HEAVY METAL LOADING TO LAKE LANIER FROM POINT SOURCES OF POLLUTION AND URBAN RUNOFF

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Abstract. An investigation into sources of heavy metal contamination in Lake Sydney Lanier has been carried out as part of the Clean Lakes Program. Previous studies have found evidence of trace metal contamination in the water column and sediments of the lake and its tributaries and in the tissues of fish. Currently, there is little quantitative data on point and non-point sources of toxic metals in the watershed. In this study, effluent samples from nine municipal and one industrial wastewater treatment plant and stormwater samples from three lake tributaries were analyzed for total recoverable mercury, arsenic, selenium, chromium, nickel, copper, zinc, cadmium, barium and lead. The most abundant metals were barium and zinc. Toxic metal loads due to stormwater runoff were always greater than those due to effluent discharges.

INTRODUCTION

Lake Lanier currently serves as a drinking water supply, recreational facility and wildlife habitat. Water quality in the lake is negatively impacted by pollution from several sources in its watershed including discharges from industrial and private facilities, municipal wastewater treatment plants, urban runoff, leachate from landfills and cemeteries, marinas and other lakeside recreational facilities, leaking underground storage and septic tanks and hazardous waste spills. Wastewater treatment plant effluents and urban runoff probably have the greatest impact on pollutant loads (York et al., 1996).

The purpose of this study was to 1) collect existing water quality data on point sources of pollution in the Lake Lanier watershed and augment it with a sampling program which specifically targeted those facilities which are expected to contribute the most to the overall pollutant load and 2) estimate loads due to urban runoff (non-point sources). The data is to be used in conjunction with other studies under the Clean Lakes Project to determine the impact of various pollution sources on the lake water quality and assist in the development of appropriate watershed management policies.

This paper deals specifically with toxic metal inputs to Lake Lanier.

BACKGROUND

Previous studies have found copper, zinc, lead and mercury in excess of state water quality standards in the water column at various points in the lake. Chromium, nickel, lead and zinc have been found in sediment samples (Hatcher et al., 1994).

In 1975-6, a US Geological Survey study of the main tributaries of the lake found that yields of lead and zinc from urban watersheds were an order of magnitude greater than from forested water sheds and that more than 60 % of the trace metals discharged into the lake were associated with suspended sediments (Faye et al., 1980).

Monitoring Data

There is a limited amount of data available on toxic metals

Table 1(a): Monitoring Data for Waste Water Treatment Plants (WWTP's)

Facility	Period	Metal	Range	Permit
Cornelia	92-95	Zn	20-120	70
Linwood	94	Cu	<10-37	
Flat Creek	94-95	Zn	<20-95	
Scovill	89-96	Cd	< 20	260
		Cr	< 20 -510	1,710
		Cu	50 - 2,000	2,070
		Fe	70 - 1,200	0.74 kg/d
		Ni	380 - 2,300	2,380
		Pb	< 50	430
		Zn	60 -250	1,480

Table 1(b): Monitoring Data for Landfills

	Surface Water	Groundwater
As	< 30	< 50
Se	< 40	< 10
Ba	< 10 - 240	< 20 - 2,700
Cr	< 10 - 870	< 10 - 30
Co		< 40 - 200
Pb	< 25 - 160	< 25
Ni	< 20 - 110	< 20
Zn	< 20 - 520	< 20 - 140
Hg	< 0.5 - 0.6	
V		< 20 - 30

in effluents discharged to the lake and its tributaries. Data from monitoring reports obtained from the Georgia Environmental Protection Division (EPD) are summarized in Table 1 (a) and (b). All concentrations are in μg/L.

SAMPLING PROGRAM

A sampling program was undertaken to obtain data from which pollutant loads from the most important point and non-point sources could be more accurately estimated. The details of the program are discussed by York et al. (1996).

Nine municipal wastewater treatment plants and one industrial plant (Scovill, Inc.) were identified as being likely to have largest impact on pollutant loading on the basis of discharge flowrate and past problems (York, 1996). Grab samples of effluent were collected from November 1995 to March 1996 and analyzed for ten toxic metals: arsenic, selenium, mercury, chromium, nickel, copper, zinc, cadmium, barium and lead.

Grab samples of stormwater were collected from two streams, Flat Creek and Limestone Creek, which receive urban runoff from the City of Gainesville and from Six Mile Creek which has a history of pollution problems.

Analyses

Samples were analyzed for total recoverable mercury using a cold vapor flow injection mercury analyzer and for arsenic and selenium by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Semiquantitative scans of effluent samples using ICP-MS indicated that metal concentrations were generally low (< 50 μg/L) with the exception of zinc from several facilities and zinc, copper and nickel from Scovill. Antimony concentrations of the order of 1 mg/L had been measured as recently as January 1995, however antimony was not detected in the semiquantitative scan and was therefore not included in the quantitative analysis. Since antimony is volatile, some may have been lost in the digestion procedure.

Six samples from Scovill and two samples from each of the municipal facilities were analyzed for total recoverable chromium, nickel, copper, zinc, cadmium, barium and lead. Stormwater samples were sent to the ICP-MS laboratory at the Department of Crop and Soil Sciences, University of Georgia. Four effluent samples were sent to the same laboratory as a quality assurance measure. Split sample analyses were within 5 μg/L with the exception of copper and zinc which were within 25 μg/L (< 20 % at higher concentrations).

Method detection limits (MDL's) for all elements measured by ICP-MS were determined according to the method specified in SW-846 (1986). The reported detection limits were five times the MDL's, accounting for a fivefold dilution factor. Problems with zinc contamination in the sample preparation resulted in a high reported detection limit for zinc (23 μg/L). However, all zinc measurements were above the detection limit and the potential error due to contamination is expected to small compared to other uncertainties in the loading calculations. The reported detection limit for mercury was taken to be 0.2 μg/L, the concentration of the lowest standard.

Calculation of Pollutant Loads

Pollutant loads from each the waste water treatment plants on each of the sampling days were calculated as the product of the flowrate and the measured concentration. The reported loads are the averages for all sampling days in kg/y.

Loads for stormwater runoff were estimated using runoff volumes computed using the Soil Conservation Service (SCS) Method for Abstractions (Chow et al., 1988). The annual runoff volume is calculated based on annual precipitation, drainage area and land usage. The drainage areas for each of the streams sampled were obtained from Hatcher et al (1994). The runoff volume for each storm event associated with the stream samples was assumed to be proportional to the precipitation for that event and this was used together with the measured concentrations to calculate a flow weighted average concentration. The reported loads were the products of the flow weighted average concentrations and the annual runoff volumes.

RESULTS AND DISCUSSION

The stormwater sampling was carried out primarily for comparison with point sources of pollution and did not constitute a comprehensive study of urban runoff. Consequently, the calculated loadings are at best, order of magnitude estimates. The actual fate of the metals measured is another uncertainty factor in the calculations.

The method used to calculate the loads due to stormwater runoff probably overestimated the total metal loads. Trace metals tend to be strongly associated with particulate matter. During high flow conditions, fine solids remain in suspension resulting in high total metal measurements. However, particulate phases have a longer average residence time in the stream than the aqueous phase; that is, the metal concentrations measured in the water column during storm events, are not necessarily representative of what, on average, reaches the lake.

Leigh (1996) estimated toxic metal loads in the lake tributaries based on average flow conditions. Estimates obtained in this way were an order of magnitude lower than those based on storm flows. However, loads based on average conditions are likely to be underestimates since high flow conditions correspond to high concentrations. Consequently, the true loading values probably lie between the two types of estimates.

Mercury, Cadmium, Arsenic and Selenium

Mercury, cadmium and selenium were below the detection limit in all samples. Arsenic was detected in effluent from Scovill only and concentrations were very low (<5 μg/L). Maximum loads from each of the thirteen sources were

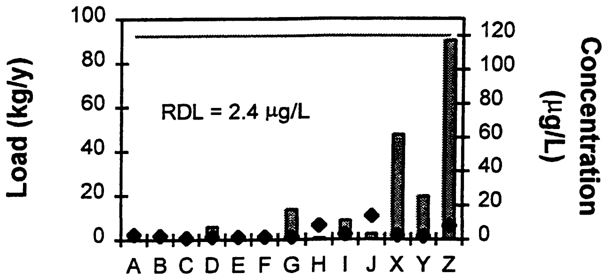


Figure 1: Chromium loads and concentrations.

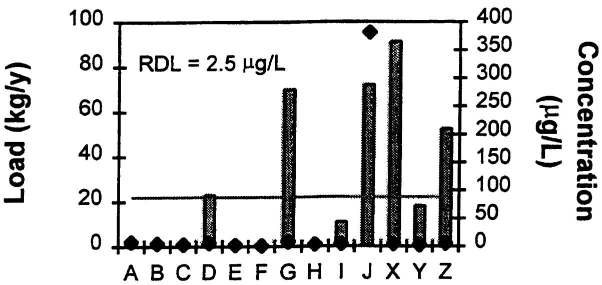


Figure 2: Nickel loads and concentrations.

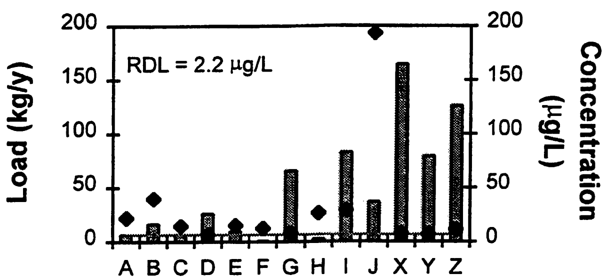


Figure 3: Copper loads and concentrations.

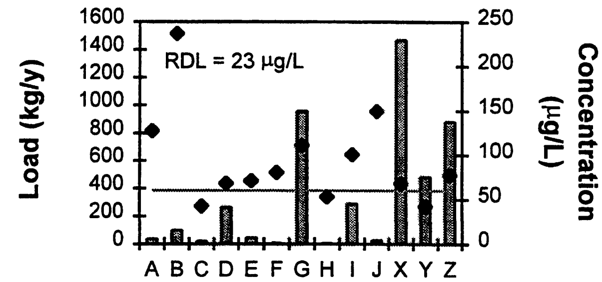


Figure 4: Zinc loads and concentrations.

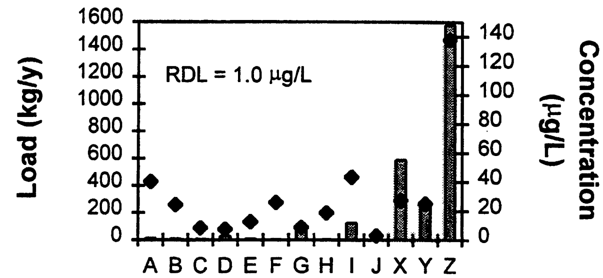


Figure 5: Barium loads and concentrations.

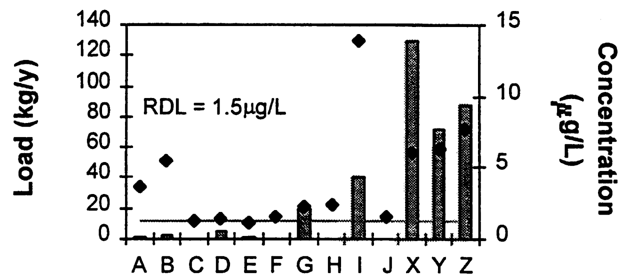
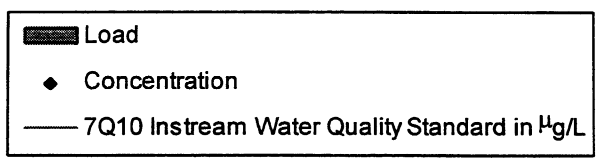


Figure 6: Lead loads and concentrations.



calculated based on the detection limit. These were 62, 12, 87 and 87 kg/y respectively for cadmium, mercury, arsenic and selenium. Detection limits for ICP-MS were generally at least an order of magnitude smaller than the detection limits reported in the EPD files allowing the maximum contaminant loading of low concentration elements to be more accurately estimated.

Flow averaged concentrations and loads for the remaining six metals are presented in Figures 1-6. The 7Q10 instream water quality standards for each element are also shown. Note that the standards refer to the diluted value of the pollutant in the stream, whereas the measured average values are for undiluted effluent.

The key for figures 1-6 and the permit flowrates for each facility are presented in Table 3.

Chromium

Measurements of chromium were all below 10 µg/L except in one sample taken at Scovill (J) on 18 December 1995 in which 86 µg/L was measured. The Scovill (J) effluent is expected to contain chromium since it includes wastewater from chromating. However, it appears that chromium removal is generally very efficient. Overall the chromium load from Scovill (J) was small compared to those from the three largest municipal facilities, Flat Creek (G), Linwood (I) and Cornelia (D) which in turn were small compared to the load due to stormwater runoff (X,Y,Z).

Nickel, Copper and Lead

Nickel and copper concentrations were less than 10 and 50 µg/L respectively except at Scovill (J). The largest nickel loads came from Scovill (J), Flat Creek WWTP (G), Flat Creek (X) and Six Mile Creek (Z). The largest copper loads were from Flat Creek WWTP (G) and the three creeks (X,Y,Z). Linwood (I) and Flat Creek WWTP (G) accounted for almost all the lead from the facilities but their contributions were small compared to the stormwater runoff.

Barium and Zinc

Barium and zinc loads were an order of magnitude greater than the other metals. Zinc was the most abundant metal and showed the most variation in samples taken from the same source. The three largest treatment plants (D,G,I) and the stormwater runoff accounted for almost all the zinc load. Barium concentrations ranged between 5 and 55 μg/L for the municipal WWTP's (A-I) and the two urban runoff streams (X,Y) but was less than 5 μg/L in Scovill (J) effluent. Up to 158 μg/L barium was measured in Six Mile Creek. The contribution of effluent discharges to the barium load was small compared to the stormwater runoff.

Relative Importance of Pollutant Sources

The results suggest that the relative importance of various pollutant sources with respect to the total pollutant load is primarily determined by the volume of flow. Consequently, the Flat Creek plant contributes more to the total metal load and is more likely to have difficulties meeting instream water quality standards than Scovill, which has much higher pollutant concentrations.

Similarly pollutant loads due to stormwater runoff are likely to be at least an order of magnitude greater than loads due to effluent discharges. Furthermore, the combined drainage areas of the three creeks sampled constitute less than 0.2 % of the total drainage area of the lake above the Buford Dam. Consequently, while yields of trace metals per unit drainage area are expected to be relatively high in the creeks sampled, they may not have a very large impact on the overall pollutant load. However, the point and non-point sources investigated may cause localized water quality problems.

Landfills may be a significant point source of trace metals, especially barium, chromium, zinc, lead and mercury (see Table 1(b)) in ground and surface water. There are eight landfills in the Lake Lanier watershed. Their impact on the lake is not easy to determine. Although contaminated surface waters will ultimately flow into the lake, contaminants in groundwater may be adsorbed or transformed by interaction with soil particles (York, 1996). It was beyond the scope of this project to determine the fate of contaminants in landfill leachate, hence the metal loads from these sources were not estimated.

SUMMARY AND RECOMMENDATIONS

Of the ten toxic metals measured, arsenic, selenium, mercury and cadmium were mostly undetectable while barium and zinc were the most abundant. The most important point sources of trace metals appear to be the larger municipal wastewater treatment plants which are already meeting state water quality requirements. Discharges from these and smaller facilities may result in localized water quality problems, however, their contribution to the overall metals loading is small compared to runoff from less than 0.2 % of the lake's drainage area. Due to the limited nature of the study, more research focusing on stormwater runoff and background metal levels in streams is required to confirm these results.

ACKNOWLEDGMENTS

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Table 3: Facilities and Streams Sampled

Key	Facility/Stream	Permit Flow (MGD)
A	Baldwin	0.3
B	Clarkesville	0.75
C	Cleveland	0.75
D	Cornelia	3
E	Dahlonega	0.72
F	Demorest	0.4
G	Flat Creek WWTP	7
H	Flowery Branch	0.2
I	Linwood	3
J	Scovill	0.144
X	Flat Creek	15.7*
Y	Limestone Creek	8.3*
Z	Six Mile Creek	8.3*

* average flow based on total annual precipitation