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European Journal of Experimental Biology, 2012, 2 (6):2192-2198

ISSN: 2248 –9215
CODEN (USA): EJEBAU

Studies on the distribution of heavy metal concentrations in River Adyar, Chennai, Tamil Nadu

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ABSTRACT

To assess the levels of heavy metals and the extent of pollution in the surface water and sediments from the River Adyar, Chennai, the present study has been undertaken. Water and sediment samples were collected from four different stations along the course of the river in Chennai. The concentrations of heavy metals such as Zinc (Zn), Cadmium (Cd), Copper (Cu), Iron (Fe) and Lead (Pb), were determined using Atomic Absorption Spectrophotometer. The ranges of heavy metals in water (µg L^{-1}) and sediment (µg g^{-1}) Zn, Cd, Cu, Fe and Pb were: 0.24-0.40; 0.23-0.36; 0.61-0.83; 4.83-5.00; 0.02-0.05; and 0.79-0.83; 0.72-0.73; 0.64-1.24; 11.91-12.8; and 0.30-0.42, in Ekatuthangal (Station-I), Guindy (Station-II), Saidapet (Station-III) and Kotturpuram (Station-IV) respectively. The heavy metal concentrations in the downstream indicated an increase in the pollution load due to movement of suspended and dissolved industrial effluents and anthropogenic wastes. Except Cadmium and Iron all the heavy metals studied were under permissible limits.

Key words: Adyar River, Heavy metals, Zinc, Cadmium, Copper, Iron, Lead.

INTRODUCTION

Rapid urbanization and industrial development during last decade have provoked some serious concerns in environment. Heavy metal contamination in river is one of the major quality issues in many fast developing cities, as the maintenance of water quality and sanitation infrastructure did not increase along with population and urbanization growth especially for the developing countries [1].

In Chennai city, the increase in population rate exponentially every year demands, more consumption of water and subsequently lead to the generation of enormous quality of waste water. Besides, it is not common to see that the establishments find way into the water system without proper prior treatments. Thus, the waste water is discharged directly into the rivers of Chennai city, River Adyar and River Cooum. Adyar river is the starting point for a new study on quality of water and important rivers of Tamil Nadu taken up by the Anna University in 2007 [2].

Heavy metals are getting important for their non-degradable nature and often accumulate through tropic level causing a deleterious biological effect. Anthropogenic activities like mining, ultimate disposal of treated and untreated waste effluents containing toxic metals as well as metal chelates [3] from industries, thermal power plants etc. and also the indiscriminate use of heavy metal containing fertilizers and pesticides in agriculture rendering serious environmental problem posing threat on human beings and sustaining aquatic biodiversity. Though some of the metals like Cd, Fe, Mn, Ni and Zn are essential as micronutrients for life process in plants and micro organisms, while many other metals like Cd, Cr and Pb have no known physiological activity, but they are proved determined beyond a certain limit [4] which is very much narrow for some elements like Cd (0.0 µg/L), Pb (0.10 µg/L) and Cu

(0.050 µg/L). The deadlier diseases like edema of eyelids, tumor, congestion of natural mucous membranes and pharynx, stuffiness of the head and gastro intestinal, muscular, reproductive, neurological and genetic malfunctions caused by some of these heavy metals [5].

Studies were carried out on the distribution of heavy metals in water and sediments from Indian regions are limited [6-15]. Therefore, the present investigation was conducted to determine the heavy metals (Zn, Cd, Cu, Fe, and Pb) concentrations in the river Adyar, Chennai.

MATERIALS AND METHODS

Study Area

Adyar River runs its way through the southern part of the Chennai city and enters the sea near Adyar. The Adyar River which originates at Chembarampakkam Lake in South Kanchipuram district is important water way though the River Adyar can be traced to a point near Guduvancheri village. It assumes the appearance of stream, only after it receives the surplus water from the Chembarampakkam Lake as well as the drainage from the areas in the south west of the Chennai. Adyar River located south of the Cooum River flows towards the east direction to reach Bay of Bengal. The present investigation was carried out in four sampling stations:

I-Ekatuthangal; II-Guindy; III-Saidapet and IV-Kotturpuram.

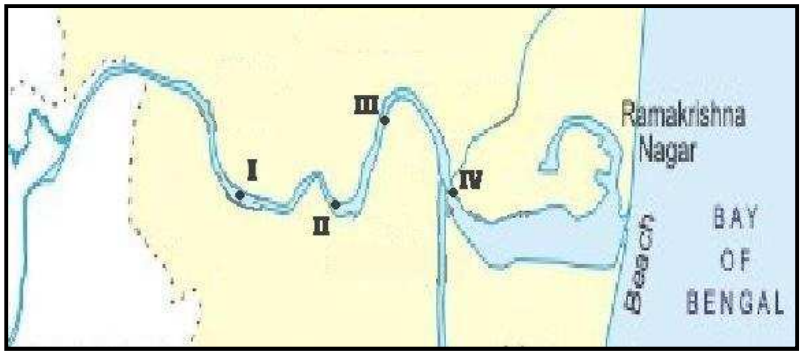

Fig: 1 Map showing the course of River Adyar.

Water samples were collected from four different stations of Adyar River. Criteria for selection of sampling station were based on the locations of industrial units and land use pattern to quantify the heavy metal concentration. The sediment samples were taken from 10 to 15 cm below the water surface using acid washed plastic containers to avoid unpredictable changes in characteristics as per standard procedures [16]. Water samples were collected in polyethylene bottles (washed with detergent then with double distilled water again and finally with sampled water). Water samples were acidified with 10% HNO3 [17] brought to the laboratory and kept refrigerated until needed for analysis. Sediment samples were collected using Eckman grabber and put into wide mouthed plastic containers, kept in ice boxes containing wet ice during the sampling trip and later stored at in deep freezer.

Concentrations of heavy metals in water samples were determined with an Atomic Absorption Spectrophotometer (GCB-Avanta) with a specific lamp for particular metal. Mean value of three replicates were taken for each determination. Appropriate drift blank was taken before the analysis of samples. The working wave length for the heavy metals are 248.3nm for Fe, 213.9nm for Zn, 324.7nm for Cu, 228.8nm for Cd, and 217nm for Pb.

Sediment samples were separated into fine and coarse material by sieving in the laboratory, prior to analysis of 63<gm dry fraction by microwave 2.3 digestion using Nitric acid, this dissolution of the biological metal concentration was undertaken using ICP-AES (Inductive coupled-Atomic Emission Spectroscopy).

RESULTS

Five heavy metals; Cu, Cd, Zn, Pb and Fe were estimated for the concetrations in four selected stations along river Adyar, Chennai. The results observed were represented in Table: 1 and Figures: 2-6. The heavy metal analyzed in the water samples of Adyar river showed the order of Fe > Cu > Zn > Cd > Pb.

In these study areas Fe in station II showed (5.60 µgL^{-1}) followed by station I (4.83 µgL^{-1}) were noticed where as in station III and station IV showed lower concentration of Fe. Cadmium is distinctly toxic and occurs with Zinc in nature. High concentration of Cd was observed in station IV (0.73 µgL^{-1}) and station I (0.72 µgL^{-1}) followed by station II (0.62 µgL^{-1}) and station III (0.52 µgL^{-1}). Copper is an essential trace element widely distributed in nature and also used in industries. Cu concentration was found to the high in station-I and station II(0.83µgL^{-1} and 0.80µgL^{-1}) and in station-III & IV, the Cu concentration was recorded as (0.61 µgL^{-1} and 0.62 µgL^{-1}) respectively.

Table: 1 Mean Concentration of heavy metal distribution in the water of River Adyar

Station	Heavy Metals In Water (µg L^{-1})				
	Fe	Cu	Zn	Cd	Pb
1.	4.83	0.83	0.40	0.36	0.06
2.	5.60	0.80	0.32	0.38	0.02
3.	4.08	0.62	0.36	0.21	0.04
4.	5.00	0.61	0.24	0.23	0.02

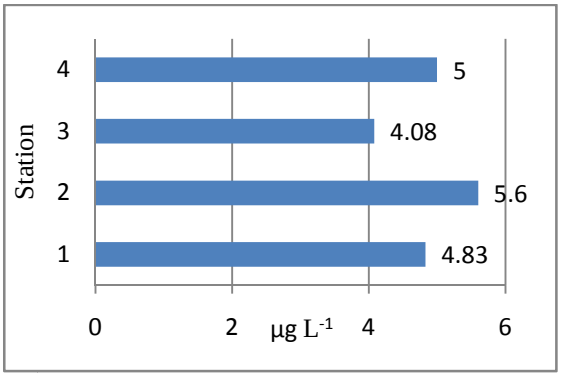

Fig-2: Distribution of Fe concentration in the water of River Adyar.

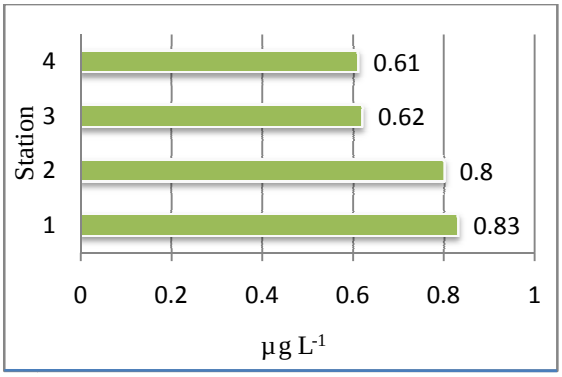

Fig-3: Distribution of Cu concentration in the water of River Adyar.

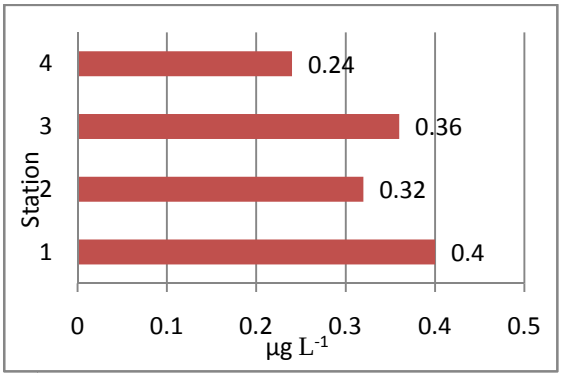

Fig-4: Distribution of Zn concentration in the water of River Adyar

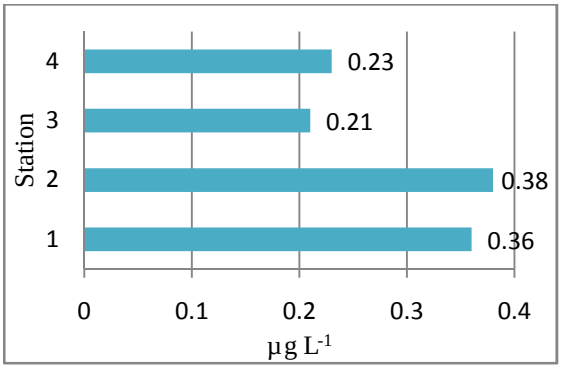

Fig-5: Distribution of Cd concentration in the water of River Adyar.

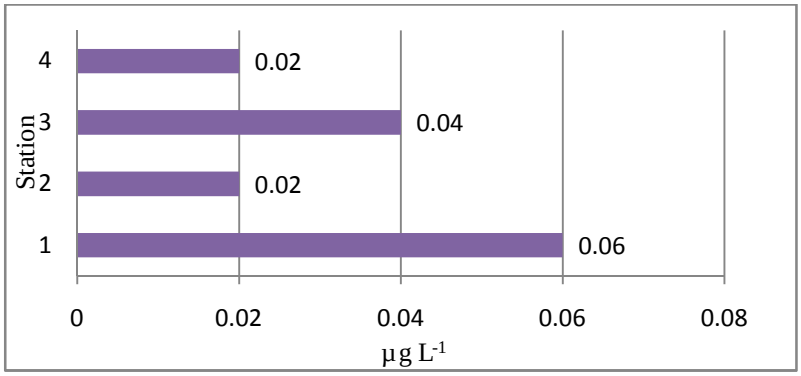

Fig-6: Distribution of Pb concentration in the water of River Adyar.

Mean concentration of heavy metal Zn was higher level in station I (0.40 µgL^{-1}) and lower levels in station IV (0.24 µgL^{-1}) and followed by station II and III (0.32 µgL^{-1},0.36µgL^{-1}).

The levels of heavy metals recorded in Adyar river sediments are presented in Table: 2; Figures: 7-11.The heavy metals analyzed in the sediment samples of Adyar river showed the order Fe > Zn > Cd > Cu > Pb. The distribution of heavy metal showed the range of (Fe 11.91-12.8µg g^{-1}; Zn 0.48-0.83µg g^{-1}; Cd 0.52-0.73µg g^{-1}; Cu 0.44-1.24µg g^{-1}; Pb 0.26-0.42 µg g^{-1}).

Table 2: Mean Concentration of heavy metal distribution in the sediment of River Adyar.

Station	Heavy Metals In Sediment (µg g^{-1})				
	Fe	Zn	Cd	Cu	Pb
1.	12.8	0.83	0.72	0.64	0.42
2.	12.2	0.48	0.62	0.52	0.38
3.	12.4	0.60	0.52	0.44	0.26
4.	11.91	0.79	0.73	1.24	0.30

The higher concentration of Fe in station I (12.8µg g^{-1}) was recorded in the sediment sample followed by station III (12.4 µg g^{-1}) whereas in station II(12.2µg g^{-1}) and station IV (11.91µg g^{-1}) the Fe concentration were lower. The maximum Zn concentration in the sediment of river Adyar was observed in station I (0.83 µg g^{-1}) and lower concentration of Zinc in station II (0.48 µg g^{-1}) whereas in station III and station IV the Zn concentration in sediment were 0.60µg g^{-1} and 0.79µg g^{-1} respectively. The major source of Cd is the coal composition metal industry and waste incineration. The higher concentration of Cd was observed in station IV (0.73µg g^{-1}) and lower concentration of Cadmium was observed in station III (0.52µg g^{-1}) whereas in station I and II the Cd concentration in sediments were 0.72µg g^{-1} and 0.62µg g^{-1} respectively.

The higher concentration of Cu in station IV (1.24µg g^{-1}) was recorded in the sediment sample followed station I (0.64µg g^{-1}) whereas in station II (0.52µg g^{-1}) and station III (0.4µg g^{-1}) the Cu concentration were lower. Mean concentration of heavy metal Pb was higher and in station I (0.42µg g^{-1}) and followed by station II and station IV (0.38µg g^{-1},0.30µg g^{-1}).

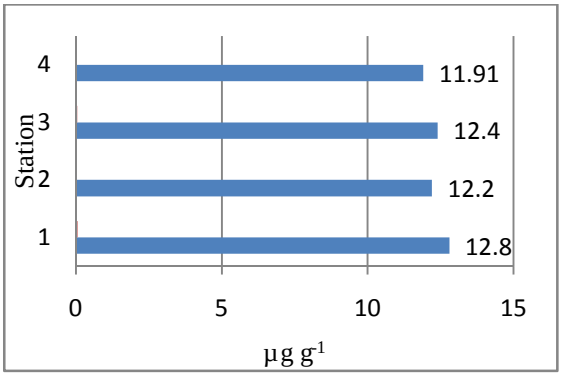

Fig-7: Distribution of Fe Concentration in the sediment of River Adyar.

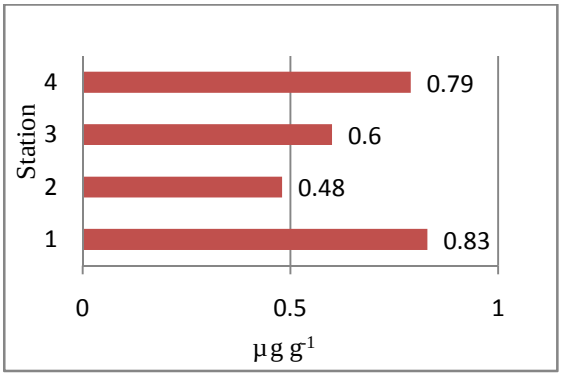

Fig-8: Distribution of Zn Concentration in the sediment of River Adyar.

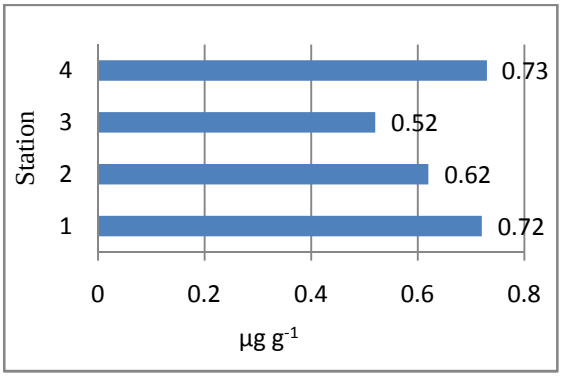

Fig-9: Distribution of Cd Concentration in the sediment of River Adyar.

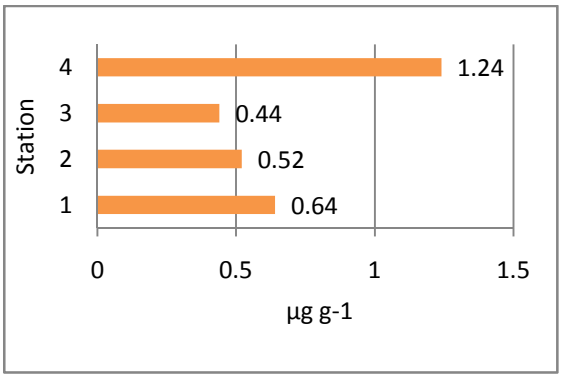

Fig-10: Distribution of Cu Concentration in the sediment of River Adyar.

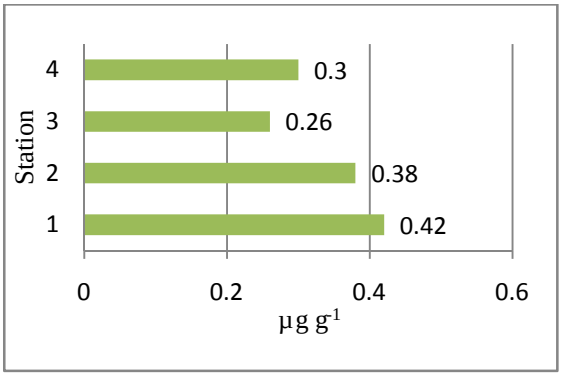

Fig-11: Distribution of Pb Concentration in the sediment of River Adyar.

DISCUSSION

Heavy metal pollution of rivers and lakes is a matter of great concern in any ecosystem especially in wet lands and water masses due to human toxicity and bio accumulative effect. In this regard heavy metal pollution of Adyar River is of great interest due to its economic and domestic implication in Chennai city generally pointed to lower concentration of heavy metal pollution compared to other areas of the world. [18] reported that the effluent from paper industry contains variety of organic and toxic heavy metals. Now days in our country so many Rivers are being polluted by heavy metals [19]. The higher concentration of metals observed during monsoon could be attributed to the heavy rainfall and sub sequent river runoff, bringing much industrial and land derived materials along with domestic, municipal and agricultural wastes, which include resides of heavy metal containing pesticides.

Iron has an essential role as a constituent of enzymes, such as cytochromes and catalase, and of oxygen transporting proteins, such as haemoglobin and myoglobin. In fresh waters, iron is also and important nutrient for algae and other organisms. Due to its high abundance with in the earth crust, Iron is ubiquitous in all fresh water environments and often reaches significantly higher concentrations in water and sediments than other trace metals. High iron concentration in fresh waters has long been considered a problem. In domestic use, iron-enriched waters may induce rust formation on plumbing fixtures, the staining of laundry and a metallic taste in drinking water. Hence, much effort has been put into the retention of iron in drinking water. The mining of iron rich ores has caused the degradation of many river ecosystems [20]. Excess of iron will also influence the presence of bacteria (Iron-reducing) in fresh water. It affects target organs like liver, cardio vascular system and kidney [21].

Copper in the aquatic environment go along with a heavy growing automobile traffic. Copper metals have a tendency to from complexes with suitable organic species present in water. In the course of stagnation of water, the portion of Cu ions interact with organic species (coming from industrial wastes) having potential complexion ability to precipitate out as in soluble as complex and deposit on the river bed and percolate towards water table. The high concentration of Cu in water is toxic to human body and causes hypertensions, uremia and also produces pathological changes in brain tissues [19].

The levels of Zinc were found to be higher in all the sediment samples collected near industrial areas than the sample collected away from industrial area. Smelting of Zinc ores is the main source of pollution from Zinc. Municipal refuse, automobiles and agricultural use of pesticides and fungicides containing ZnSo4 are the additional sources of environmental pollution due to Zinc. Zinc is very essential micronutrient in human beings and only at very high concentration it may cause harmful effects. Zinc influences growth rate and bone development. The deficiency of zinc manifests itself by retardation of growth, anorexia, lesions of the skin and appendages, impaired development and function of reproductive organ [22].

Cadmium is a crystalline non-essential metal and its static state in the natural environment is Cd [19]. Cd is one of the most dangerous pollutants due to its high-potential toxic effects. Cadmium is extremely toxic and the primary use of water high in Cd could cause renal disease and cancer to consumers [23]. The high concentration of cadmium may be due to input of sewage of discharge of industrial metal or plastic pipes constitute a possible source of Cd in water. Like other metals in solution cadmium tends to be absorbed by suspended particles and bottom sediments. For this reason even in polluted rivers the cadmium levels in the water phase may be below the detectable limit [24]. Cadmium toxicity may results in hyper tension, hepatic injury, lung damage, teratogenicity and bone defects [25]. [26] has observed minimal Pb concentration during pre monsoon and summer and maximal during monsoon season from Pondicherry marine environs. The relative enrichment of Cd and as in the near shore sediments during the post

monsoon could be attributed to the particulate fractions derived from the river runoff caused by monsoonal flow and occurrence of relatively higher percentage of in addition to the natural sources of heavy metals in the coastal waters [27].

Lead in water mainly comes from lead processing industries, or due to the use of lead pipes. Natural and untreated water supplies contain about 0.01-0.03 g/L of lead. Problems exist however in areas with soft slightly alkaline water which may dissolve lead from the lead pipes, plastic pipes in which lead has been used as a stabilizer [24]. Contamination of lead in water is a potential problem. The major biochemical effect of lead is its interface with haemosynthesis, which leads to haematological damage. Lead plays an important role in biomethylation. Higher levels of lead in the blood can cause kidney dysfunction and brain damage because it is toxic to the central and peripheral nervous system [22].

CONCLUSION

The concentration of heavy metals from two different samples water and sediment from four different stations of Adyar River were determined. The results indicated that there was a low concentration of heavy metals in water than in sediment samples and River Adyar has significant basal contamination levels that do not reach those of clearly polluted areas. However there is a need for monitoring pollution levels in the river.

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