Research in Plant Biology, 3(6): 01-05, 2013 ISSN : 2231-5101
www.resplantbiol.com

Regular Article

An assessment of heavy metal accumulation in mangrove species of Bhitarkanika, Odisha, India

S S Panda*, N Chaturvedi, N K Dhal and N C Rout

Environment and Sustainability Department, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar-751013, Orissa, India
*Corresponding Author email: swati.sucharita8@gmail.com

Mangroves are one of the most biologically important and productive ecosystems in the world. Heavy metals are known to pose a potential threat to terrestrial and aquatic biota. However, little is known on the toxic levels of heavy metals found in mangrove plants in India. To understand heavy metal toxicity, we analyzed heavy metals accumulation in sediment samples collected from surrounding root zone and in the leaves and stem of sixteen different plant species in the Bhitarkanika mangrove forest reserve in Odisha, India. Bhitarkanika mangrove ecosystem receives heavy metal pollution from upstream areas of Brahmani and Baitarani estuary. Few studies were carried about the capacity of mangrove plants to take up and store heavy metals in them. Hence, current investigation was carried out to analyze trace metal accumulation in sediment and plant parts such as stems and leaves of different mangrove plants by Atomic Absorption Spectroscopy (Shimadzu, AA- 6300). The heavy metal concentration in sediment was found to be in the range of 5.99 to 92.00 µg/gm. Metals concentration in sediment samples during the study was in the order of accumulation : Zn>Cu>Pb. The accumulation of heavy metal was higher in stem as compared to leaf.

Key words: Bhitarkanika, Heavy metal, Mangroves, Sediment

A mangrove may refer to individual trees or shrubs found in warmer tropical or subtropical latitudes or the ecosystem itself. Mangroves grow in intertidal or estuarine areas, most commonly in Africa, Australia, Asia and North and South America. Asia harbors the largest area of mangroves in the world while India contributes nearly 3% of the global mangrove habitat (FAO, 2003). India is one among the 25 hotspots of the richest and highly endangered eco-regions of the world (Myers et al., 2000; Agoramoorthy and Hsu, 2002a, 2005a). India's diverse plant species are mainly found in various types of forest such as tropical, sub-tropical, temperate, sub-alpine, alpine, dry open, open, evergreen, deciduous, littoral and mangrove that occupy 20% of the total geographical area (Negi, 1993). Mangrove trees are unique as they have developed structures to adapt to high and variable salinity conditions in brackish waters and waterlogged and anaerobic soil conditions, both of which are caused by environmental factors in mangroves. With increasing urbanization and industrialization, coastal areas of all tropical littoral countries in Asia, especially India have been subjected to considerable environmental stress due to domestic sewage, industrial effluents, heavy metals and other toxic waste (Agoramoorthy and Hsu, 2005b; Hsu et al., 2006). However, scientific data on the toxic levels of heavy metals found in mangroves are limited in India, which is experiencing economic boom and industrial outburst in recent decades. One of the major sources of heavy metal pollution is the mining and smelting of metalliferous ores (Li and Thornton, 2001). Besides the contamination from the weathering and leaching processes of mine tailings, untreated mine drainage also contributes large amounts of heavy metals to nearby streams and rivers. Heavy metals released into aquatic systems are generally bound to particulate matter, which eventually settle down and become incorporated into sediments. Many studies have been carried out on various plants to determine its heavy metal accumulation capability in different aquatic and forest environments and vegetable crops (Nirmal Kumar *et al*., 2006, 2007, 2009; Silva *et al*., 2006; Yu *et al*., 2007). There are several studies on heavy metal contamination in mangrove sediments and their effects on organisms but little is known about heavy metals uptake by mangrove plants (Seng *et al*., 1987; Ismail and Asmah, 1992). Therefore, an attempt was made to get first-hand information, hitherto not available, on heavy metal levels in plants that grow in the Bhitarkanika mangrove ecosystem, Odisha, India.

Materials and Methods

Description of Sampling Site

Mangroves of Bhitarakanika, located at Kendrapada district of Orissa, lies in the estuarine region of rivers Brahmani and Baitarani. The whole of the mangrove forests, and part of the rivers/ streams providing shelter to the endangered salt-water crocodile, fall within the Bhitarakanika National Park. It lies within $86^{0}46'$ to $86^{0}52'$ East longitude and $20^{0}30'$ to $20^{0}48'$ North Latitude (Figure 1). The samples were collected from five different locations viz. Kantaikhai (BKS-1), Khola(BKS-2,3), Mahisamunda (BKS-4) and Dangamala(BKS-5) arbitrarily during the year 2012-13 and sealed in sterile polythene bags.

Sample collection, preparation and analysis

The sediment samples surrounding the root systems of different mangrove species were collected using vertical corer, transferred to clean polyethylene bags and shade-dried to constant weight. Sediments were ground and sieved through mesh (size of 0.5mm) before digestion. Matured leaves (2nd and 3rd from the top of the branch) and stem of sixteen different mangrove plant species were collected.The plant parts viz. stems and leaves samples were washed thoroughly, shade-dried, homogenised and grounded to a fine powder. Samples then stored in plastic vials with labels and kept in desiccators. The samples of sediment and plant-parts were examined for detection for various heavy metals. Accurately 1 g of dry powder of each sample was weighed, and digested with con. HNO_3, H_2SO_4 and H_2O_2 (2:6:6) as prescribed by Saison *et al*. (2004). Towards the end of the digestion, the flasks were brought to near dryness. The solutions were made to 20 ml each in measuring cylinder with double distilled water and examined for heavy metals by Inductive Coupled Plasma Analyser (ICPA) (Perkin-Elmer ICP Optima 3300 RL, U.S.A) at CSIR-IMMT. Mean values of triplicate of each sample of the sediment and plant samples were calculated and considered.

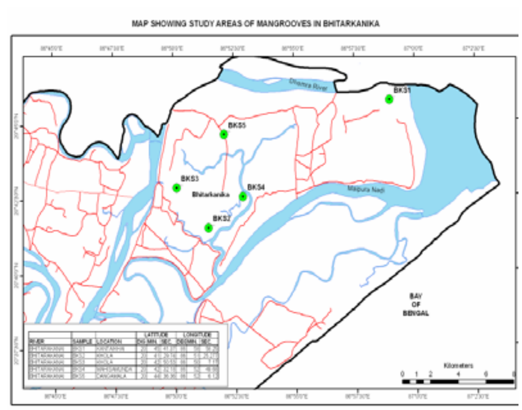

Figure 1- Map showing different sampling location

Results

The concentration of heavy metal analyzed for sixteen mangrove species were found to be significantly different depending upon the metal and plant species (Table 1). The accumulation of metals in plant parts was much lesser as compared to the sediment samples. The heavy metals concentration in sediment sample was in the range of 5.99 to

92.00 µg/gm. The accumulation of heavy metals in stem was more as compared to leaf parts which might be due to the high cation exchange capacity of xylem vessels which helps the metals to get attached to it.

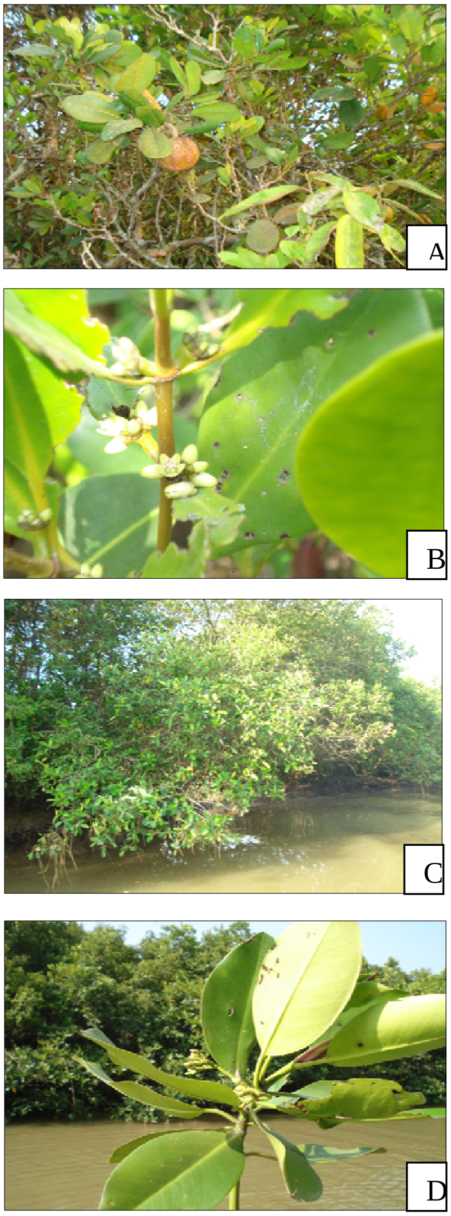

Figure 2 : Potential mangroves plants. A. *Xylocarpos granatum*, B. *Ceriops decandra*, C. *Avicennia alba*, D. *Rhizophora mucronata*

The concentrations of lead among sixteen plant species were in the range of 1.57 to 18.93 µg/gm in case of stem and in leaves it varies from 0.03 to 4.21 µg/gm. The maximum concentration of copper was recorded in the stem of *Avicennia alba* (10.03 µg/gm) while leaf sample *Ceriops decandra* (8.05 µg/gm) accumulated highest amount of copper.

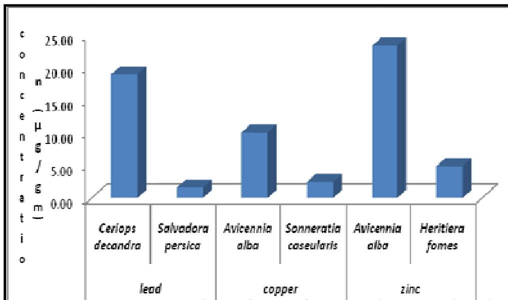

Figure-1: Accumulation of various heavy metals in stem selected mangrove species

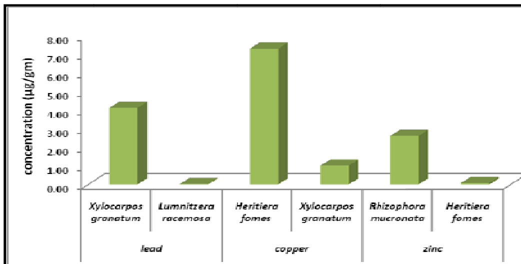

Figure-2 : Accumulation of various heavy metals in leaves of selected mangrove species

Similarly in case of zinc, *Avicennia alba* (23.33 µg/gm) accumulate maximum in the stem and in leaf the maximum uptake was recorded in *Rhizophora mucronata* (2.16 µg/gm). From the present investigation it was concluded that all mangroves have the capacity and adaptability to the heavy metal stress. But the accumulation of metals (lead, cadmium, zinc) is found to be different in different species as well as in different parts. Species like *Avicennia alba*, *Ceriops decandra*, *Xylocarpos granatum*, *Rhizophora mucronata* were found to accumulate more heavy metals as compared to other species (Fig 1 & 2). Although the total amount of heavy metals retained in mangrove plants were lower than those in soil, heavy metals did accumulate in plants, especially in leaves. Excess metals were translocated from root to stem, then to leaf and the degree of upward movements depends upon the mobility of heavy metals.

Table 1. Metallic composition of sediment and plant samples of Bhitarkanika mangrove ecosystem (nd*- not detected)

S. No.		Lead(μg/gm)			Copper(μg/gm)			Zinc(μg/gm)		
	Plant species	Sediment	Stem	Leaf	Sediment	Stem	Leaf	Sediment	Stem	Leaf
1	*Heritiera fomes*	13.66	2.94	0.20	20.02	4.66	7.30	50.11	4.86	0.08
2	*Derris scandens*	10.91	6.76	nd*	17.19	7.58	4.81	70.13	7.19	0.12
3	*Xylocarpos granatum*	9.66	2.81	4.12	13.11	7.69	1.02	62.39	8.26	0.24
4	*Ceriops decandra*	19.02	18.93	nd*	7.13	2.68	8.05	40.13	8.75	0.45
5	*Salvadora persica*	13.99	1.57	0.11	10.22	3.14	4.31	49.91	11.48	0.41
6	*Lumnitzera racemosa*	20.68	2.65	0.03	11.98	3.03	4.78	80.13	7.90	2.35
7	*Avicennia alba*	8.76	3.92	0.17	14.39	10.03	4.43	65.03	23.33	0.26
8	*Agloia cucullata*	17.21	1.65	3.70	15.15	3.26	4.31	42.57	7.90	0.32
9	*Sonneratia caseularis*	13.11	1.94	0.51	12.12	2.44	5.60	64.00	13.13	0.38
10	*Cerbera odollum*	11.91	2.20	0.54	6.13	6.53	2.83	92.00	10.64	2.12
11	*Phoenix paludosa*	8.66	5.37	0.06	15.44	6.06	3.31	57.78	12.79	2.39
12	*Intsia bijuga*	5.99	2.63	3.13	21.98	6.53	2.44	37.77	17.42	2.12
13	*Sonneratia apetala*	10.19	5.71	0.28	20.09	8.87	2.33	43.39	27.83	2.17
14	*Dalbergia spinosa*	7.07	2.89	0.13	12.92	4.50	1.99	40.76	12.32	2.01
15	*Aegialitis rotundfolia*	9.01	2.01	2.12	10.33	5.20	2.69	45.14	14.21	1.98
16	*Rhizophora mucronata*	12.55	5.81	2.98	7.34	7.70	4.31	41.21	20.12	2.61

Conclusions

This study has shown that mangrove plants possesses the capacity to uptake selected heavy metals via roots and storing those in its stems and leaves without any sign of injury. With age, its capability of accumulating heavy metals is also increasing. From the study, it can be concluded that few species like *Avicennia alba*, *Ceriops decandra*, *Xylocarpos granatum*, *Rhizophora mucronata* have greater potential and capacity to uptake and sustain in the ecosystem (Figure 2). Hence plantation of such mangrove species in the polluted coastal areas should be carried out in order to combat the pollution stress and for conservation of mangrove ecosystem.

Acknowledgements

The authors are thankful to Prof. B.K Mishra, Director, Institute of Minerals and Materials Technology, Bhubaneswar for providing necessary facilities to carry out the work.

References

Agoramoorthy G & Hsu MJ (2002 a). Biodiversity surveys are crucial for India. Current Science 82, 244e245.

Agoramoorthy G & Hsu MJ (2005 a). Borneo's proboscis monkeys e a study of its diet of mineral and phytochemical concentrations. Current Science 89, 454e457.

Agoramoorthy G & Hsu MJ (2005b). China's battle against escalating environmental pollution. Current Science 89, 1074e1075.

Agoramoorthy G (2006). Computer recycling builds garbage dump overseas. Nature 441, 25.

FAO (2003). Status and Trends in Mangrove Area Extent Worldwide, Forest Resources Assessment Working Paper No. 63. Forest Resource Division, FAO, Rome.

Ismail A and Asmah MIN (1992). Copper, zinc, lead and cadmium in intertidal mollusks and sediment off Seberang

Perai coastline, Malaysia. 4th Princess Chulabhorn International Science Congress, Bangkok, Thailand.

Myers N, Mittermeier RA, Mittermeier CG, Fonseca GAB & Kent J (2000). Biodiversity hotspots for conservation priorities. Nature 403,853e856.

Negi SS (1993). Biodiversity and its Conservation in India. Indus Publishing Company, New Delhi.

Nirmal Kumar JI, Soni H and Nirmal Kumar R (2006). Biomonitoring of selected freshwater macrophytes to assess the lake trace element contamination: A case study of Nal Sarovar Bird Sanctuary, Gujarat, India. Journal of Limnology 65(1): 9-16.

Nirmal Kumar JI, Soni H and Nirmal Kumar R (2007). Characterization of Heavy Metals in Vegetables Using Inductive Coupled Plasma Analyzer (ICPA). Journal of Applied Science and Environmental Management 11 (3): 75-75.

Nirmal Kumar JI, Soni H and Nirmal Kumar R (2009). Hyper accumulation and mobility of heavy metals in vegetable crops in India. The Journal of Agriculture and Environment 10:29-38.

Seng CE, Lim PPE and Ang TT (1987). Heavy metals concentrations in coastal sea water and sediment of Prai Industrial Estate, Penang, Malaysia. Mar Pollut Bull 18:611-612.

Silva CAR, de Silva AP and Oliveira SR (2006). Concentration, stock and transport rate of heavy metals in a tropical red mangrove, Natal, Brazil. Marine Chemistry 99:2-11.

Thornton Li XD (2001). Chemical portioning of trace and major elements in soils contaminated by Hyper mining and smelting activities. Applied Geochemistry 16: 1693-1706.

Yu KF, Kamber BS, Lawrence MG, Greig A and Zhao JX (2007). High precision analysis on annual variation of heavy metals, lead isotopes and rare earth elements in mangrove tree rings by inductively coupled plasma mass spectrometry. Nuclear Instruments and Methods in Physics Research, Section B-Beam interactions with materials and atoms 255:399-408.