SURVEY OF NONPOINT TRACE METAL INPUTS TO LAKE LANIER

David S. Leigh[1] and Douglas W. Gamble[2]

AUTHORS: [1]Associate Professor, [2]Graduate Assistant, University of Georgia, Department of Geography, Athens, GA 30602-2502.
REFERENCE: Proceedings of the 1997 Georgia Water Resources Conference, held March 20-22, 1997, at The University of Georgia, Kathryn J. Hatcher, Editor, Institute of Ecology. The University of Georgia, Athens, Georgia 30602-2202.

Abstract. In order to explore the possibility of anomalously high trace metal contributions to Lake Lanier, sediment and water samples from the watershed and lake were analyzed for toxic trace metals (USEPA "priority pollutants"). Sediment samples were collected from the mouths of 50 tributary streams and from 83 other sites, including lake bottom, stream beds and banks, and soils in the watershed. Water samples were collected from 18 tributary mouths during three flow events, including baseflow, low runoff, and moderate runoff flows. None of the sediment sites contained metal concentrations at "hazardous" levels and only a few sites contained metal concentrations that were marginally above NOAA's conservative "lowest effect level" for metals in aquatic sediment. None of the water samples exceeded USEPA drinking water standards, but several samples slightly exceeded the Georgia EPD instream water criteria for mercury (Hg) and lead (Pb). Former gold mines are possible sources for Hg, and urban areas were recognized as contributors of Hg and Pb. In general, the Lake Lanier watershed is relatively clean in terms of trace metals, with a few urban and formerly mined areas contributing metals that exceed the natural background levels.

INTRODUCTION

Previous water quality studies at Lake Sidney Lanier detected a few high trace metal contents in water and fish tissue samples (Hatcher, 1994), particularly for arsenic, mercury, nickel, selenium, and zinc. Thus, a research plan was devised to evaluate nonpoint contributions of trace metals to the lake and to identify specific watersheds or distributed sources that may have been contributing anomalous concentrations of metals to the lake. Soil, sediment, and water samples were collected from the entire watershed to address the research objectives.

METHODS

Sampling was conducted from August 1995 until July 1996 to obtain a comprehensive survey of metal contents in sediment and water of the Lake Lanier watershed. Details of sampling and analysis are discussed below.

Soil and Sediment Samples

Soil and sediment samples were collected at 133 sites in the Lake Lanier watershed, including six subsets: (1) 50 stream bed composites from the mouths of 50 different streams entering the lake; (2) 20 miscellaneous stream bed composites that targeted certain distributed source areas; (3) 18 miscellaneous stream bank composites that targeted certain distributed source areas; (4) 30 lake bottom composites from the heads of 6 different bays that represented watersheds with different land uses; (5) 10 deep lake bottom sediment composites from 5 sites (2 samples at each site); and (6) 10 soil sample composites (A horizon) from 10 different sites. Soil and stream sediment samples were sieved to pass a 0.25 mm mesh prior to chemical analysis to represent the approximate size of suspended sediment delivered to the lake. Determinations for the concentration of 22 different elements (Table 1) were made by inductively coupled plasma (ICP) and atomic absorption (AA) spectrometry methods following an aqua-regia leach (3:1 concentrated HCl-HNO3 mix). Mercury was measured by cold vapor atomic absorption. Selenium was measured by atomic absorption following an HCl/KClO3-organic extraction.

Water Samples

Water samples were collected three times at the mouths of 18 different stream sites (54 samples). Sampling times included a baseflow, low runoff, and moderate runoff events. The average discharge of the three events equaled the mean annual flow for each stream. In addition to stream samples, lake water samples were collected and analyzed from four sites, including surface and lake bottom waters. The 54 stream samples (3 x 18 sites) and two lake water samples (at Buford Dam) were analyzed for unfiltered "total recoverable" metals following digestion in hot HNO3. An additional 70 samples were analyzed for "filtered" metals, including the 56 samples matched by "total recoverable" metals and 14 other samples. Both filtered and unfiltered samples were collected using acid-rinsed polyethylene bottles and other EPA protocol. Analysis of 21 different elements (Table 2) was made by inductively coupled plasma mass spectrometry (ICP-MS) methods without preconcentration. "Ultra-clean" lab facilities were not used, so that parts-per trillion concentrations of Hg could be spurious.

RESULTS

Sediment Results

Metal concentrations of soil and sediment were compared to Georgia EPD standards for contaminated soil and NOAA's values for the "lowest effect level" of metals on sediment (Long and Morgan, 1991). The NOAA criteria have no regulatory status. A total of 28 sites (out of 133) slightly exceeded EPD or

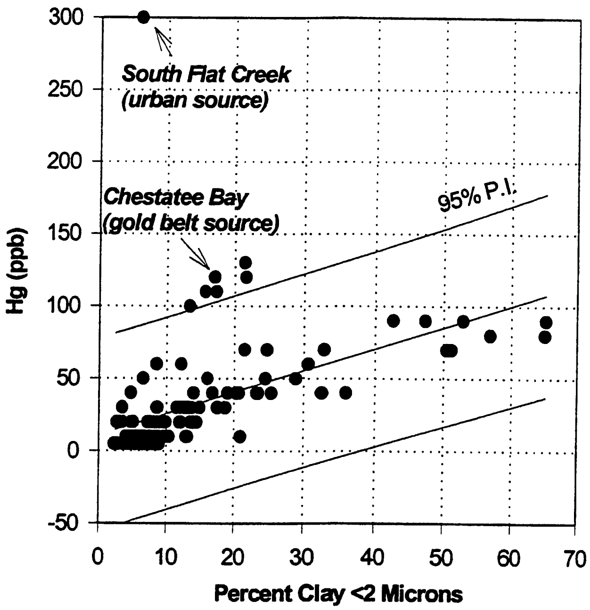

Figure 1. Plot of percent clay vs. Hg (ppb) in aquatic sediment samples (stream and lake bottom).

NOAA criteria (whichever was lowest) for one or more of the following elements: Co, Hg, Ni, Pb, V, Zn (Table 1). However, based on correlations between metal concentration and percent clay, many of these sites appear to represent high natural background levels rather than anthropogenic sources of pollution. In general, Hg, Pb, and Zn were the only "priority pollutants" that were evident as clear and persistent products of anthropogenic sources, which were typically traced to urban source areas. Anthropogenic sources of sediment-bound Hg also are evident from the Dahlonega Gold Belt, which includes the Chestatee River watershed, but not at levels that exceed the NOAA criteria of 150 ppb for Hg (Figure 1). Gold Belt sources of Hg are consistent with the observations of Leigh (1997). In summary, no extremely high levels of metals were detected.

Water Results

None of the water samples exceeded EPA drinking water criteria. However, 13 samples slightly exceeded Georgia EPD instream water criteria for Hg (0.012 ,μg/L) and 11 for Pb (1.3 μg/L) (Table 2). The maximum Hg concentration observed was 0.144,μg/L and the maximum Pb level observed was 3.07 μg/L, both of which were from total recoverable samples. Single occurrences of slightly high Ag and Cu were also observed in total recoverable samples. Like the sediment samples, urban sources of Hg and Pb were evident from the water samples. To a lesser extent, Hg could be linked to watersheds that had former gold mines that probably used mercury for amalgamation of gold. However, other sources of anthropogenic mercury are possible, including atmospheric sources. In general, the water samples indicate that the Lake is relatively clean in terms of trace metal concentrations. While Hg is apparent at somewhat elevated levels in water, fish tissue samples are generally below EPA guidelines (Hatcher, 1994).

CONCLUSIONS

The findings of this research indicate that Lake Lanier and its watershed are generally clean in terms of trace metal loadings. Observations of Hg and Pb that exceed Georgia EPD criteria are relatively low and close to instrumental detection limits, thus exceeding the EPD criteria by a narrow margin. In fact, the metal contents of most sediment and water samples are quite comparable to those measured in forested watersheds of North Carolina (Tables 1 and 2) that are "totally forested and barren of highways, houses, farmlands, channelized streams, and other man-related activities" (Caldwell, 1992). Urban sources and former gold mines are the most obvious sources of anomalous concentrations of metals delivered to the lake, but other sources cannot be ruled out.

LITERATURE CITED

Caldwell, W. S., 1992. Selected water-quality and biological characteristics of streams in some forested basins of North Carolina, 1985-88. U. S. Geological Survey WRIR 92-4129.

Hatcher, K. J., 1994. Diagnostic/Feasibility study of Lake Sidney Lanier, Georgia. Report submitted to the Georgia EPD.

Leigh, D. S., 1997. Mercury tainted overbank sediments from past gold mining in north Georgia, U.S.A. Environmental Geology, In Press.

Long, E. R., and L. G. Morgan, 1991. The potential for biological effects of sediment-sorbed contaminants tested in the national status and trends program. NOAA Technical Memorandum NOS/OMA 52.

Table 1. Summary of sediment-bound metal concentrations from stream, lake, and soil samples from the Lake Lanier watershed. Concentrations in parts per million (ppm), unless noted in percent (n=133).

Element	*GA EPD Soil Criteria (ppm)*	*NOAA's Lowest Effect Level (ppm)* [1]	*Avg. (ppm)*	*S.D. (ppm)*	*Min. (ppm)*	*Max. (ppm)*	*# of Sites Exceeding EPD or NOAA*[1] *Criteria*	*Maximum Two from Forested Basins in NC*[2]
% Aluminum (Al)	NA	NA	2.3	1.72	0.24	7.74	NA	13.0, 5.4
Antimony (Sb)	4	2	< 2	--	< 2	< 2	0	---
Arsenic (As)	20	33	< 4	--	< 2	16	0	---
Barium (Ba)	1000	NA	125	73	10	330	0	---
Beryllium (Be)	2	NA	< 0.5	--	< 0.5	2	0	---
Cadmium (Cd)	2	5	< 0.5	--	< 0.5	0.5	0	1.0, 0.1
Chromium (Cr)	100	80	30	15	5	73	0	68, 18
Cobalt (Co)	20	NA	8	5	1	22	1	---
Copper (Cu)	100	70	18	13	1	61	0	16, 4.6
% Iron (Fe)	NA	NA	2.55	1.43	0.36	7.79	NA	---
Lead (Pb)	75	35	15	11	2	48	8	17, 9.9
Manganese (Mn)	NA	NA	340	263	30	1560	NA	---
Mercury (Hg)	0.5	0.15	0.032	0.038	0.005	0.300	1	0.32, 0.06
Molybdenum (Mo)	NA	NA	< 1	--	< 1	2	NA	---
Nickel (Ni)	50	30	9	6	1	47	1	15, 7.9
Phosphorus (P)	NA	NA	398	297	80	1440	NA	---
Selenium (Se)	2	NA	< 0.2	--	< 0.2	1	0	---
Silver (Ag)	2	1	< 0.2	--	< 0.2	0.3	0	---
Thallium (Tl)	2	NA	< 10	--	< 10	< 10	?	---
Uranium (U)	NA	NA	< 10	--	< 10	< 10	NA	---
Vanadium (V)	100	NA	52	31	7	166	7	---
Zinc (Zn)	100	120	55	28	4	162	10	70, 42

notes:
NA = not applicable
1 NOAA criteria of Long and Morgan (1991), which have no regulatory status.
2 These values are from Caldwell (1992, pp. 66-67) and represent totally forested watersheds in North Carolina without any human-related structures or activities.

Table 2. Summary of total recoverable metal concentrations (μg/L) in water samples collected from the mouths of tributaries to Lake Lanier (n=56) from 18 sites (3 samples at each site) and two lake samples at Buford Dam.

Element	*Detection Limit (μg/L)*	*USEPA Drinking Water MCL (μg/L)*	*GA EPD Instream '95 Water Criteria (μg/L)* [1]	*Min. (ppb)*	*Max. (ppb)*	*# of Sites / Samples Exceeding EPD Criteria*	*Maximum Two from Forested Basins in NC*[2]
Aluminum (Al)	5.0	NA	NA	<5.0	2142	NA	9200
Antimony (Sb)	0.02	6	NA	<0.02	0.40	NA	---
Arsenic (As)	0.02	50	50	<0.02	2.21	0	<10
Barium (Ba)	0.01	2000	NA	6.54	123.09	NA	---
Beryllium (Be)	0.05	4	NA	<0.05	0.12	NA	---
Cadmium (Cd)	0.05	5	0.7	<0.05	0.08	0	2, <10
Chromium (Cr)	0.05	100	120	<0.05	3.65	0	10, <25
Cobalt (Co)	0.005	NA	NA	<0.005	1.67	NA	5, <50
Copper (Cu)	0.05	TT	6.5	0.38	15.33	1 / 1	120, <10
Iron (Fe)	2.0	NA	NA	26.21	2095	NA	2606, 1754
Lead (Pb)	0.01	TT	1.3	0.13	3.07	9 / 11	64, 50
Manganese (Mn)	0.02	NA	NA	4.15	401.5	NA	380, 370
Mercury (Hg)	0.02	2	0.012	<0.02	0.14	11 / 13	1.0, 0.7
Molybdenum (Mo)	0.02	NA	NA	<0.02	24.38	0	---
Nickel (Ni)	0.1	100	88	<0.10	8.08	0	15, <50
Selenium (Se)	5.0	50	5	<5.0	<5.0	0	1.0, <5
Silver (Ag)	0.02	NA	0.12	<0.02	0.13	1 / 1	---
Thallium (Tl)	0.002	2	NA	0.0024	0.04	NA	---
Uranium (U)	0.002	20	NA	<0.002	0.20	NA	---
Vanadium (V)	0.05	NA	NA	0.07	5.64	NA	---
Zinc (Zn)	0.10	NA	60	<0.10	47.61	0	140, 130

notes:

NA not applicable; TT treatment technique

1 at low hardness <100 mg/l

2 These values are from Caldwell (1992, pp. 52-57) and represent totally forested watersheds in North Carolina without any human-related structures or activities.