition of mercury in the U.S. and Canada, 1996-2004: Results, trends, and future directions of the NADP mercury deposition network (abs.): 8th Annual International Conference on Mercury as a Global Pollutant Abstracts, T-208, p. 242.

Gobeille, A.K., Morland, K.B., Bopp, R.F., Godbold, J.H., and Landrigan, P.J., 2005, Body burdens of mercury in lower Hudson River area anglers. Environmental Research, v. 101, p. 205-212.

Kolker, A., Mose, D.G., and Sptizer, S., 2004, Filling a gap with 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.

NADP, 1995, National Atmospheric Deposition Program Office, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820, http://nadp.sws.uiuc.edu.

Olson, M.L., and DeWild, J.F., 1999, Low-level collection techniques and species-specific analytical methods for mercury in water, sediment and biota: U.S. Geological Survey Water Resources Investigation Report 01-466, 14 p.

Walcek, C., 2003, Fate of atmospheric trace gases: Wet Deposition, Chapter 19 of Potter, T.D., and Colman, B.R., eds., Handbook of Weather, Climate and Water: Atmospheric Chemistry, Hydrology, and Societal Impacts: John Wiley & Sons, Inc., p. 357-371.