INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES Volume 2, No 1, 2011

Research article **ISSN 0976 – 4402**

Concentration of heavy metals in Seagrasses tissue of the Palk Strait, Bay of Bengal

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ABSTRACT

Seagrasses are considered as good indicators of heavy metals in the marine environment. Palk Strait is situated in the southeast coast of India, dominated with the seagrasses. The aim of this investigation to measure the various metals concentration (Mn, Fe, Cu and Zn) in two seagrasses species, *Cymodocea serrulata, Syringodium isoetifolium* in four selected stations (Karankadu, Soliyakudi, Thondi and Sundrapandiyapattinam) along the Palk Strait. In order to get more information and environmental conditions of the experimental area, total metal concentration was determined in coastal water and in the sediment. From the result, *C.serrulata* accumulates more amounts of metals than S. isoetifolium. Among all the four stations, station III (Thondi) observed high amount of metal concentration in seagrass tissues as well as its ambient environment.

Keywords: *Cymodocea serrulata, Syringodium isoetifolium*, Heavy metals, Palk Strait

1. Introduction

Seagrasses are the only marine flowering plants, capable of completing their life cycle when they are submerged completely in the seawater. The primary production rates of seagrasses are closely linked to the higher production rates of associated fisheries and thus the seagrass communities make significant contributions to the coastal productivity. Growth of human populations along coastal environments as well as poor water management practices has resulted in the complete loss of seagrass meadows (Kemp *et al*., 1983; West, 1990; Short and Wyllie- Echeverria, 1996; Peter *et al*., 1997). The catastrophic loss of seagrasses clearly illustrated linked with coastal development and associated reduction in water quality. Seagrasses growing in estuaries are particularly vulnerable to contamination from anthropogenic sources, more so than coastal seagrasses.

Contamination in the estuaries, coastal regions and marine environments can arise from discrete point sources of industrial waste which normally contains the heavy metals like Zinc, Manganese, Iron, Copper and other trace elements. These heavy metals are stable and persistent environmental contaminants of coastal waters and sediments. Where as seagrasses are growing in shallow coastal habitats can be damaged by shipping traffic, contaminated bilge water, and accidental spills and contaminated by antifouling compounds. Heavy metals can enter the marine environment naturally *via*; weathering, erosion of rock and soils (Batley, 1996) or through urban and municipal runoff, storm water, sewage, industrial effluents, mining operations, atmospheric deposition and agricultural activity (Batley, 1996; Irvine and Brich, 1998; Haynes and Johnson, 2000). Bioavailability of heavy metals is influenced by environment and physio- chemical parameters of water and sediment (Batley, 1987; Ward, 1989; Batley *et al*., 1999; Aluton *et al*., 2001). Though the natural process of biomagnifications, minute quantities of metals become part of the various food chains and concentrations become elevated to levels which can prove to be toxic to both human and other living organisms (Ackefors, 1971; Bryan, 1971).

The main difficulty with understanding metal impacts on seagrasses is quantifying the exposure, as it is transient and highly variable in its distribution between water, sediment, seagrasses and epiphytes. It is important to establish how much heavy metal is really available in the water column to be absorbed by the seagrasses (Haynes *et al*., 2000). The species of seagrasses being assessed, the tissue type, sampling period and the level of contamination. Most of the heavy metals research has focused on the accumulation of metals in to seagrasses (Sanchiz *et al*., 2001). Seagrasses are good as biomonitors, as their tissue metal content often reflects bio available water and sediment content (Sanchiz *et al*., 2001). These heavy metals generally disrupt the function of photosynthesis however; permanent damage may not be caused, since the impact can be reversed by the removal of the metals such as Cadmium, Copper, Manganese and Lead (Prasad and Strzalka, 1999). These types of toxicity based investigations provide an ecological perspective of the impact of metals. The potential for recovery from heavy metal exposure is an important as understanding of the degree of damage caused by exposure. In this study interest in Mn, Fe, Cu and Zn and these metals concentration in the seagrasses along the Palk Strait.

2. Materials and Method

2.1. Description of Study Area

Present study the water, sediment and Seagrasses samples were collected from the coastal region of Palk Strait of four different stations *viz*., Karankadu (Station- I), Soliyakudi (Station- II), Thondi (Station- III) and Sundrapandiya Pattinam (Station- IV) in Palk Strait, Southeast coast of India. Generally sampling sites of water body were selected for considering that the locations should be in close proximity of the inlet points of the ocean (Fig. 1).

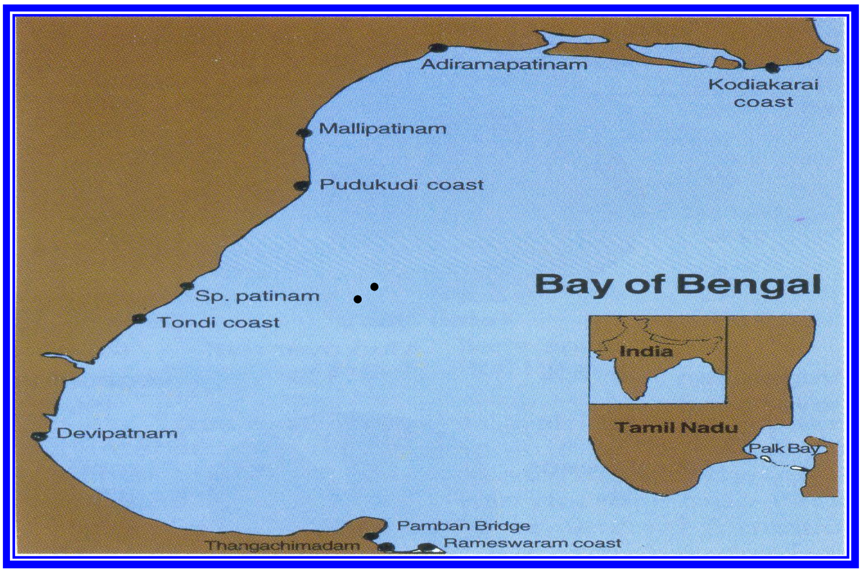

Figure 1: Map showing the study area along Palk Strait

2.2. Heavy Metal Analysis in Water and Sediment

For the analysis of heavy metals, sub surface seawater was collected randomly and immediately stored in pre-acid cleaned polypropylene containers and transported to the laboratory to avoid contamination. The water sample was than filtered through a millipore filtering unit using Millipore filter paper (mesh 0.45µm). Filtered seawater pH was adjusted to 4± 0.1 by addition of Nitric acid. The heavy metals were extracted using APDC- MIBK complex (Brooks *et al*., 1967). The pre concentrated solution was stored in clean polythene bottles. Sediment samples were collected from seagrass bed, using a pre cleaned and acid washed PVC corer and immediately kept in pre cleaned and acid washed polythene bags which were sealed. Sediment samples were washed with metal free double distilled water and dried in an oven at 105ºC and ground to powder with the help of mortar and pestle. Analysis of metal was done after redrying the samples, from which 250mg was taken and digested with a mixture of concentrated HNO_3, H_2SO_4 and $HClO_4$. The mixture was boiled, evaporated to near dryness and then resuspended in 2N hydrochloric acid. This was passed through a paper filter and made upto 25ml with metal free double distilled water (Chester and Hughes, 1967).

2.3. Heavy Metal Analysis in Seagrass Samples

The dominated two seagrass species, *Cymodoceae serrulata, Syringodium isoetifolium* were collected from all the four stations. Seagrass samples were collected at low tide levels in January 2009. Healthy seagrasses were picked carefully from their substrates and washed thoroughly with ambient water to remove sediment, debris and associated fauna. Cleaned seagrasses were placed in acid washed polythene bags and transported to the laboratory in an ice box. The sample were than washed 3 times in metal- free double distilled water and dried at 105ºc and ground to powder. An aliquot of 250mg powder of each seagrass was digested with 2M HNO_3 (Say *et al*., 1990) and filtered through a filter paper and made upto 25ml with metal free double distilled water. The resulting solutions were stored in acid washed polythene containers. The concentration of trace metal in all the samples were determined by aspirating the samples into a Perkin-Elmer (Model 373) Atomic Absorption Spectrophotometer (AAS with background correction and acetylene as fuel) and expressed as µg metal ml^{-1} for water and µg metal g^{-1} dry weight for sediment and seagrasses. Number of detectable amounts of Manganese, Iron, Copper and Zinc were found in the reagent blanks. Analysis of the NIES Sargasso samples obtained from Japan was carried out to check on the technique. Triplicate samples were analyzed and their mean values are reported.

3. Results and Discussion

The data show that the concentration of heavy metals in water, sediment and selected seagrasses in all the four stations (Table. 1). The heavy metals such as Manganese, Iron, Copper and Zinc occur in the seawater in different forms and in different concentrations. The metals Mn, Fe, Cu, and Zn concentration (0.89, 0.30, 0.70 and 0.60µg.l^{-1} respectively) in water sample was high in station III. The Mn and Zn concentration (0.02 and 0.03µg.l^{-1}) was comparatively low in station IV. Fe and Cu concentration (0.12 and 0.05µg.l^{-1}) was low in station I. The detection of heavy metal in the seagrass species, in water and sediment investigated supports previous evidence that seagrasses are able to accumulate the metals from the marine environment (Brix and Lyngby, 1983; Neinhuris, 1986).

In sediment the Mn, Fe, Cu and Zn concentration (61.50, 75.40, 45.50 and 49.50µg.g^{-1} respectively) was higher in station III compared to other stations. The Mn, Fe and Cu (29.40, 16.50 and 13.00µg.g^{-1}) in the station IV is relatively low. The Zn concentration is very low in station II (21.40µg.g^{-1}) (Table. 1). Trace element accumulation in sediments is the result of long-term exposure, whereas trace element concentrations in water mainly result from recent contamination. Environmental parameters such as rainfall, ocean currents, wind and other geographical conditions were affect the heavy metal distribution in the sediments of the world coastal regions (Klien and Goldberg, 1970; Subramaniam Mohanachandran, 1990; Ramachandran, 1990).

Table 1: Concentration of Heavy metals in water, sediment and seagrass tissue samples

Stations	**Heavy Metals**			
	Mn	**Fe**	**Cu**	**Zn**
Water Sample (Stations I- IV) (µg l^{-1})				
I	0.57	0.12	0.05	0.50
II	0.57	0.20	0.50	0.10
III	0.89	0.30	0.70	0.60
IV	0.02	0.20	0.50	0.03
Sediment Sample (Stations I- IV) (µg g^{-1})				
I	54.50	35.40	15.60	31.30
II	39.44	26.40	36.70	21.40
III	61.50	75.40	45.50	49.50
IV	29.40	16.50	13.00	36.50
Tissue Samples- Above Ground Level (Stations I- IV) (µg g^{-1})				
Cymodocea serrulata				
I	0.25	0.35	0.22	0.50
II	0.31	0.32	0.13	0.05
III	0.90	1.33	0.53	0.54
IV	0.24	0.33	0.15	0.33
Syringodium isoetifolium				
I	0.30	0.22	0.05	0.22
II	0.50	0.23	0.08	0.15
III	0.45	0.56	0.32	0.59
IV	0.35	0.33	0.07	0.33
Tissue Samples- Below Ground Level (Stations I- IV) (µg g^{-1})				
Cymodocea serrulata				
I	0.99	0.77	0.54	0.50
II	1.73	0.64	0.40	0.94
III	6.14	2.85	0.96	3.88
IV	2.10	1.22	0.80	0.68
Syringodium isoetifolium				
I	0.67	0.73	0.53	0.99
II	2.91	1.33	1.14	0.88
III	7.93	1.32	1.48	1.52
IV	2.45	2.04	1.03	2.00

Analyses of metal concentrations in plant tissues often provide useful evaluation of point-source pollution in the water column. This is particularly true when monitoring studies regard habitats affected by various point sources of pollution. In the seagrass samples the above ground tissue and below ground tissue are separately analyzed for the presence of heavy metals. Concentrations of Mn, Fe and Cu in above ground tissues (0.90, 1.33 and 0.53$\mu g.g^{-1}$ respectively) were higher in *Cymodocea serrulata* when compared to *Syringodium isoetifolium* tissue at station III. The Zn concentration (0.59$\mu g.g^{-1}$) was high in *S. isoetifolium* tissues at station III. Mn concentration (0.24$\mu g.g^{-1}$) was low in *C. serrulata* tissues at station IV. The Fe and Cu concentration (0.22 and 0.05$\mu g.g^{-1}$) is low in the *S. isoetifolium* tissues at station I. The concentration of Zn (0.05$\mu g.g^{-1}$) was low in *C. serrulata* at station II (Table. 1)

The concentration of Fe, and Zn (2.85 and 3.88$\mu g.g^{-1}$) in the below ground tissue of seagrass was higher, at Station III *C. serrulata* tissue sample has higher than other samples in other stations. The Mn and Cu concentration (7.93 and 1.48 $\mu g.g^{-1}$) was relatively high in the *S. isoetifolium* at station III. Concentration of Fe and Cu (0.64 and 0.40$\mu g.g^{-1}$) was low in *C. serrulata* tissue at Station II and the Mn concentration (0.67$\mu g.g^{-1}$) was low in the *S. isoetifolium* plant tissues at station I. The Zn concentration (0.50$\mu g.g^{-1}$) was low in *C. serrulata* tissue at station I (Table. 1)

Different rates of accumulation of heavy metals in the soft tissues were found and this might be due to the different mechanisms for metal binding and regulation. The metal availability can be influenced by sediment cation exchange capacity, water and sediment pH, redox potential, water temperature, salinity, organic concentration and other metals (Ward, 1989). The energy derived from the photosynthesis and the oxygen released can improve conditions for active absorption of elements and the pH of the growth medium also a factor (Balsherg, 1989). Heavy metals were accumulated in below ground tissues of the seagrasses than above ground parts. Because plants with numerous roots were accumulate more metals. Roots of aquatic plants absorb from the sediments and accumulate high concentrations, factors such as light intensity, oxygen tension and temperature are known to affect the uptake of minerals and heavy metals (Devlin, 1967). Thus, there were both intra specific and intra specific differences in the accumulation of metals in seagrasses (Ho, 1988). These variations in the heavy metals concentrations of the seagrasses may be attributed to the environmental and metabolic levels of different phonological stages of the samples (Fujiyama and Maeda, 1979; Eide *et al.*, 1980).The Aquatic plants growing in the study area exhibit different trace element concentrations, depending on the plant organ, an both the sampling time and the sampling sites.

The Concentration factors (CFs) were worked out to know the efficiency of seagrasses to accumulate different heavy metal from their ambient environment and from their food (Table. 2 and 3). A low Concentration Factor is indicative of low accumulation of elements by the plants where as high concentration factors indicate active uptake (Alberts *et al*., 1990). Vande and Groot (1974) and Bower *et al.,* (1978) have studied the metal uptake, translocation and effects in plants growing on naturally polluted and unpolluted sediments. Their results suggest that aquatic plats may facilitate the transportation of metals from sediments up into shoots. These metals are there by available to grazing mollucs and they reintroduced into the food web via fish to birds and humans (Brown and Chow, 1977). In the present study period could be due to the difference in the sources of the heavy metals, determined by a complex equilibrium governed by various physical, chemical and biological factors. The bioaccumulation of metals by a plant depends on time of year as there are seasonal variations in growth and chemical composition influencing the pattern of accumulation in addition to variations in the activity concentrations in the environment.

Table 2: Concentration factors for heavy metals in seagrasses

Stations	**Heavy Metals**			
	Mn	**Fe**	**Cu**	**Zn**
CFs of Above Ground Tissue (Stations I- IV)*				
Cymodocea serrulata				
I	0.438	2.916	4.400	1.00
II	0.543	1.600	0.260	0.500
III	1.011	4.433	0.757	0.900
IV	12.00	1.650	0.300	11.00
Syringodium isoetifolium				
I	0.526	1.833	1.000	0.440
II	0.877	1.150	0.160	1.500
III	0.505	1.866	0.640	0.933
IV	17.500	1.650	0.140	11.000
CFs of Below Ground Tissue (Stations I- IV)**				
Cymodocea serrulata				
I	0.018	0.021	0.034	0.015
II	0.043	0.024	0.010	0.043
III	0.099	0.081	0.021	0.078
IV	0.071	0.073	0.061	0.018
Syringodium isoetifolium				
I	0.012	0.020	0.033	0.031
II	0.073	0.050	0.031	0.041
III	0.128	0.017	0.032	0.030
IV	0.083	0.123	0.079	0.054

(* CFs= Con. of element Tissue/Con. of element in water)
(** CFs= Con. of element Tissue/Con. of element in sediment)

Table 3: CFs in relation to water and sediment concentration

Stations	Name of the Species	Metal concentration level
CFs in relation to water concentration		
I	*C. serrulata*	Cu> Fe> Zn> Mn
	S. isoetifolium	Fe>Cu>Mn>Zn
II	*C. serrulata*	Fe> Mn> Zn> Cu
	S. isoetifolium	Zn> Fe> Mn> Cu
III	*C. serrulata*	Fe> Mn> Cu> Zn
	S. isoetifolium	Fe> Zn> Cu>Mn
IV	*C. serrulata*	Mn> Zn> Fe> Cu
	S. isoetifolium	Mn> Zn> Fe> Cu
CFs in relation to sediment concentration		
I	*C. serrulata*	Cu> Fe> Mn> Zn
	S. isoetifolium	Cu> Zn> Fe> Mn

II	*C. serrulata*	Zn>Mn>Fe>Cu
	S. isoetifolium	Mn> Fe>Zn>Cu
III	*C. serrulata*	Mn>Fe>Zn>Cu
	S. isoetifolium	Mn>Cu>Zn>Fe
IV	*C. serrulata*	Fe> Mn> Cu> Zn
	S. isoetifolium	Fe>Mn>Cu>Zn

4. Conclusion

Generally the accumulation of heavy metals in the station III was very high as compared with other stations. The increase in urbanization and industrialization leads to an increase of marine discharges and, therefore the total load of pollutants being delivered to the sea. These discharges may contain heavy metals among other pollutants. More over, the concentrations of heavy metals are increased from year to year. So it is concluded from the present study the Palk Strait is rapidly getting polluted with metals.

Acknowledgement

The authors are thankful to Alagappa University and University authorities for providing the facility to complete this work.

5. References

1. Alberts, J.J., Price, M.T., and Kania, M. (1990),. Metal concentration in tissues of *Spartina alterniflora* (Loisel.) and sediment of Georgia salt marshes. Estuarine, Coastal and Shelf sciences 30, pp 47-58.

2. Alutoin, S., Boberg. J., and Nystrom Mand Tedengren, M. (2001), Effects of the multiple stressors copper and reduced salinity on the metabolism of the hermatypic coral *Porites lutea*. Marine Environmental Research, 52, pp 289- 299.

3. Balsberg-Pahlsson, A.M. (1989), Toxicity of heavy metals (Zn, Cu, Cd, Pb) to vascular plants A literature review. Water Air Soil Pollution, 47, pp 287– 319.

4. Bately, G.E. (1996), Heavy metals and tributyltin in Australian coastal and estuarine waters. In: Zann, L.P. and D.C. Sutton (eds). The state of the Marine Environment Report for Australia. Technical Annex: 2. Pollution, Department of the Environment, Sport and Territories, Canberra. pp 63-72.

5. Bately, G.E. (1987). Heavy metal speciation in waters, sediments and biota from Lake Macquarie, NewSouthWales. Australian Journal of Marine Freshwater Research, 38, pp 591-606.

6. Bately, G.E., Apte, S.C., and Stauber, J.L. (1999), Acceptability of aquatic toxicity data for the derivation of water quality guidelines for metals. Marine & Freshwater Research, 50, pp 729-738.

7. Bower, P.M., Simpson, H. J., Williams, S. C., and Li, Y. H. (1978), Heavy metals in the sediments of Foundry Cove, Cold Spring, New York. Environmental Science & Technology, 12, pp 683– 7.

8. Brix, H., Lyngby, J.E and Schierup, H.H. (1983), Eelgrass (*Zostera marinea* L.) as an indicator organism of trace metals in the Limfjord, Denmark. Marine Environmental Research, 8, pp 165-181.

9. Brooks, R.R., Presley, B. J., and Kaplan, I. R. (1967), APDC- MIBK extraction system for the determination of trace metals in saline waters by atomic absorption spectroscopy. Talanta, 14, pp 809- 816.

10. Brown, J.R. and Chow, L. Y. (1977), Heavy metal concentrations in Ontario fish. Bulletin Environmental Contamination and Toxicology, 17, pp 190–5.

11. Bryan, G.W. (1971), The effects of heavy metals (other than mercury) on marine and estuarine organisms. Proceedings of the Royal Society of Londan, 177, pp 389– 410.

12. Devlin, R.M.R. (1967), Plant physiology. New York, Reinhold, p. 564.

13. Eide, I., Myklestad, S., and Melson, S. (1980), Long term uptake and release of heavy metals by *Ascophyllum nodosum* (L.) Jol. (Phaeophyceae) insitu. Environmental Pollution, Series A, 23: 19- 28.

14. Fujiyama, T and Meada, M. (1979), Content and uptake of trace metals in benthic algae, *Entermorpha* and *Porphyra.* 1. Measurement and variation of trace metal content of *Porphyra* grown in natural environment. Journal of the Faculty of Fisheries and Animal Husbandry, Hiroshima University 16: 23- 32.

15. Haynes, D and Johnson, J. E. (2000), Organochlorine, heavy metal and polyaromatic hydrocarbon pollutant concentrations in the Great Barrier Reef (Australia) environment: A review of Marine Pollution Bulletin, 41, pp 267- 278.

16. Ho, Y.B. (1988), Metal levels in three intertidal macroalgae in Hong Kong waters. Aquatic Botany, 29, pp 367- 372.

17. Irvine, I and Birch, G. F. (1998), Distribution of heavy metals in surficial sediments of Port Jackson, Sydney, NewSouthWales. Australian Journal of Earth Sciences, 45, pp 297- 304.

18. Kemp, W.M., Boynton, W. R., Twilley, R. R., Court Stevenson, J., and Meena, J.C. (1983), The decline of submerged vascular plants in upper Chesapeake Bay: Summary of results concerning possible causes. Mar. Soc. Tech. J. 17:78- 89.

19. Nienhuis, P.H. (1986), Background levels of heavy metals in nine tropical seagrass species in Indonesia. Marine Pollution Bulletin, 17, pp 508– 511.

20. Peters, E.C., Gassman, N. J., Firman, J. C., and Richmond, R. H., and Power, E. A. (1997), Ecotoxicology of tropical marine ecosystems. Environmental Toxicology & Chemistry, 16, pp 12- 40.

21. Prasad, M.N.V and Strzalka, K. (1999), Impact of heavy metals on photosynthesis. Pp 117- 138. In: Prasad, M.N.V and Hagemeyer. J (eds)

22. Say, P.J., Burrows, I.G., and Whitton, B. A. (1990), *Entermorpha sp.* as a monitor of heavy metals in estuaries. Hydrobiologia 195, pp 119- 126.

23. Short, F.T and Wyllie-Echeverria, S. (1996), Natural and human- induced disturbances of seagrasses. Environmental Conservation, 23(1), pp 17- 27.

24. Vande, D.W and Groot, A.J. (1974), Heavy metals in river sediments. Geol Mijnb 53, pp 201– 203.

25. Ward, T.J. (1989), The accumulation and effects of metals in seagrass habitats. In: Larkum, A.W.D., McComb, A.J., Shepherd, S.A. (Eds.), Biology of Seagrasses: A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region. Elsevier, New York, pp 797–820.