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Original Research Paper

Phytoremediation Study of Aquatic Macrophytes Collected from Five Lakes of Bangalore, India

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ABSTRACT

A phytoremediation study was carried out at 5 major lakes of Bangalore to ascertain the degree of heavy metal contamination. The study focused on assessment of heavy metal accumulation in three aquatic macrophytes used as biomonitors, in comparison with water and sediments (abiotic monitors) for phytoremediation. The aquatic plants (biomonitors) *Hydrilla verticillata, Nelumbo nucifera, Eichhornia crassipes* were analysed along with sediments and water for Cu, Co, Pb, Zn and Ni contamination in five lakes (Aggrahara, Arakere, Naganaikanakere, Amblipura and Hulimavu). The order of accumulation of heavy metals was observed, in general, was Hulimavu > Ambalipura > Naganaikanakere > Arakere > Aggrahara. Based on the concentration, the toxicity status observed in macrophytes was *H. verticillata* > *N. nucifera* > *E. crassipes.* The heavy metals are arranged in the following descending order: Cu > Zn > Pb > Co > Ni in macrophytes; Zn > Cu > Ni > Pb > Co in water and Zn > Cu > Ni > Co > Pb in sediments. The selected biotic species showed maximum absorption of copper and zinc in all the lakes.

INTRODUCTION

Heavy metal pollution is one of the main problems for the ecosystems due to technological development. Diverse industrial wastes have aggravated the problem of water pollution. This problem becomes complex because of the qualitative and quantitative differences in pollution according to the industries involved, and due to the non-degradability of inorganic pollutants like heavy metals which are hazardous when discharged into a water body (Abida Begum et al. 2008a, b, 2009a, b). Several studies have shown that constructed wetlands are very effective in removing heavy metals from polluted wastewaters. Algae and aquatic plants play a key role in aquatic ecosystems because they are at the base of food webs. Also, they are a food resource and provide oxygen and shelter for many aquatic organisms. They also contribute to the stabilisation of sediments and bioconcentration of compounds and are used as bioremediatives. Direct discharge of contaminants increase the concentration of trace elements in aquatic systems, thus, resulting in their accumulation in sediments. In aquatic systems, where pollutant inputs are discontinuous and pollutants are quickly diluted, analyses of plants provide time-integrated information about the quality of the system (Abida Begum & Harikrishna 2008). Phytoremediation has several advantages and is the most significant one in study of sublethal levels of bioaccumulated contaminants within the tissues /components of organisms, which indicate the net amount of pollutants integrated over a period of time. Biomonitoring of pollutants using some plants as accumulator species, accumulate relatively large amounts of certain pollutants, even from much diluted solutions without obvious noxious effects.

MATERIALS AND METHODS

The description of the lakes taken in the study is given in Table 1. Surface water and composite sediment samples during January 2009 to March 2009 were collected at random from different areas of the lakes, covering all directions. The water samples were filtered and preserved in plastic bottles by the addition a few drops of nitric acid, while sediment samples were preserved after air-drying in plastic bags (Abida Begum et al. 2009 c,d). The samples were labelled carefully and brought to the laboratory for further analysis. Three aquatic plants *Hydrilla verticillata, Nelumbo nucifera* and *Eichhornia crassipes* from the lake were collected during February 2009 as passive biomonitors for estimating the toxicity status induced by 5 heavy metals Cu, Co, Pb, Zn and Ni. Aquatic plants were thoroughly washed to remove all adhered soil particles. Samples were cut into small pieces, air dried for 48 hours and finally dried at 85°C in hot air oven for two hours (Garty 2001, Valdman & Leite 2000). In warm condition, the samples were ground and passed through 1 mm sieve. Fine powder of plants (2.5 g/50 mL distilled water) was subjected to acid digestion by adding 8 mL concentrated nitric acid on hot plate, and filtrate was diluted up to 50 mL with distilled water (Valdman & Leite 2000). Heavy metals analysis was performed on an Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The phytoremediation study was carried out in five major lakes of Bangalore to ascertain the degree of heavy metal contamination. The study focused on assessment of heavy metal accumulation in three aquatic macrophytes used as biomonitors, in comparison with water and sediments (abiotic monitors) for phytoremediation. The results of the heavy metal analysis of aquatic plants *H. verticillata, N. nucifera* and *E. crassipes* along with sediments and water in the five lakes are given in Tables 2, 3, 4 and Figs. 1, 2, 3.

In water copper was 19.67 ppm in Agarahara lake, and 12.43 and 21.45 ppm in Ambalipura and Hulimavu lakes; cobalt was 1.76 ppm in Agarahara lake and 1.75 and 2.05 ppm in Ambalipura and Hulimavu lakes; lead was 4.21 ppm in Agarahara lake and 8.55 ppm in Hulimavu lake; zinc was 145.65 ppm in Agarahara lake and 198.62 ppm in Hulimavu lake, and nickel was 8.43 ppm in Agarahara lake and 11.98 ppm in Hulimavu lake.

In sediments copper was 102.78 ppm (Agarahara lake), 125.54 ppm (Ambalipura) and 140.95 ppm (Hulimavu lake); cobalt 31.49 ppm (Agarahara lake), 40.75 ppm and 45.42 (Ambalipura and Hulimavu lake); lead 8.65 ppm (Agarahara lake), 12.05 ppm (Hulimavu lake); zinc 1889 ppm (Agarahara lake), 2565 ppm (Hulimavu lake) and nickel 46.35 ppm (Agarahara lake), and 70.35 ppm (Hulimavu lake). Table 3 shows the mean values of concentration of the five elements in three species of macrophytes in the five lakes.

Table 1: Description of five lakes in Bangalore.

Stations	Name of the lakes	Location
S1	Begur (Aggrahara) Doddakere Lake	Towards east of Begur and towards west of Hosur Road.
S2	Arakere Lake	Lake is located between Hulimavu and Arakere, Banneraghatta Road.
S3	Naganaikanakere	Lake is located near Beguar village, Bommanahalli, Hosur Road.
S4	Kelaginakere Amblipura Lake	The Lake is located in the interior area south of Sarjapura Road.
S5	Hulimavu Lake	Lake is located near Hulimavu village, Bannerghatta Road.

Table 2: Physicochemical analysis of water in various lakes of Bangalore.

Parameters	WHO Standards	Aggrahara Lake	Arakere Lake	Naganaikanakere Lake	Amblipura Lake Lake	Hulimavu Lake
Turbidity (NTU)	-	1224	1622	510	1780	590
Colour (Pt-Co)	201	185	223	254	219	219
TDS (mg\L)	500-1500	980	1480	1620	478	1376
DO (mg/L)	5.0-6.0	5.5	1.34	3.6	1.34	4.5
BOD (mg\L)	28-30	1.2	1.4	1.8	1.2	1.5
COD (mg\L)	-	54	25.7	17.5	25.2	52
Conductivity (mV)	-	3.0	8.9	55.9	8.8	23.45
pH	7-8.5	6.2	5.9	5.3	5.9	6.5
P (mg\L)	5	6.5	6.2	8.5	5.1	6.2
NH_3 (mg\L)	0.2	30	14.9	6.4	15.2	16.98
NO_3 (mg\L)	20	0.0	0.0	0.05	0.0	0.0
NO_2 (mg\L)	-	0.0	0.01	0.01	0.01	0.0
SO_4 (mg\L)	42-45	0.4	0.06	0.09	0.08	0.5
Cl (mg\L)	200-600	254	215	213	229	245
Na (mg\L)	200	6.8	28	29	40	42
K (mg\L)	75-200	6.2	15.4	12.1	16.2	125
Ca (mg\L)	150-200	21	17	14.4	19	132
Mg (mg\L)	50-150	23	21	12.3	21	45
Total Hardness (mg\L)	200-600	118	117	96	117	109

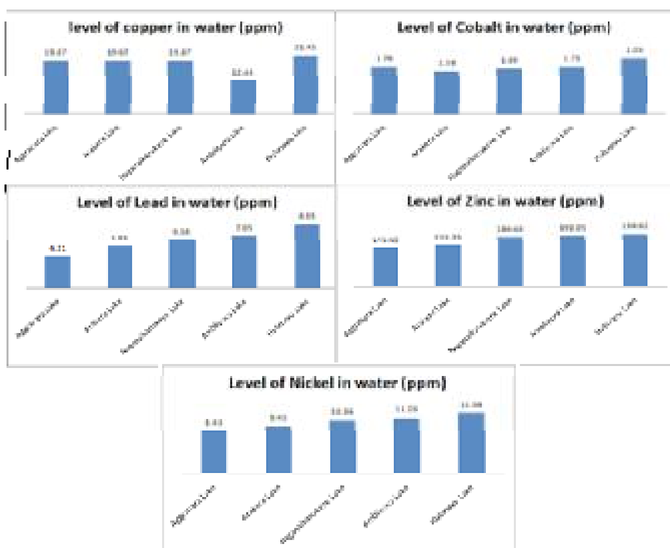

Fig. 1: Ranges of heavy metals contents and toxicity status in water.

***E. crassipes*:** In *E. crassipes* copper was 44.75 ppm (Aggarahara lake), 1617.21 ppm (Arakere lake); cobalt 5.19 ppm (Naganalake), 25.45 ppm (Agarrahara and Hulimavu lake); lead 4.47 ppm (Hulimavu lake), 9.81 ppm (Ambalipura lake and Aggarahara lake); zinc 235.25 ppm (Amblipura lake), 709 ppm (Nangana lake and agarahara lake), and nickel 4.81 ppm (Nagnalake) and 28.83 ppm (Aggarahara lake).

Table 3: Heavy metal concentration (ppm) of water and sediments in various lakes of Bangalore.

Metal	Aggrahara lake		Arakere lake		Naganaikanakere lake		Amblipura lake		Hulimavu lake	
	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water
Cu	102.78	19.67	105.78	19.67	115.35	19.67	125.54	12.43	140.95	21.45
Co	31.49	1.76	34.67	1.58	38.78	1.69	40.75	1.75	45.42	2.05
Pb	8.65	4.21	9.58	5.65	10.65	6.58	11.73	7.05	12.05	8.55
Zn	1889.56	145.65	2006.56	155.35	2316.00	186.69	2451.32	192.05	2567.05	198.62
Ni	46.35	8.43	52.63	9.45	59.35	10.56	65.05	11.05	70.35	11.98

Table 4: Mean heavy metal concentration (ppm) in macrophyte species.

Taxon	Element (ppm)	Aggrahara Lake	Arakere Lake	Naganaikanakere Lake	Amblipura Lake	Hulimavu Lake
E. crassipes	Cu	44.75	1617.21	16.32	114.32	54.73
	Co	25.75	23.72	5.19	8.16	23.72
	Pb	9.81	5.13	7.16	9.81	4.47
	Zn	709.07	423.66	709.07	235.25	327.73
	Ni	28.83	8.13	4.81	9.81	14.38
N. nucifera	Cu	45.34	1732.35	17.65	125.38	59.06
	Co	28.45	25.65	6.14	8.95	26.74
	Pb	10.05	7.52	8.85	10.55	5.58
	Zn	721.50	436.75	743.00	246.75	340.65
	Ni	29.40	9.62	5.64	9.96	16.45
H. verticillata	Cu	52.31	1756.52	18.55	132.64	62.75
	Co	31.45	26.75	7.34	9.62	35.45
	Pb	11.27	8.34	9.35	131.84	6.85
	Zn	721.36	442.56	745.35	9.05	345.05
	Ni	30.31	10.05	8.93.75	11.78	17.82

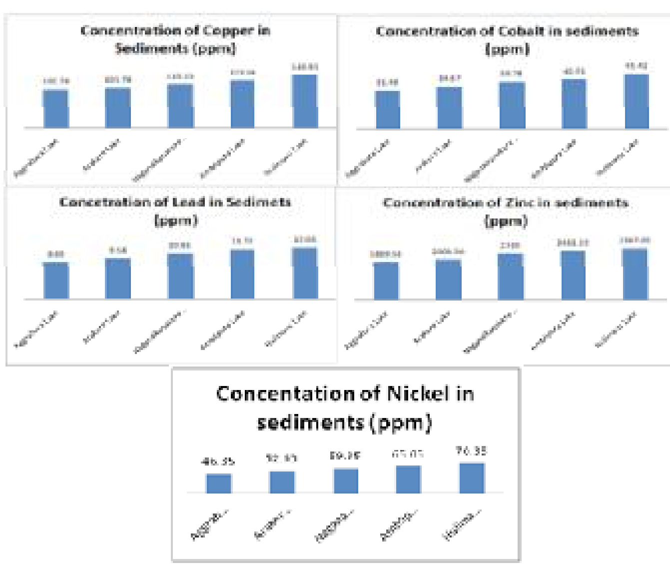

Fig. 2: Ranges of heavy metal contents in sediments.

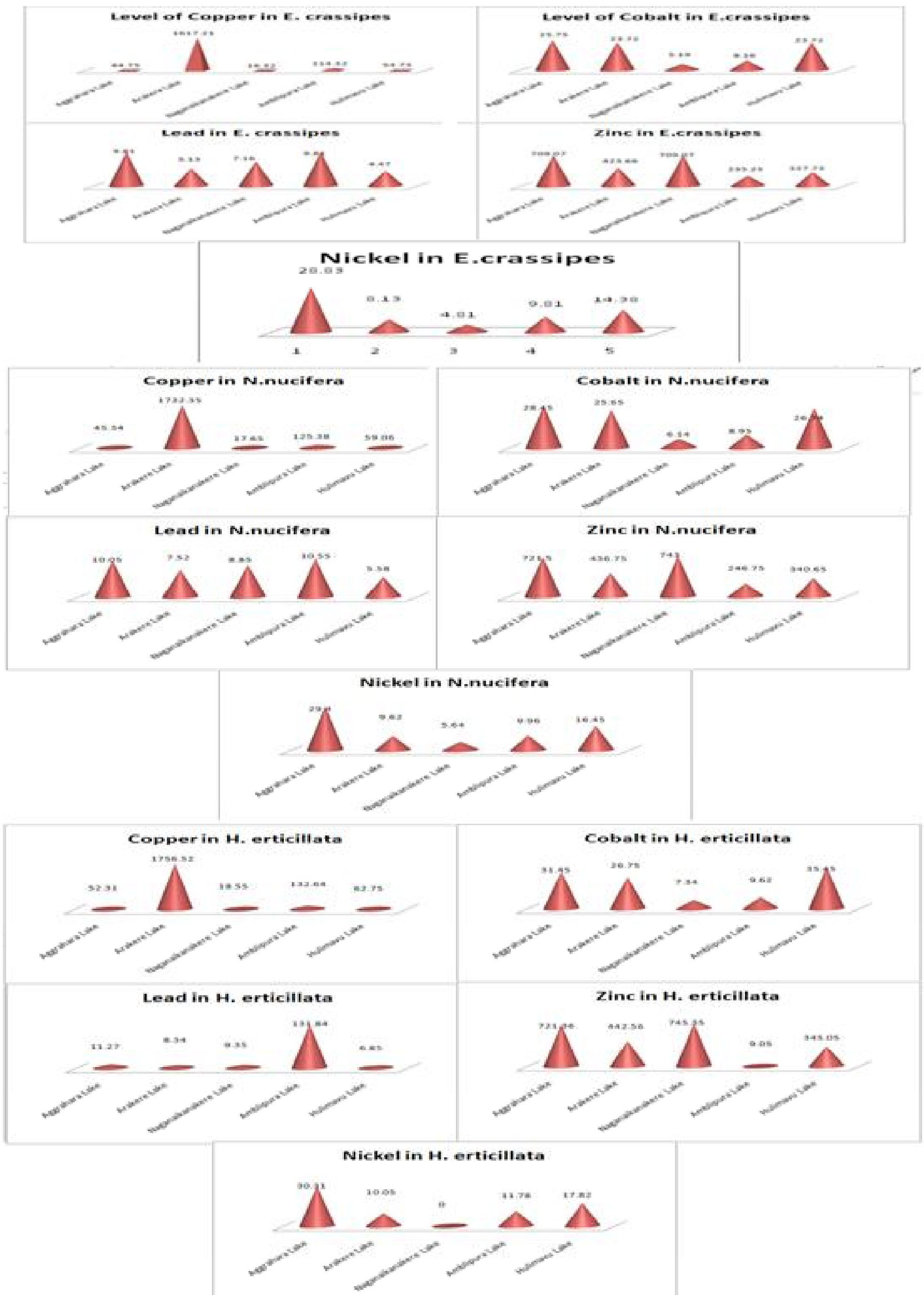

Fig. 3: Ranges of heavy metals content and toxicity status in the tested plant species.

***N. nucifera*:** Copper was 45.34 ppm (Aggarahara lake), 1732.35 ppm (Arakere lake); cobalt 6.14 ppm (Naganalake), 28.45 ppm (Agarrahara lake); lead 5.58 ppm (Hulimavu lake), 10.55 ppm (Ambalipura lake); zinc 246.75 ppm (Ambalipura lake), 743 ppm (Nangana lake), and nickel 5.64 ppm (Nagna lake) and 29.4 ppm (Aggarahara lake).

H. verticillata: In *H. verticillata* copper was 52.31 ppm in Agarrahara lake, 1756 ppm in Arakere lake; cobalt 7.34 ppm in Nagana lake, 35.45 ppm in Hulimavu lake; lead 6.85 ppm in Hulimavu lake, 131.84 ppm in Ambalipura lake; zinc 9.05 ppm in Ambalipura lake, 745.35 ppm in Nangana lake, and nickel 30.31 ppm in Aggarahara lake. In general, the highest mean concentration value was recorded in *H. verticillata* followed by *N. nucifera* and *E. crassipes*.

The heavy metal absorption capacity of macrophytes is of the order for copper was *H. verticillata* (1756 ppm in Arakere lake) > *N. nucifera* (1732.35 ppm in Arakere lake) > *E. crassipes* (1617.21 ppm in Arakere lake), for cobalt was *H. verticillata* (35.45 ppm in Hulimavu lake) > *N. nucifera* (28.45 ppm in Agarrahara lake) > *E. crassipes* (25.45 in Agarrahara and Hulimavu lake), for lead was *H. verticillata* (131.84 ppm in Ambalipura Lake) > *N. nucifera* 10.55 ppm in Ambalipura lake) > *E. crassipes* (9.81 ppm in Ambalipura lake and Aggarahara lake) for zinc was *H. verticillata* (745.35 ppm in Nangana lake) > *N. nucifera* (743 ppm in Nangana lake) > *E. crassipes* (709 ppm in Nangana lake and Agarahara lake), and for nickel was *H. verticillata* (30.31 ppm in Aggarahara lake) > *N. nucifera* (29.4 in Aggarahara lake) > *E. crassipes* (28.83 in Aggarahara lake).

CONCLUSIONS

The order of accumulation of heavy metals in lakes was, in general, Hulimavu > Ambalipura > Naganaikanakere > Arakere > Aggrahara. Based on the concentration and toxicity status observed in macrophytes the accumulation was *H. verticillata* **>** *N. nucifera* **>** *E. crassipes.* The heavy metals are arranged in the following descending order: Cu > Zn > Pb > Co > Ni in macrophytes, Zn > Cu > Ni > Pb > Co in water, and Zn > Cu > Ni > Co > Pb in sediments. These selected biotic species showed maximum absorption of copper and zinc in all the lakes. High eutrophication was observed in Hulimavu lake as compared to the other lakes.

REFERENCES

Abida Begum and Harikrishna, S. 2008. Study on the quality of water in some streams of Cauvery river. E-Journal of Chemistry, 5(2): 377-384.

Abida Begum, S. Harikrishna and Irfanulla Khan 2008a. Chemical composition of rainwater in south Bangalore, Karnataka. Rasayan J. Chem., 1(4): 774-781.

Abida Begum, Harikrishna, S., Irfanulla Khan, Ramaiah, M., Veena, K. and Vinutha, K. 2008b. Nutrients and heavy metal profile of Madivala lake, Bangalore South. Rasayan Journal of Chemistry, 1(3): 572-580.

Abida Begum, Ramaiah, M., Harikrishna, S., Irfanulla Khan and Veena, K. 2009a. Heavy metal pollution and chemical profile of Cauvery river water. E-Journal of Chemistry, 6(1): 47-52.

Abida Begum, Ramaiah, M., Harikrishna, S., Irfanulla Khan and Veena, K. 2009b. Analysis of heavy metals concentration in soil and lichens from various localities of Hosur road. E-Journal of Chemistry, 6(1): 13-22.

Abida Begum, Harikrishna, S. and Irfanulla Khan 2009c. Analysis of heavy metals in water, sediments and fish samples of Madivala lake of Bangalore, Karnataka. International Journal of ChemTech Research, 1(2): 245-249.

Abida Begum, Harikrishna, S. and Irfanulla Khan 2009d. A survey of persistent organochlorine pesticides residues in some streams of the Cauvery river, Karnataka, India. International Journal of ChemTech Research, 1(2): 237-244.

Garty, J. 2001. Biomonitoring of atmospheric heavy metals with lichens, theory and application, Critical Reviews in Plant Sciences, 20: 309-371.

Valdman, E. and Leite S.G.F. 2000. Biosorption of Cd, Zn and Cu by *Sargassum* sp. waste biomass. Bioprocess Engineering, 22: 171-173.