Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 15	No. 2	pp. 549-554	2016

Original Research Paper

ICP-AES Estimation of a Few Heavy and Toxic Metal Ions Present in Water Samples Collected from the Three Lakes Situated in Bangalore City

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 05-05-2015
Accepted: 24-06-2015

Key Words:
ICP-AES
Heavy metal ions
Bangalore lakes
Water pollution

ABSTRACT

Four water samples were collected following accepted procedures from each of the three lakes Agara, Hebbal and Madiwala at different locations during the dry season month of February 2009 and rainy season month of July 2008. The levels of heavy and toxic metals As, Cu, Fe, Hg, Mn, Ni, Pb, Sb and Zn were determined using ICP-AES in sequential mode, and were found to be within the desirable and permissible limits. But the water samples of Hebbal and Agara lakes were found to be containing lead that was exceeding the desirable limit prescribed by WHO and Central Pollution Control Board and was more in the dry season samples than those in the rainy season. These two lakes are surrounded by motor ways leading to various parts of the country including the Ring road and National Highway-7, where there are heavy vehicular movements and are obvious major contributors in addition to those from multiplicities of urban developments.

INTRODUCTION

Most of our water resources are gradually becoming polluted due to the addition of foreign materials from the surroundings. These include organic matter of plant and animal origin, land surface washing, and industrial and sewage effluents. Rapid urbanization and industrialization with improper environmental planning often lead to discharge of industrial and sewage effluents into lakes. The lakes have complex and fragile ecosystems without having self cleaning ability accounting for ready accumulation of pollutants in their water bodies.

Water pollution is a major global problem which requires ongoing evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells). It has been suggested that water pollution is the leading worldwide cause of deaths and diseases and accounting for the deaths of more than 14,000 people daily. An estimated 580 people in India die of water pollution related illness every day. In addition to the acute problems of water pollution in developing countries, developed countries also continue to struggle with pollution problems. For example, in the most recent national report on water quality in the United States, 45 percent of assessed stream miles, 47% of assessed lake acres, and 32 percent of assessed bays and estuarine square miles were classified as polluted. Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, such as drinking water, or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish. Natural phenomena such as volcanoes, algal blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water.

Industrial facilities generate ordinary domestic sewage that can be treated by municipal facilities. Industries that generate wastewater with high concentrations of conventional pollutants (e.g. oil and grease), toxic pollutants (e.g. heavy metals, volatile organic compounds) or other non-conventional pollutants such as ammonia, need specialized treatment systems. Some of these facilities can install a pre-treatment system to remove the toxic components, and then send the partially treated wastewater to the municipal system. Industries generating large volumes of wastewater typically operate their own complete on-site treatment systems. Some industries have been successful at redesigning their manufacturing processes to reduce or eliminate pollutants, through a process called pollution prevention. Therefore, a better understanding of heavy metal ion sources, their accumulation in the soil and the effect of their presence in water and soil on plant systems are important issues on risk assessments. Heavy metal ions are natural components of the earth crust but enter animal bodies via food, drinking water, air and found to be bio-accumulative and are important pollutants. Heavy and toxic elements found in water could be normally from industrial, consumer wastes and acid rain. Therefore, a planned study to determine and quantify the heavy and toxic element concentration present in the water samples is important, both from its pollution and potability point of view.

STUDY AREA

Hebbal lake: It is located at northern part of Bangalore and exactly besides NH-7 along the junction of Bellary road and outer ring road. It was one of the three lakes constructed in 1537 by Kempegowda and covering an area of 75 hectare. The lake is surrounded by the residential areas Yeshwanthpura, Mattikere, Rajmahal, BEL and HMT layout (Fig. 1a).

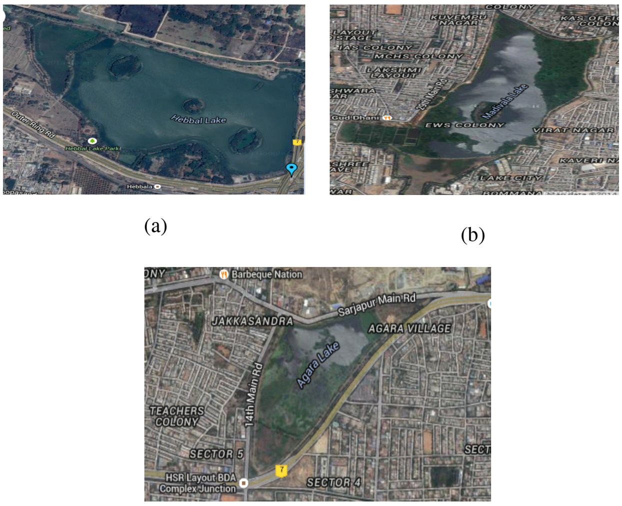
Madiwala lake: It is the biggest lake of the city and situated in BTM layout located at south east of Bangalore city, spreading across an area of 114 hectare. The residential areas Madiwala, BTM layout, Bommanahally and Rupena Agrahara are surrounding the lake and the lake is considered to be a home for many migrating birds (Fig. 1b).

Agara lake: It is near HSR layout in south east of Bangalore city adjoining to the outer ring road. It is spreading in an area of about 50 hectare. The surrounding residential areas include Agara, HSR layout, Venkateshwara Layout and some parts of Koramangala (Fig. 1c).

MATERIALS AND METHODS

Water samples were collected from four different locations of the respective lake in two seasons, namely, rainy season during the month of July 2008 and dry season during the month of February 2009. Water samples were collected from about one meter depth from the surface of the water in polyethylene bottles which were previously washed with detergent then with double-distilled water followed by 2 M nitric acid, then double-distilled water again and finally with sampled water. Water samples were acidified with 10% HNO_3, brought to the laboratory and refrigerated until needed for analysis.

The sample (200 mL each) contained in a beaker was digested with 25 mL of aqua regia (3:1 ratio of nitric acid and hydrochloric acid) on a water bath and evaporated to dryness. It was cooled and added another 25 mL of acid and digested again to remove all organic matter (Stefanson et al. 2007). Finally the sample was heated for about 30 minutes on a water bath, cooled and made up to 25 mL. The sample so prepared was used for trace elements analyses by ICP-AES method using ICP-AES (JOBIN-YVON) instrument. The software provided to the instrument automatically identifies the interfering elements during the course of analysis.



(a) (b) (c)

Fig. 1: Geographical view of (a) Hebbal Lake, (b) Madiwala Lake, (c) Agara Lake

Operating Condition	
Parameters of the method	
Analysis mode	Normal
Rinsing time	Fixed (5.0 s)
Rinsing pump speed	High speed
Transfer time	10.0 s
Stabilization time	1.0s
Transfer pump speed	Normal
Delay of synchronization	0 s
Stop of pump during replacement	No
Parameter	**Specification**
Power	1000 W
Normal speed pump	20
Plasma gas flow rate	14 (PL1) L/min
Sheath gas flow rate	0.2 (G-1) L/min
Auxiliary flow rate	0.0
Sheath gas stability time	3.0 s
Nebulization flow rate	0.02
Nebulization pressure	1.0 bar
Sample uptake	1 mL/min
Argon Humidifier	No
Wave lengths chosen for analysis	
Arsenic	193.658 nm
Copper	213.598 nm
Iron	259.940 nm
Mercury	194.227 nm
Manganese	257.610 nm
Nickel	221.609 nm
Lead	220.211 nm
Antimony	231.833 nm
Zinc	202.551 nm

The calibration graphs for the chosen elements were constructed with their respective standard solutions (0, 0.5, 1.0, 1.5 and 2.0 ppm). The blank correction of the instrument was made using a blank sample prepared by using double distilled water for digestion solution. After the blank correction the respective samples were analysed and the results were tabulated. The contents in the Tables 1 to 3 correspond to the results obtained for the samples collected in the rainy season (July -2008) and the contents of the Tables 4 to 6 correspond to the results obtained for the samples collected during dry season (February -2009).

RESULTS AND DISCUSSION

Heavy and toxic elements selected for determining the water quality of the lakes situated in Bangalore city are arsenic (As), copper (Cu), iron (Fe), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), antimony (Sb), and zinc (Zn). Central Pollution Control Board, Government of India identifies desirable limits of certain heavy metals in (μ/L) for lake water namely iron, zinc, copper, nickel and lead must be corresponding to 500, 200, 50,100 and 50 respectively (Lokeshwari & Chandrappa 2007). Whereas World Health Organization is identifying the permissible limit of manganese as 0.5 mg/L. Similarly as approved by Ministry of Water Resources, Government of India (CPCB 2000) the permissible limit for arsenic is 0.05 mg/L.

The results obtained for the analysis of heavy metals in the three lakes in the two seasons are presented in Tables 1-6 and Figs. 2-7. The average concentration of the elements detected in the water samples collected from three different lakes situated at three different areas of Bangalore city is compared with the standard data (CPCB 2000 and Lokeshwari & Chandrappa 2006). The average concentrations of the results are presented in Tables 7 and 8. Lake-wise comparison of the average concentrations of the elements determined for the samples collected during the rainy and dry seasons are also made.

Hebbal lake: The concentration of the elements, arsenic (As), copper (Cu), iron (Fe), nickel (Ni), manganese (Mn) and antimony (Sb) and zinc (Zn) were within the desirable and permissible limits of approved standard data. The so called highly poisonous environmental pollutant, mercury (Hg), was not found in the rainy and dry season water samples. As far as the seasonal variation is concerned the concentration of the elements detected are found to be increased in dry season. This may be attributed to the fact that the lake water becomes concentrated during dry season. The concentration of lead (Pb) in dry season water samples was exceeding the desirable limit, which could be attributed to motorways on the highway NH-7 and the ring road.

Agara lake: Arsenic was not found in the rainy season samples, but found in the dry season samples falling within the permissible limits and it may be attributed to the mixing of sewage water with lake water or due to diverted sewage drains or flooding of sewage water during the rainy season. The element mercury was not detected in the water samples of the lake collected during the rainy and dry seasons. Copper (Cu), iron (Fe) nickel (Ni), manganese (Mn), antimony (Sb) and zinc (Zn) found in the samples were within the permissible and desirable limits of the standard data (Statistical Data from BBMP website of 2009 and Lokeshwari & Chandrappa 2007). The concentration lead (Pb) found in the dry season was exceeding the desirable limit, which could be attributed to vehicle movements on the ring road. On considering the seasonal variation, the average concentration of the elements found in the lake water was increased in dry season. This may be attributed to the fact that the lake water becomes concentrated during the dry season.

Madiwala lake: The data analysis of the water samples during dry and rainy seasons revealed that the concentrations of the considered trace elements were within the permissible limit and desirable limit as per the standard data (CPCB 2000 and Lokeshwari & Chandrappa 2006). This lake is located in the interior part of the BTM layout surrounded by residential areas. The BBMP is maintaining a park and also providing boating facility in the lake.

CONCLUSION

The analyses of water samples of selected lakes reveal that all the considered trace elements were within permissible and desirable limits (CPCB 2000 and Lokeshwari & Chandrappa 2006). As far as the seasonal variation is concerned, the concentration of the elements detected in all the water samples in all the three lakes was found to increase in dry season. This may be attributed to the fact that the lake waters become concentrated during the dry season. The concentrations of lead (Pb) found in the samples of Hebbal lake and Agara lake collected during the dry seasons were crossing the permissible limits and that could be due to vehicular movements around these lakes, since these lakes are situated beside the National Highway (NH-7) and the outer ring road. The other sources of water pollution might be due to sewage water diverted to the lake water system.

ACKNOWLEDGEMENT

Author, M. Kiran Kumar gratefully acknowledges the University of Mysore, Mysore for the kind permission to do the research work and the Forensic Science Laboratory Bangalore, for providing instrumentation and other facilities.

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Table 1: Observed concentrations of heavy metals in the samples of Hebbal Lake in July-2008 (rainy season).

Sample	Concentration µg/L (SD) (average of three replicates) of elements in the sample								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Sample No.1	ND (0.10)	2.5 (0.02)	10 (0.01)	ND (0.01)	42.5 (0.01)	ND (0.00)	22.5 (0.01)	7.5 (0.01)	2.5 (0.00)
Sample No.2	ND (0.01)	7.5 (0.00)	22.5 (0.01)	ND (0.01)	17.5 (0.01)	ND (0.00)	2.5 (0.01)	20 (0.01)	12.5 (0.00)
Sample No.3	2.5 (0.01)	5.0 (0.00)	12.5 (0.05)	ND (0.01)	7.5 (0.01)	2.5 (0.00)	22.5 (0.01)	25.0 (0.01)	5.0 (0.00)
Sample No.4	ND (0.01)	2.5 (0.00)	10.0 (0.01)	ND (0.01)	22.5 (0.04)	ND (0.00)	12.5 (0.01)	7.5 (0.01)	25.0 (0.00)
Average(µg/L)	0.625	4.37	13.62	ND	22.5	0.625	15.0	15.0	11.25

Table 2: Observed concentrations of heavy metals in the samples of Agara Lake in July-2008 (rainy season).

Sample	Concentration µg/L (SD) (average of three replicates) of elements in the sample								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Sample No.1	ND (0.01)	3.0 (0.00)	12.5 (0.01)	ND (0.01)	22.5 (0.01)	2.5 (0.00)	2.5 (0.01)	20 (0.01)	50 (0.00)
Sample No.2	ND (0.01)	2.5 (0.00)	10 (0.01)	ND (0.01)	17.5 (0.01)	12.5 (0.00)	20.0 (0.01)	2.5 (0.01)	47.5 (0.00)
Sample No.3	ND (0.01)	ND (0.00)	2.5 (0.01)	ND (0.01)	12.5 (0.01)	12.5 (0.00)	15.0 (0.01)	20.0 (0.01)	5.0 (0.00)
Sample No.4	ND (0.01)	2.5 (0.00)	20 (0.01)	ND (0.01)	12.5 (0.01)	10 (0.00)	15 (0.01)	5.0 (0.01)	5.0 (0.00)
Average(µg/L)	ND	2.0	11.25	ND	16.25	9.37	13.12	11.87	26.86

Table 3: Observed concentrations of heavy metals in the samples of Madiwala Lake in July-2008 (rainy (season).

Sample	Concentration µg/L (SD) (average of three replicates) of elements in the sample								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Sample No.1	ND (0.01)	5.0 (0.00)	22.5 (0.01)	ND (0.01)	10.0 (0.01)	15.0 (0.00)	5.0 (0.01)	100 (0.01)	2.5 (0.00)
Sample No.2	ND (0.00)	12.5 (0.00)	5.0 (0.01)	ND (0.01)	17.5 (0.01)	5.0 (0.00)	22.5 (0.01)	2.5 (0.01)	5.0 (0.00)
Sample No.3	ND (0.01)	10 (0.00)	10 (0.01)	ND (0.01)	17.5 (0.01)	2.5 (0.00)	20.0 (0.01)	22.5 (0.01)	ND (0.00)
Sample No.4	ND (0.00)	5.0 (0.00)	7.5 (0.01)	ND (0.01)	22.5 (0.01)	2.5 (0.00)	7.5 (0.01)	2.5 (0.01)	ND (0.00)
Average(µg/L)	ND	8.2	11.25	ND	16.87	7.25	13.75	9.35	1.87

Table 4: Observed concentrations of heavy metals in the samples of Hebbal Lake in Feb-2009 (dry session).

Sample	Concentration (µg/L) of elements in the sample								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Sample No.1	10 (0.01)	8.75 (0.00)	42.5 (0.01)	ND (0.01)	83.75 (0.01)	2.5 (0.01)	123.5 (0.01)	47.5 (0.01)	23.75 (0.00)
Sample No.2	7.5 (0.01)	6.25 (0.00)	55.0 (0.01)	ND (0.01)	71.5 (0.01)	6.25 (0.00)	101.25 (0.01)	60.0 (0.01)	31.5 (0.00)
Sample No.3	2.5 (0.01)	11.25 (0.00)	67.5 (0.05)	ND (0.01)	46.25 (0.01)	11.25 (0.00)	75.0 (0.01)	65.0 (0.01)	18.75 (0.01)
Sample No.4	2.5 (0.01)	12.5 (0.00)	92.5 (0.01)	ND (0.01)	36.25 (0.04)	11.25 (0.00)	118.75 (0.01)	36.50 (0.01)	12.5 (0.00)
Average(µg/L)	5.62	9.68	64.36	ND	59.44	7.80	104.62	52.25	21.62

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Table 5: Observed concentrations of heavy metals in the samples of Agara Lake in Feb-2009 (dry season).

Sample	Concentration (µg/L) of elements in the sample								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Sample No.1	23.75 (0.01)	6.5 (0.00)	42.5 (0.01)	ND (0.01)	93.75 (0.01)	11.25 (0.00)	63.75 (0.01)	22.5 (0.01)	25.0 (0.00)
Sample No.2	23.75 (0.01)	5.0 (0.00)	67.5 (0.01)	ND (0.01)	121.5 (0.01)	18.25 (0.00)	101.25 (0.01)	22.5 (0.01)	12.75 (0.00)
Sample No.3	23.75 (0.01)	8.75 (0.00)	50.0 (0.01)	ND (0.01)	56.5 (0.01)	18.75 (0.00)	95.0 (0.01)	47.5 (0.01)	6.25 (0.00)
Sample No.4	11.25 (0.01)	11.25 (0.00)	55.0 (0.01)	ND (0.01)	8.75 (0.01)	7.5 (0.00)	11.25 (0.01)	10.0 (0.01)	6.25 (0.00)
Average (µg/L)	20.62	7.80	53.75	ND	70.12	13.94	67.80	25.62	12.50

Table 6: Observed concentrations of heavy metals in the samples of Madiwala Lake in Feb-2009 (dry season).

Sample	Concentration (µg/L) of elements in the sample								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Sample No.1	5.0 (0.01)	6.25 (0.00)	42.5 (0.01)	ND (0.01)	8.75 (0.01)	7.5 (0.00)	11.25 (0.01)	25.0 (0.01)	18.75 (0.00)
Sample No.2	11.25 (0.01)	11.25 (0.00)	11.25 (0.01)	ND (0.01)	33.75 (0.01)	12.5 (0.00)	11.5 (0.01)	2.5 (0.01)	31.25 (0.00)
Sample No.3	2.5 (0.01)	3.75 (0.00)	80.0 (0.01)	ND (0.01)	11.25 (0.01)	12.25 (0.01)	12.5 (0.00)	10.0 (0.01)	6.25 (0.00)
Sample No.4	1.25 (0.01)	11.25 (0.00)	42.5 (0.01)	ND (0.01)	8.75 (0.01)	11.25 (0.00)	11.25 (0.01)	2.5 (0.01)	18.75 (0.00)
Average(µg/L)	5.0	7.80	44.0	ND	15.62	18.80	10.00	9.43	10.90

Table 7: The average concentration of elements present in the lake water samples during rainy season (July 2008).

Name of the lake	Amount of elements in (µg/L)								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Hebbal	0.625	4.37	13.62	ND	22.5	0.625	15.00	15.00	11.25
Agara	ND	2.0	11.25	ND	16.25	9.37	13.12	11.87	26.86
Madiwala	ND	8.2	11.25	ND	16.87	7.25	13.75	9.35	1.87
Desirable/ permissible limit of heavy/ toxic metal ions	50	50	300	0.001	500	200	50	100	200

Table- 8: The average concentration of elements present in the lake water samples during dry season (February 2009).

Name of the lake	Amount of elements in (µg/L)								
	As	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Zn
Hebbal	5.62	9.68	64.36	ND	59.44	7.80	104.62	52.25	21.62
Agara	20.62	7.80	53.75	ND	70.12	13.94	67.80	25.62	12.50
Madiwala	5.00	7.80	44.00	ND	15.62	18.80	10.00	9.43	10.90
Desirable/ permissible limit of heavy/ toxic metal ions	50	50	300	0.001	500	200	50	100	200

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