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HEAVY METAL CONTAMINATION IN GULSHAN-BARIDHARA LAKE, DHAKA

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Abstract

Concentrations of cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), and lead (Pb) in the pelagic water of Gulshan-Baridhara Lake were determined. The samples were collected from ten different spots in summer (April, 2007) and monsoon (August, 2007) seasons. The concentrations of Cd, Cr, Cu, Ni and Pb in the lake water varied from 0.068 - 0.091, 0.048 - 0.225, 0 - 6.135, 0 - 0.062 and 0.023 - 0.067 mg/l during the summer season, respectively. Mean values of the samples collected from mid points for Cd, Cr, Cu, Ni and Pb of ten stations in summer were 0.083, 0.100, 2.336, 0.074, and 0.046 mg/l, respectively. In monsoon the concentration of above mentioned heavy metals varied from 0.016 - 0.019 mg Cd/l, 0.005 - 0.035 mg Cr/l, 0.002 - 0.018 mg Cu/l, 0.007 - 0.159 mg Ni/l, and 0.052 - 0.151 mg Pb/l. Mean values of these heavy metals in monsoon were 0.018, 0.018, 0.011, 0.037 and 0.093, mg/l, respectively. The depletion factor was less than unity for Pb and exceptionally high for Cu. Finally the study revealed that among the heavy metals only Pb concentration exceeded the standard level during the monsoon, otherwise concentrations of all other four heavy metals (*viz.* Cd, Cr, Cu and Ni) exceeded the standard level of drinking-, fishing- and surface water as set up by WHO, GOB, USEPA, DOE and FWPCA, for the summer period.

Introduction

Water pollution by heavy metals due to human activities is causing serious ecological problems in many regions of the world. Metals which are discharged into natural waters at increased concentrations in sewage, industrial effluents or from mining operations can have severe toxicological effects on humans and aquatic ecosystems.

Dhaka, one of the world's newest mega cities, is facing incredible environmental problems. At present the city is agglomerated with more than 10 million population.(1) Almost all of the mega cities face major freshwater challenges. Water pollution of Dhaka city is already in rampant condition. Abhat *et al.*(2) referred a recent Japanese

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report that the city dwellers are being slowly poisoned by Pb concentration in the city air ten times higher than the government safety limit. The indiscriminate discharge of domestic sewage, industrial effluents, and open dumping of solid wastes has become a great concern from the point of water-environment degradation.(2)

At one time pristine lakes used to surround different areas of Dhaka city. However, in the frenzy of urbanization, in the last 30 years or so, a drastic reduction of its lakes and canals has been noticed in Dhaka. In the recent past some studies have been carried out on the quality of surface water sources such as rivers, ponds, artificial lakes and reservoirs of Dhaka city corporation and most of them were found unsatisfactory for human use.(3-5) Gulshan-Baridhara lake is an artificial lake of Dhaka Metropolis. As a part of the natural drainage system this lake still plays an important role and simultaneously the lake is also one of the major sources of water to recharge the ground water. Bangladesh Government has declared it as an "Ecologically Critical Area" in 2001 under the Environment Preservation Act and Environment Preservation Rules. The present paper deals with the contamination of Cd, Cr, Cu, Ni and Pb in Gulshan-Baridhara lake.

Materials and Methods

Gulshan-Baridhara lake is located 23º48' N and 90º25' E of Dhaka city. The length of the lake is 3.8 km which covers an area of 0.0160 km^2. It has an average depth of 2.5 m, and a volume of 12 $\times 10^5/m^3$ (6-7). The lake is a channel-like elongated water body which is located in the northern fringe of the main part of Dhaka city. The lake is an old left back river channel but excavated later on in two phases. The western side of the lake was excavated during 1959-1960 and the eastern side during 1962-1964 for building residential areas. The lake has inlets through which it is connected with some old river channel and is, therefore, affected by flood water during peak flooding seasons.(8) Many drains and gullies discharge into the lake. In 1998-1999 Gulshan-Baridhara lake was temporarily drained to remove accumulated bottom sediments (about 0 - 30 cm).(9)

Water samples were collected from ten different stations considering two sampling points in each (Fig. 1) i.e., edge- and mid-point of the lake. The sampling was carried out in April and August, 2007 each as a representative month for summer and monsoon, respectively.

Samples of lake water were collected at a depth of 20 cm from the surface water level by hand dipping acid cleaned pre-washed plastic bottles of 500 ml from ten locations along the Gulshan-Baridhara lake. The mid-point sample was collected with the help of a boat. The collected samples were carried to the Department of Soil,

Water and Environment of Dhaka University in insulated ice-box immediately after the collection.

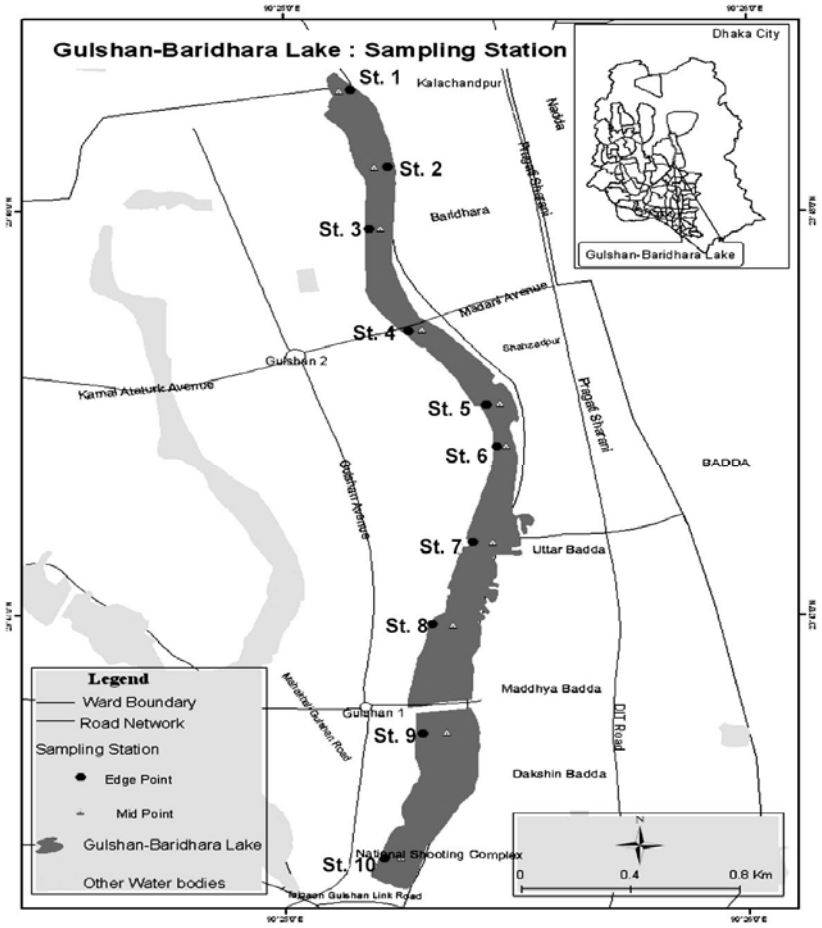

Fig. 1. Map showing the sampling stations of the studied area.

For heavy metal analysis water samples were filtered through the Whatman Filter Paper No. 42. and acidified with concentrated HCl to lower the pH < 2.0. All these samples were kept in the refrigerator at 4ºC for further analyses.

Heavy metals (Cd, Cr, Cu, Ni and Pb) of the water samples were determined by the AAS method (Model-Perkin Elmer Analyst 800) by using the software Winlab 32™ Changing Technique after digesting the samples with concentrated HNO_3 in the Laboratory of Centre for Advanced Research in Physical, Chemical, Biological and Pharmaceutical Sciences of the University of Dhaka.

Results and Discussion

Heavy metal (Cd, Cr, Cu, Ni, and Pb) concentrations varied in water, sampled in summer and monsoon. The values showed the sequences of Cu > Cr > Cd > Pb > Ni in summer and Pb > Ni > Cr > Cd > Cu in monsoon.

During the summer, Cd concentrations in the Gulshan-Baridhara lake water ranged from 0.068 - 0.091 mg/l. The highest concentration was found at St. 4 and St. 6 and the lowest value was observed at St.10. On the other hand during the monsoon concentrations of Cd ranged between 0.016 and 0.019 mg/l (Fig. 2a). Recommended

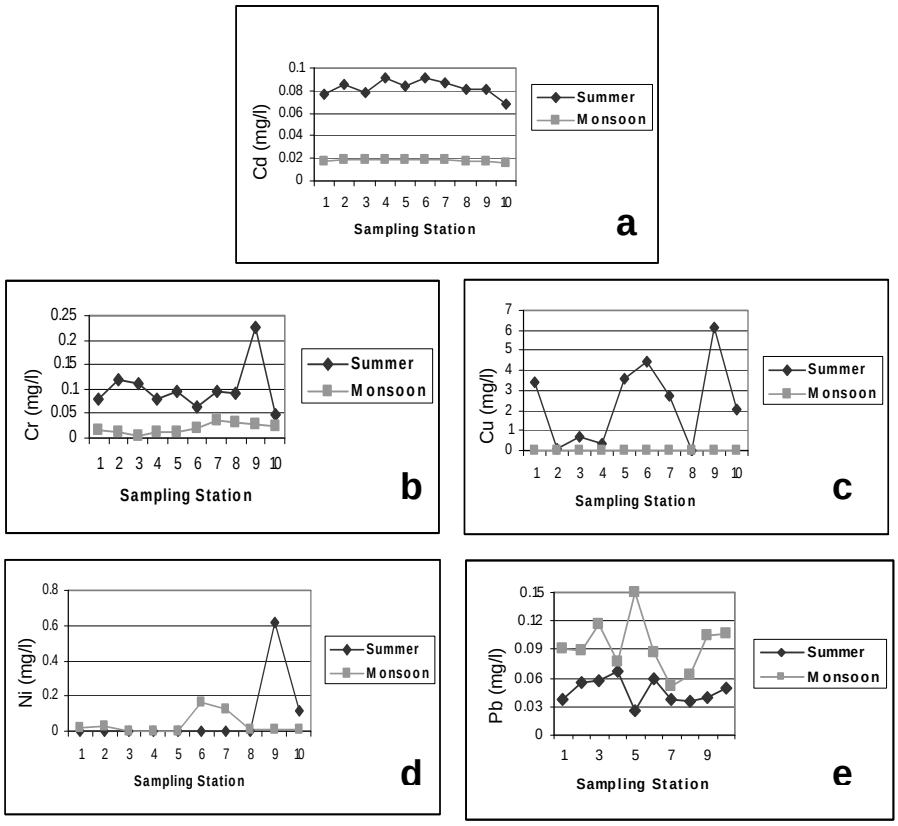

Fig. 2. Concentration of heavy metal in Gulshan-Baridhara lake at different stations and in seasons: (a) Cd, (b) Cr, (c) Cu, (d) Ni and (e) Pb.

value for Cd in surface water criterion is 0.010 mg/l.[10] Values found in the Gulshan-Baridhara lake were well above the surface water criteria limits. Cadmium concentrations also exceeded the drinking water quality standards by GOB[11], WHO[12], and USEPA[13] guideline value (Table 1). Discharge from electro-plating units and zinc smelters are the main source of Cd contamination in water.[14] Metallic and plastic pipes can also contribute Cd in water [15]. High content of Cd in the lake

water might be due to discharge from the small electroplating industries in the catchments of the lake and also from the surface drain pipe or septic tank pipe connected to Gulshan-Baridhara lake.

The mean concentrations of Cd in the lake water were 0.083 and 0.018 mg/l during the summer and monsoon, respectively. The values are above the surface water criterion limit set up by FWPCA.[10]

Chromium concentrations during the summer in the lake varied considerably and ranged from 0.048 - 0.225 mg/l. The highest concentration was observed at St. 9 and the lowest was observed at St. 10. On the other hand during the monsoon the values ranged between 0.005 and 0.035 mg/l (Fig. 2b).

Table 1. Drinking water quality standards.

Parameter (mg/l)	USEPA (2000)[13]	WHO (1993)[12]	Bangladesh (GOB, 1997)[11]
Cd	0.005	0.003	0.01
Cr	0.10	0.05	0.05
Cu	1.31	0-2.0	1.5
Ni	0.10	0.02	-
Pb	0.015	0.01	0.10

Concentration of Cr in the river Karnaphuli was 0.060 mg/l and in the river Halda it was 0.01 mg/l as reported by Bashar *et al.*[16] Dixit and Tiwari[17] found maximum concentration of this metal of 0.2 mg/l in the Shahpura lake of Bhopal, India. Gulshan-Baridhara lake contained much higher values but showed approximately same value as that reported by Dixit and Tiwari.[17] In summer at Sts. 2, 3, and 9 Cr concentration exceeded all standards.[10-13, 18]. High amount of Cr in the lake water might be due to large amounts of particulate matter in the lake, which retained Cr as adsorbed ion. Acute toxicity of Cr to invertebrates is highly variable, depending upon species[19] and the concentration of Cr may create toxic effect on aquatic organisms.

Concentrations of Cu during the summer varied significantly and ranged between 0.101 and 6.135 mg/l. The highest concentration was observed at St. 9. Concentrations were moderate at Sts. 1, 5, 6, 7, and 10. High content of Cu in the lake water at St. 9 might be due to various type of garbage, household materials, cans, etc. which have been piled up near this spots of the lake.

Dixit and Tiwari[17] reported that maximum Cu concentration in the Shahpura lake of Bhopal, India was 1.4 mg/l during the summer while in monsoon it was 0.16 mg/l. Chowdhury *et al.*[20] reported the concentrations of Cu in the three rivers Buriganga, Turag and Shitalakhya and the values ranged from 0.00 - 0.01, 0.03 -

0.07 and 0.00 - 0.05 mg/l, respectively. Compared to these values, Cu concentrations in different seasons in the Gulshan-Baridhara lake were high. Lethal Cu concentration for fish and aquatic invertebrates ranged from 0.02 - 3.0 mg/l.[21] In this respect high Cu content in the lake is also a threat to its fish community and aquatic invertebrates. Every year lots of dead fishes are found to float in the lake water. Seasonal mean concentrations of Cu in Gulshan-Baridhara lake are presented in Fig. 2c. The values exceeded the limit mentioned for drinking-, fishing-, and irrigation water standards.[11-13, 18]

Concentrations of Ni at different stations of the lake water during the summer were below the detection limit. However, at the St. 9, the Ni concentration was 0.623 mg/l. On the other hand, during the monsoon the values ranged from 0.007 - 0.159 mg/l except Sts. 3, 4, and 5. In the latter stations the values were below the detection limit (Fig. 2d). Nickel contents obtained in the present investigation were below the FWPCA[10] standard except at Sts. 6 and 7 during the monsoon. The concentrations were also below the drinking water quality standard (Table 1) but exceeded at Sts. 6 and 7 during the monsoon.

In summer, Pb concentrations ranged between 0.023 and 0.067 mg/l. The highest concentration was observed at St. 4 and the lowest was at St. 5. On the other hand during monsoon, the values ranged from 0.052 - 0.151 mg/l. The highest concentration was found at St. 5 and the lowest was found at St. 7. (Fig. 2e). Lead concentrations were higher in the monsoon than in the summer. In Dhanmondi lake, Pb concentrations varied from 0.151 - 0.210 mg/l during the dry period and from 0.030 - 0.120 mg/l during the wet period as reported by Ali *et al.*[22] Dixit and Tiwari[17] found that in the Shahpura lake of Bhopal, India the highest value of Pb was 2.9 mg/l and the lowest value was 0.1 mg/l during the summer and monsoon, respectively. Compared with the Pb concentration of Gulshan-Baridhara lake, the content of Pb in Shahpura lake was in general higher. Concentrations of Pb exceeded all standards[11-13] but at Sts. 1, 5, 7, 8, and 9 below the guideline value [10]. In monsoon at Sts. 3, 5, 9, and 10 Pb concentrations exceeded the standard values of fishing water, industrial water and irrigation water. [18]

The depletion of heavy metal contents (Cd, Cr, Cu, Ni and Pb) due to seasonal variation in the lake water is presented in Table 2. The data indicated that the depletion factor was not around unity. The depletion factor ranged from 0.49 - 140.73. These values deviated extremely from each other, specially in the case of Cu (depletion factor = 140.73) and Pb (depletion factor = 0.49). However, quite similar depletion factor was observed for Cd and Cr (Table 2).

The depletion factor revealed that the concentration of heavy metals normally decreased in case of Cd and Cr but drastically decreased in case of Cu due to

commencement of monsoon rain. But for Pb the situation is just reverse. Here concentration of Pb drastically increased in monsoon.

Table 2. Depletion in concentrations of heavy metals in Gulshan Baridhara lake depending on seasonal variations.

Compartment	Heavy metal	Depletion factor = Concentrations in summer/ concentrations in monsoon
Water	Cd	4.50
	Cr	5.37
	Cu	140.73
	Ni	2.01
	Pb	0.49

From the results of the experiment it can be clearly stated that the concentrations of studied pollutants were higher during the summer particularly in the month of April, when the rainfall was comparatively low. But during the monsoon the values were in general low and fall within various standard levels.[11-13, 18] This adjustment might have occurred because of rainfall and dilution. Only in the cases of lead, concentration level was high during the monsoon. It might be due to the high percentage of lead in Dhaka's air in recent time, which mixed up with rain water during monsoon and finally reached to the water bodies through precipitation. Lead concentrations exceeded the standards of drinking water at Sts. 1, 5, 7, 8 and 9. When the fishing-, industrial- and irrigation water standards were taken into consideration, Pb concentration exceeded the standard level at Sts. 3, 5, 9 and 10.

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