NUTRIENTS AND HEAVY METAL PROFILE OF MADIVALA LAKE, BANGALORE SOUTH, KARNATAKA

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ABSTRACT

Analysis of Heavy metal iron (Fe), zinc (Zn), copper (Cu), nickel (Ni), chromium (Cr), lead (Pb) and cadmium (Cd) for the parameters like water, plants, sediment and fish was carried out in Madivala Lake Bangalore South . The analysis reveals that the Madivala lake is contaminated by certain heavy metals. The sequence of the order of the concentrations of the metals in general was : for water samples in 8 various stations Cr > Ni > Pb > Cu > Fe > Zn, for 7 Plant Species Cd > Cr > Fe ≈ Zn ≈ Cu ≈ Pb, for 8 soil samples and for 5 fish Species Cd > Cr > Fe > Zn ≈ Cu > Pb , Pb > Cu ≈ Cr > Zn ≈ Ni > Fe, and in particular the heavy metal concentration for various parameters was Water > Plants> Sediments > Fish respectively. The geoaccumulation indices of the heavy metals revealed that the tank is heavily contaminated. This might increase the bioaccumulation levels in fish and increase the actual dose of metals to which the local population will be exposed.

Key words: *Madivala Lake ; Health risk; Heavy metal contamination.*

INTRODUCTION

Lakes are a dynamic inland aquatic system that supports and maintains a balanced adaptive community of organisms having diverse species composition, and the functional organization of all the organisms supports a unique biotic integrity. Lakes, the major life supporting systems, are facing ecological degradation today, due to undesirable anthropogenic activities. The undesirable activities and unscientific utilization of resources from the lakes have caused undesirable environmental problems, thus threatening the biodiversity sustained by it. It is again important to note that these species-rich aquatic ecosystems are capable of self maintaining,

however the delicate equilibrium is sensitive to external stimuli such as human activities promoted by socio-economic goals. Exercising a control on the prevailing anthropogenic activities is necessary to sustain these socio-economically and bio-aesthetically important aquatic ecosystems. These aquatic ecosystems representing the highest levels of ecological integration clearly emphasizes the obligatory relationships, interdependence and interactions. The rich biodiversity sustained by nature in these lakes is as a result of the interweaved functioning of several complex factors. Limnobiotic status of certain lakes as studied by limnologists showed that several physical, chemical and biological factors act simultaneously to influence the biotic fluctuations.[1-3]

Bangalore lies in the southeast of the South Indian state of Karnataka. It is in the heart of the Mysore Plateau, at an average elevation of 920 m. It is positioned at 12.97° N 77.56° E and covers an area of 741 km^2. Bangalore receives about 900 mm of rain annually, the wettest months being August, September, October Bangalore's pollution is not only affecting our health. It could actually be draining this city of its colour. Around 30 years ago, in Bangalore, there were about 262 lakes which subsequently reduced to 81. As reported, these lakes were created for drinking, bathing, agricultural, recreational and fishing purposes as there was no river which flows throughout the year.

Due to its undulating topography, although it rains heavily (870 mm over a period of nearly 8 months in a year), the rain water is not available for various uses. It is this reason that the protection of existing lakes and their water quality is of utmost importance. Therefore, the rain waters are stored in lakes and ground water aquifers are allowed to constantly recharge. South Zonal Office, CPCB, Bangalore, has been regularly (on monthly basis) monitoring the water quality of Ulsoor, Madiwala and Sankey tanks respectively right since 1997 and it is an ongoing activity.[5,6,8]

Industrial, agricultural and domestic wastes are continuously discharged into water-bodies. Such pollutants, particularly heavy metals, can endanger public health by being incorporated into the food chain. Heavy metals are not biologically degraded like many organic pollutants; thus, heavy metals tend to accumulate, particularly in sediments in association with organic and inorganic matter, and involves adsorption, complex formation and chemical combination. this is the beautiful lake called the madivala lake in south Bangalore. but like many water bodies of Bangalore this too is threatened with pollution. This paper documents and discusses the results of an investigation of heavy metal concentrations in various components of a man-made tropical lake, Madivala lake area is 114.3 hectare, shore line is 5.84 k.m., depth is 4.5m, breadth is 0.7km and length is 1.8 k.m. Karnataka State Forest Department carries out the routine maintenance of this lake. Children park and boating facility are available. Madiwala lake receives sewage and storm water from surroundings localities. Untreated sewerage flows in to the lake from Bommanahally CMC area kodichikkanahally side the lake is dirty, and full of hyacinth weeds.

To many people, heavy metal pollution is a problem associated with areas of intensive industry. However, roadways and automobiles now are considered to be one of the largest sources of heavy metals. Zinc, copper, and lead are three of the most common heavy metals released from road travel, accounting for at least 90 of the total metals in road runoff. Lead concentrations, however, consistently have been decreasing since leaded gasoline was discontinued. Smaller amounts of many other metals, such as nickel and cadmium, are also found in road runoff and exhaust.

About half of the zinc and copper contribution to the environment from urbanization is from automobiles. Brakes release copper, while tire wear releases zinc. Motor oil also tends to accumulate metals as it comes into contact with surrounding parts as the engine runs, so oil leaks become another pathway by which metals enter the environment. On the road surface, most heavy metals become bound to the surfaces of road dust or other particulates. During precipitation, the bound metals will either become soluble (dissolved) or be swept off the roadway with the dust. In either case, the metals enter the soil or are channelled into a storm drain. Whether in the soil or aquatic environment, metals can be transported by several processes. These processes are governed by the chemical nature of metals, soil and sediment particles, and the pH of the surrounding environment. Most heavy metals are cations, meaning they carry a positive charge. Zinc and copper, for instance, both carry a 2^+ charge. Soil particles and loose dust also carry charges. Most clay minerals have a net negative charge. Soil organic matter tends to have a variety of charged sites on their surfaces, some positive and some negative.[9-11] The negative charges of these various soil particles tend to attract and bind the metal cations and prevent them from becoming soluble and dissolved in water. The soluble form of metals is thought to be more dangerous because it easily is transported and more readily available to plants and animals. By contrast, soil bound metals tend to stay in place.

Metal behaviour in the aquatic (streams, lakes and rivers) environment is surprisingly similar to that outside a water body. Streambed sediments exhibit the same binding characteristics found in the normal soil environment. As a result, many heavy metals tend to be sequestered at the bottom of water bodies. Some of these metals will dissolve. The aquatic environment is more susceptible to the harmful effects of heavy metal pollution because aquatic organisms are in close and prolonged contact with the soluble metals[12]. pH tends to be a master variable in this whole process. pH is a measure of the concentration of hydrogen (H^+) ions dissolved in water. H^+ is the ion that causes acidity; however, it is also a cation. As a cation it is attracted to the negative charges of the soil and sediment particles. In acid conditions, there are enough H^+ ions in to occupy many of the negatively charged surfaces of clay and organic matter. Little room is left to bind metals, and as a result, more metals remain in the soluble phase.

EXPERIMENTAL

The seven sampling stations that were selected based on topography and other significant features, five were positioned in lake while two were in a sewage inlet drain. Samples of water, soil, plants and fish were collected during Jan & Feb 2008. The water samples were analyzed for pH, Conductivity, total Nitrogen, Phosphate, Potassium, and Sulphur as per the standard methods.[14] The analysis of heavy metals [iron (Fe), cadmium (Cd), zinc (Zn), copper (Cu), lead (Pb) nickel and chromium (Cr)] in water, Soil, Plants and fish was also performed[1].

Methodology

Electrical conductivity (EC) of the water samples and EC of the soil samples was determined from saturation extract by conductivity meter. Measurement of pH of the water and soil samples were done (soil and water ratio 1:25) with help of a glass electrode pH meter. Plant, water and soil samples were digested for the determination of total Nitrogen (N_2) following Kjeldahl's method. For the determination of Sulfur (S), Potassium (K), Phosphorus (P), iron (Fe), cadmium (Cd), zinc (Zn), copper (Cu), lead (Pb) nickel and chromium (Cr). Plant samples were digested with Nitric Acid (HNO_3), Perchloric Acid ($HClO_4$) mixture (2:1) in a closed system. Phosphorus contents of samples were determined by Vanadomolybdate yellow colour method. Sulphur contents of the samples were determined by the method of Hunt. Potassium contents of the samples were determined by Flame photometer. Heavy metals were determined by atomic absorption spectrophotometer (GBC Avanta version1.31).

Samplings had been carried out in the month of February 2008. Water samples (500 ml) were filtered using Whatman No.41 filter paper for estimation of dissolved metal content and preserved with 2 ml nitric acid to prevent the precipitation of metals. Both the samples were concentrated to tenfold on a water bath and subjected to nitric acid digestion using the microwave-assisted technique.

Sediments samples at surface level (0–10 cm in depth) were collected from the same locations where the plants were sampled[13]. Soil samples were air-dried and ground into fine powder, filtered and digested with aqua regia on a sand bath for 2 hr. After evaporation to near dryness, the samples were dissolved with 10 ml of 2% nitric acid, filtered and then diluted to 50 ml with distilled water.

The tested six plant species (Table -3 and Fig-3) Enhydra fluctuans Lour, Spilanthes acmella L., Polygonum hydropiper L., Cyperus rotundus L., Echinochloa colonum L. (radish (Raphanus sativus L.), wallflower (Cheiranthus cheiri L), erysimum (Erysimum cheiranthoides L), orache (Atriplex hortensis L.), sorrel (Rumex acetosa L.), and antirrhinum (Antirrhinummajus L.) were thoroughly washed to remove all adhered soil particles. Samples were cut into small pieces, air-dried for 2 days and finally dried at 100 ^oC in an hot-air oven for 3 h. The samples were ground in warm condition and passed through 1 mm sieve[15]. Digestion of these samples (2 g each) was carried out using 10 ml nitric acid, according to the procedure used for soil samples.

Study of fish muscle, for commercially important fishes like Etroplus suratensis, Murrels (Channa marulius), Catfishes (Heteropneustes fossilis) and small palaemonid prawns were investigated for the amount of heavy metals shown in Table 3. About 1 g of fish sample was weighed, digested, then 5 m1 Conc. H_2SO_4, 4 m1 1:1 HCl and 0.2 m1 of 2% sodium molybdate were added.. The mixture was gently refluxed for 1 hour and cooled; then 4 m1 of 1:1 nitric acid/perchloric acid was added, boiled and diluted to a final 50 m1. A portion was taken for the determination of Fe, Cd, Co, Cr, Zn, Cu and Pb.[4]

RESULTS AND DISCUSSION

Madivala Lake receives untreated domestic sewage from residential areas in Bangalore city. Soil pH values as affected by industrial effluents are presented in **Table 1**. It is revealed from the data that pH values showed variation with distance from the influent source to effluent sources. The values ranged from 6.67 to 8.55. Although the pH values of Bommanahally CMC area and Kodichikkanahally side area are maximum. Electrical conductivity is a measure of the dissolved salts present in soil and water. The values of water and Saturation extract of the soil varied in the range of 114 to 1788 **$\mu S\ cm^{-1}$**. The EC values varied irregularly in relation to distance (**Table 1**), i.e., due to the connection of different drainage systems. Nutrient contents of the Soil and water samples were analyzed for N, P, K and S which are essential for plant growth. Different kinds of plants were found to grow in Station 6 and 7. There was no difference in total Nitrogen content of the water samples (**Table 2**). Soils from these stations however showed extreme variation in the total nitrogen contents of the soils. The nitrogen content varied between 785 and 4850 ppm in influent and effluent areas. (**Table 2**). The higher contents of total nitrogen in soils are due to the untreated sewage water. The contents of total nitrogen in the plant samples varied between 6760.00 and 32240.00 ppm, The uptake of nitrogen by different plant species varied considerably. EchinochloacolonumL.(radish (Raphanus sativus L.) showed the highest percentage of nitrogen and lowest value was shown by orache (Atriplex hortensis L.) (**Fig3).** Potassium, sulphur and phosphorus values decreased with the distance in all the tested parameters. Heavy metal Fe concentration was maximum in plant orache (Atriplex hortensis L.) 160.57 ppm,Cu in plant orache (Atriplex hortensis L.)27.6ppm, Cd in plant sorrel (Rumex acetosa L.) 1.34ppm, Zn in fish Ruditapes decussates 160ppm (Fig-4) **,** Cu in

Echinochloacolonum L. radish (Raphanus sativus L.) 219.18ppm and chromium was maximum in plant orache (Atriplex hortensis L.) 82.0 ppm. In general the heavy metals concentration in, water samples Cr > Ni > Pb > Cu > Fe > Zn, plants was Cd > Cr > Fe ≈ Zn ≈ Cu ≈ Pb, in fish Cd > Cr > Fe > Zn ≈ Cu> Pb and in soil samples was Pb > Cu ≈ Cr > Zn ≈ Ni > Fe

CONCLUSION

Water pollution is not only an aesthetic problem, but a serious economic and public health problem as well. Periodical monitoring of the water quality is thus required to assess the condition of surface water. This will be helpful in saving the lake from further degradation. The results obtained in this investigation provides the characteristics of water most of all parameters are within the permissible limits prescribed except Calcium, Magnesium, Zinc, Lead and Nickel. The overall quality of water in not suitable for the harvest of fish. The levels of trace elements such as Zinc, Lead and Nickel are to be taken care of as far as the total quality is concerned. They all play significant roles in metabolic processes. In view of the importance of fish to diet of man, it is necessary that biological monitoring of the water and fish meant for consumption should be done regularly to ensure continuous safety of food. Safe disposal of domestic sewage and industrial effluents is not practiced.

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Table-1:Nutrients And Heavy Metal concentration (For Soil Parameter) of Madivala Lake, Bangalore.

Stations	pH	EC µS cm^{-1}	Total N	K ppm	S ppm	P ppm	Fe ppm	Cd ppm	Zn ppm	Cu ppm	Pb ppm	Cr ppm
S_1	7.03	933	11.07	119.07	218.75	2.50	0.18	0.01	0.09	<0.01	0.27	0.35
S_2	6.81	1788	10.96	109.96	984.35	13.12	1.14	0.01	0.03	0.01	0.22	0.31
S_3	8.17	1247	12.50	29.29	992.12	6.25	2.04	0.01	0.06	0.02	0.15	0.25
S_4	7.19	1000	11.04	10.54	355.93	3.12	3.45	0.01	0.03	0.01	0.39	0.12
S_5	8.02	1017	10.39	18.42	515.62	4.75	5.44	0.01	0.43	<0.01	0.20	0.31
S_6	7.17	160	11.52	13.69	226.30	1.75	5.60	0.01	0.05	0.01	0.63	0.30
S_7	7.18	114	11.35	11.47	725.00	1.87	5.69	0.01	0.06	<0.01	0.65	0.36

Table-2 :Nutrients and Heavy Metal concentration (For water parameter) in Madivala Lake, Bangalore .

Stations	pH	EC µS cm^{-1}	Total N ppm	K ppm	S ppm	P ppm	Fe ppm	Cd ppm	Zn ppm	Cu ppm	Pb ppm	Cr ppm
S_1	6.65	467	1077.00	1790.70	10850.00	40.00	0.12	0.22	1.6	1.7	2.67	1.6
S_2	6.78	245	2296.00	1899.60	6380.00	230.00	0.15	1.85	2.55	2.4	219.1[illegible]	1.8
S_3	7.10	715	755.00	992.90	7230.00	450.00	0.24	0.96	5.64	4.5	29.67	2.6
S_4	7.24	475	610.40	1853.60	8410.00	350.00	0.25	1.28	6.89	11.5	32.00	9.5
S_5	7.55	397	388.90	2642.10	5310.00	100.00	1.23	1.42	5.45	22.8	30.88	18.5
S_6	7.45	1212	4852.00	2369.00	6470.00	170.00	1.78	1.08	23.55	23.6	26.07	17.3
S_7	7.30	1234	4834.80	2747.00	3360.00	70.00	2.79	1.38	27.50	26.1	36.61	31.2

Table-3 :Heavy Metals Concentration (For plants Species) grown in around Madivala Lake, Bangalore

Plant Samples	Total N ppm	Fe ppm	Cd ppm	Zn ppm	Cu ppm	Pb ppm	Cr ppm
Enhydra fluctuans Lour	28040.00	0.03	1.06	11.0	6.0	2.67	4.8
EchinochloacolonumL.(radish (Raphanus sativus L.)	32240.00	0.34	0.32	13.5	7.3	219.18	5.5
wallflower (Cheiranthus cheiri L)	22340.00	0.32	1.04	24.0	8.5	29.67	11.5
erysimum (Erysimum cheiranthoides L)	24490.00	0.08	0.87	34.0	12.6	32.00	32.4
antirrhinum (Antirrhinummajus L.)	10840.00	80.43	0.82	88.9	25.0	30.88	62.6
sorrel (Rumex acetosa L.)	11870.00	123.67	1.34	95.4	26.4	26.07	56.5
orache (Atriplex hortensis L.)	6760.00	160.57	1.01	105.0	27.6	36.61	82.0

Table-4 :Heavy Metals Concentration (For Fish Species) Harvested in Madivala Lake, Bangalore

Fish Samples	Fe ppm	Cd ppm	Zn ppm	Cu ppm	Pb ppm	Cr ppm
Etroplus suratensis	31.0	1.06	17.0	2.3	2.67	<0.01
catfishes (Heteropneustes fosillis)	34.0	0.32	28.5	2.4	19.14	<0.01
Murrels (Channa marulius)	45.0	1.04	145.5	2.4	29.67	<0.01
palaemonid prawns	95.45	0.87	153.5	2.3	32.00	0.44
Ruditapes decussatus	112.0	0.82	160.0	4.9	30.88	0.47

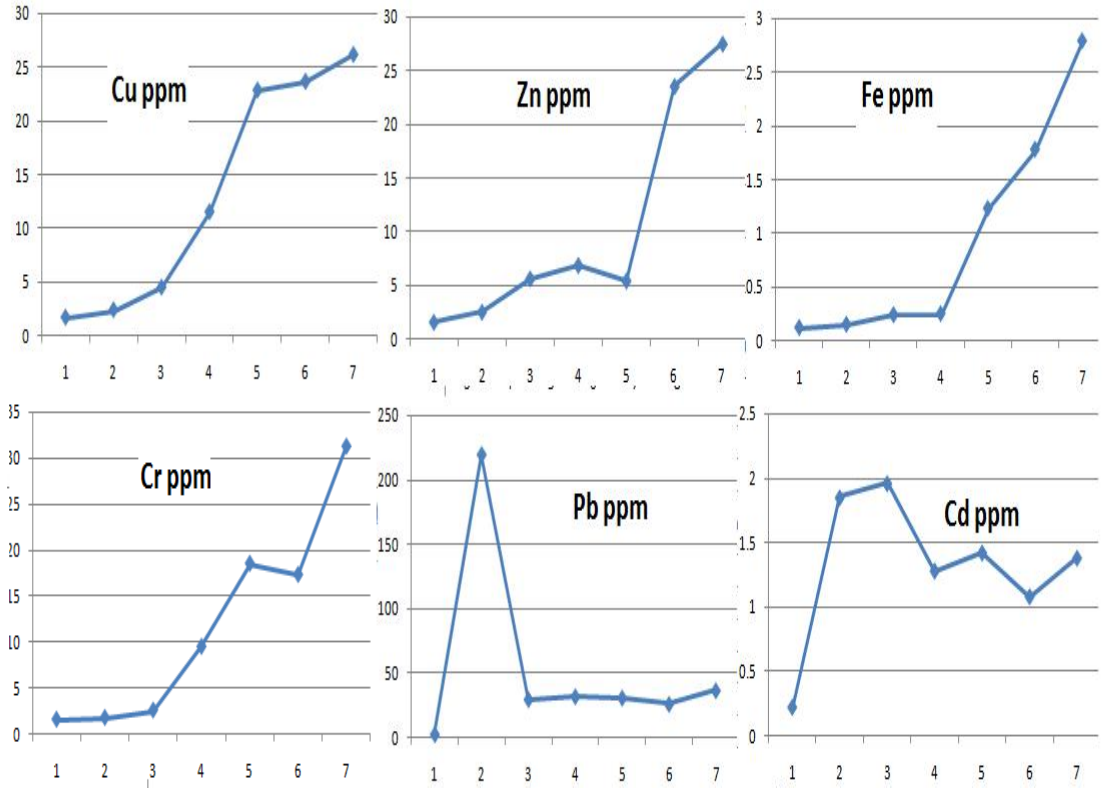


Figure -1 Heavy metal concentration of Soil Parameter in seven Stations of Madivala Lake, Bangalore

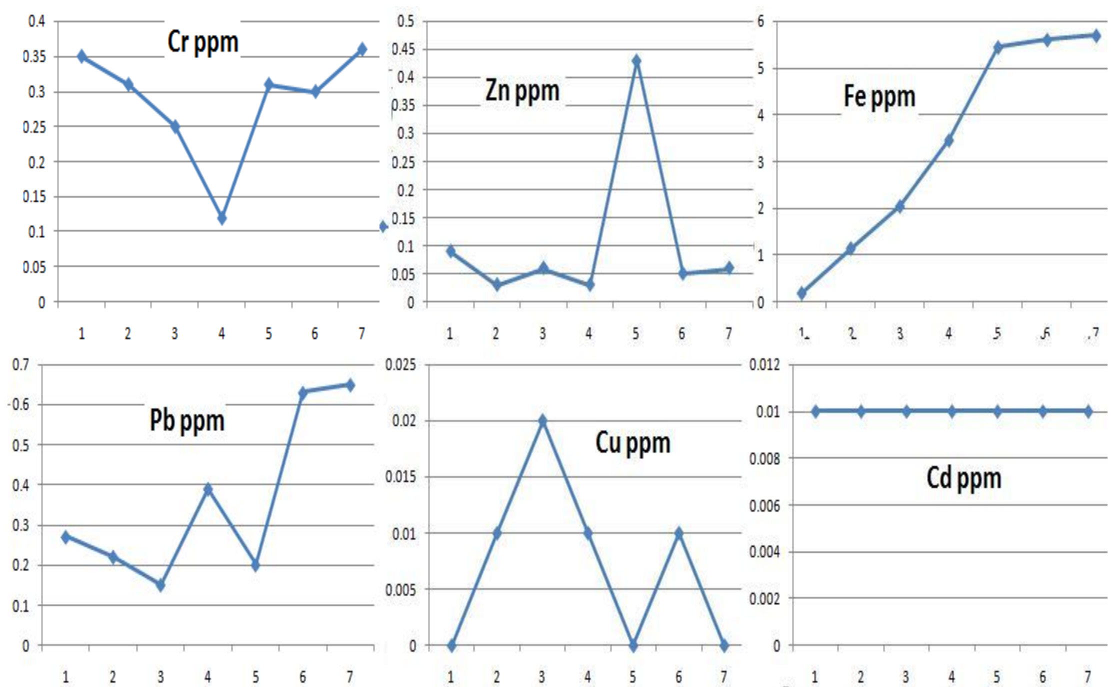
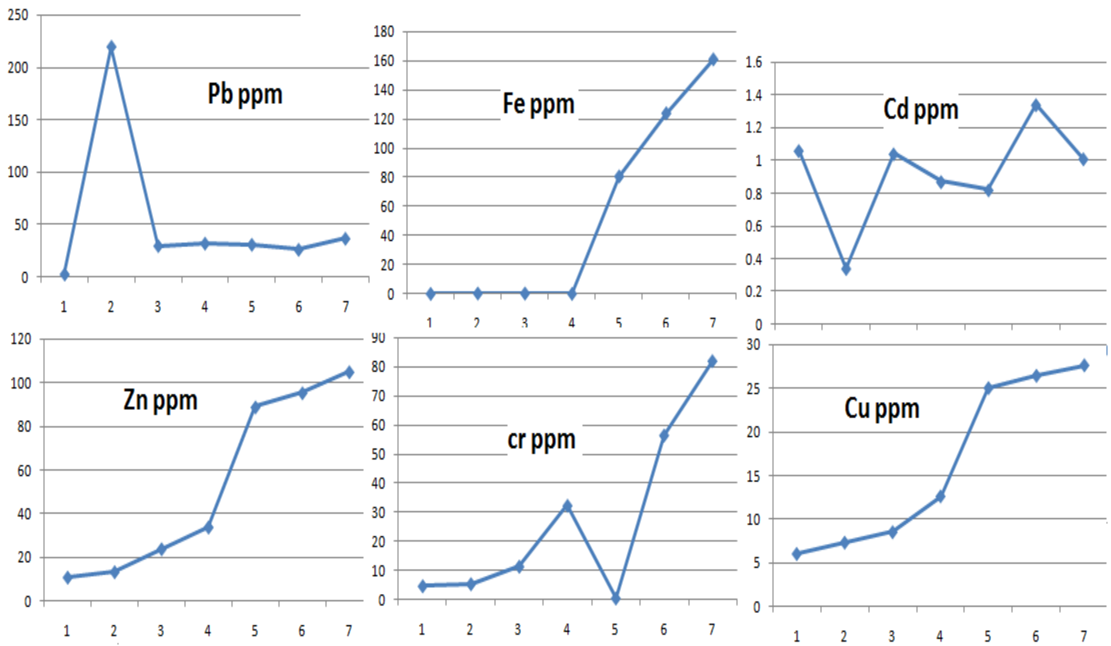
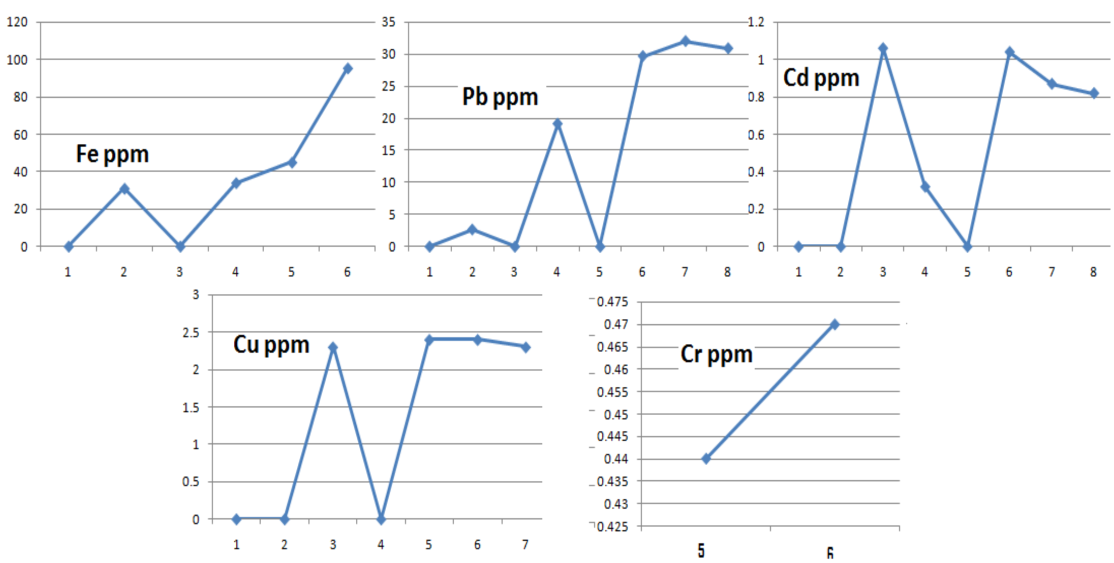


Figure -2 Heavy Metal Concentration of water parameter in seven Stations of Madivala Lake, Bangalore



1.Enhydra fluctuans Lour 2.EchinochloacolonumL.(radish (Raphanus sativus L.) 3.wallflower (Cheiranthus cheiri L) 4.erysimum (Erysimum cheiranthoides L) 5.antirrhinum (Antirrhinummajus L.) 6.sorrel (Rumex acetosa L.) 7. orache (Atriplex hortensis L.)

Figure-3 Heavy Metal level in Plants of Madivala Lake, Bangalore



1.Etroplus suratensis **2.**catfishes (Heteropneustes 3.Murrels (Channa marulius) 4.palaemonid prawns 5.Ruditapes decussatus

Figure-4 Heavy metal Levels in Fish Samples of Madivala lake, Bangalore

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