American-Eurasian Journal of Scientific Research 4 (2): 73-80, 2009
ISSN 1818-6785

Heavy Metal Monitoring of Rameswaram Coast by Some *Sargassum species*

N. Jothinayagi and C. Anbazhagan

Department of Botany, Annamalai University, Annamalai Nagar-608 002, Tamilnadu, India

Abstract: Seaweeds have a high capacity to bind trace metals. Seaweeds are generally considered as the best bioindicator of aquatic bodies for nutrients as well as heavy metals. The use of organisms like algae to identify areas of trace metal contamination is attractive as these organisms concentrate metals from the ambient water. Accumulation of cadmium, cobalt, chromium, copper, iron, lead, manganese, nickel and zinc were determined in *Sargassum* species collected from Rameswaram coast. The concentration of the heavy metals is varied significantly in between the species and also their parts. The results showed that all the metals are lower in airbladder than in receptacle, stem and leaf. Chromium, iron and manganese content were higher in a1l the parts than in other metals studied. According to these findings *Sargassum wightii* were effectively used as the bioaccumulation study from the polluted sites.

Key words: Pollution · Heavymetal · *Sargassumspecies* · *Bioaccumulation*

INTRODUCTION

The presence of heavy metals in the environment is a major concern because of their toxicity to flora and fauna. Moreover, recovery of heavy metals from industrial waste streams is becoming increasingly important as society realises the necessity for recycling and conservation of essential metals.

Although dead algae have been utilized successfully in heavy metal adsorption [1, 2] living algae may be more advantageous due to metabolic uptake and continuous growth. Marine macroalgae, accumulate trace metals from solution and for this reason, have been used extensively as biomonitors of metal contamination of seawater [3, 4]. The present investigation was made on the bioaccumulation capacity of different *Sargassum* species in Rameswaram coast, Tamilnadu, India.

MATERIALS AND METHODS

Study Area and Sampling Stations: The study area Rameswaram is laid by South East of India Bay of Bengal and Indian ocean (Map-1).

Sampling Procedures: A minimum of four samples of the most commonly occurring *Sargassum* species such as *S. wightii, S. ilicifolium, S. liniarifolium* and *S.polycystum* were collected from the coast. All the thalli were thoroughly cleaned with seawater followed by running tapwater to remove adhering particulate matters. *Sargassum* species were separated into different portions like stem, leaf, airbladder and receptacle and oven dried at 30°C to constant weight and then pulverised to ensure uniform particle size.

Analytical Methods for Sample: Accurately weighed portions *of S.wightii, S.ilicifolium, S.liniarifolium* and *S.polycystum* (about 1 g dry weight) were digested in 8ml of concentrated HNO_3. The solutions were filtered through Whatman (589/2) filter paper and diluted accurately to 25ml volume with double deionised water. These solutions were analysed for heavy metal concentrations using a Perkin Elmer AA7 atomic absorption spectrophotometer. All the samples were analysed in triplicates. The concentrations are expressed as milligram per kilogram dry weight (mg/kg D.wt.) and the quoted values are means.

Statistical Analysis: All the analysis were made in three replicates. Statistical analysis was based on SPSS (Version 11.0) program. One way ANOVA test was carriedout to detect the significance of differences ($P<0.05$ or $P<0.01$) of variables.

Corresponding Author: Dr. C. Anbazhagan, Department of Botany, Annamalai University, Annamalai Nagar-608 002, Tamilnadu, India

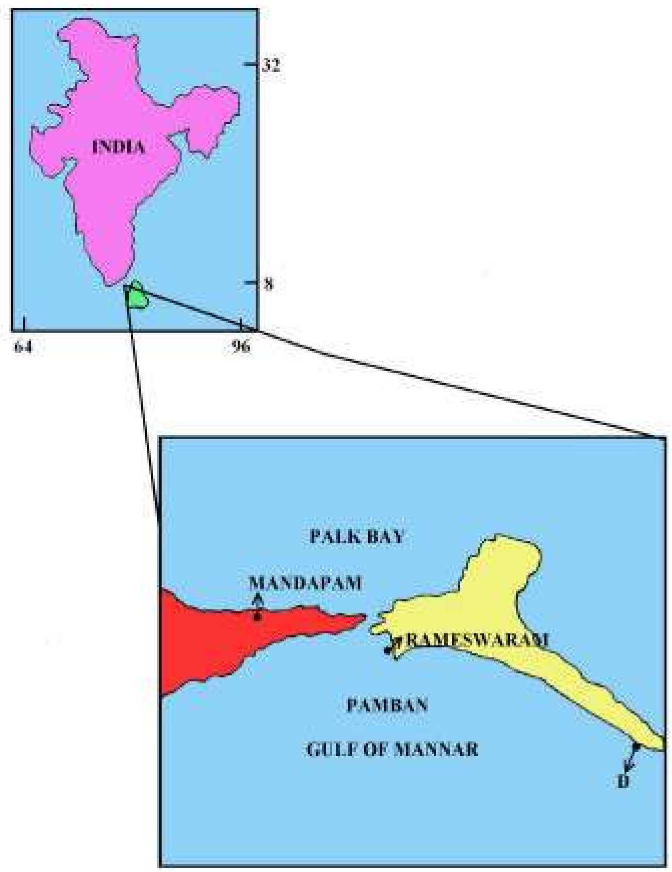

Fig. 1: Map showing collection spot

RESULTS

The heavy metals accumulation by *Sargassum* species were shown in Figures 2 to 10. The level of the metals in *Sargassum* species varied widely depending on their parts. The accumulation of different metals such as Cr, Cd, Cu, Co, Pb, Fe and Mn in the parts of stem, leaf, airbladder and receptacle of S. *wightii* was higher than in other species studied. The accumulation of metals are varied significantly between the species. The *S. wightii* contain higher amount of metals in all the parts followed by *S. ilicifolium, S. linarifolium* and *S. polycystum* ($P<0.05$). Among the heavy metals studied, iron was higher in all the parts followed by chromium. The results obtained in this study also indicate that different species of *Sargassum* have different affinities for different heavy metals ($P<0.01$ or $P<0.05$).

The higher accumulation of chromium was observed in the receptacle followed by leaf, stem and airbladder of *S. wightii*.

The other studied metals varied significantly due to their accumulating parts. The heavy metal nickel was higher in stem followed by leaf, receptacle and airbladder ($P<0.01$). Almost 50% accumulation of nickel was recorded in the stem of *S. wightii* followed by *S. ilicifolium* (35%). In case of the lead it was higher in stem sample than in leaf, receptacle and airbladder. Almost 20%, 15%, 10% and 9% of lead was accumulated in the stem, leaf, receptacle and air bladder of *S. wightii* ($P<0.05$). Similarly, the heavy metals copper, manganese and cadmium were higher in receptacle, when compared with stem, leaf and airbladder of all the *Sargassum* species ($P<0.05$).

The heavy metals lead, cobalt and zinc were higher in the stem followed by leaf, receptacle and airbladder.

The results from this study clearly illustrate that not all elevated concentrations of heavy metals in the marine environment necessarily reflect increased levels of pollution.

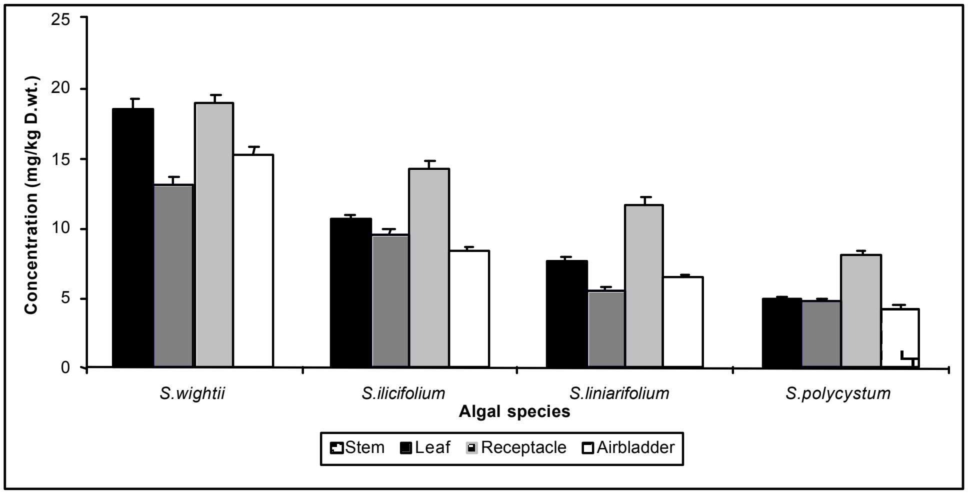

Fig. 2: Accumulation of copper content in different parts of *Sargassum* species

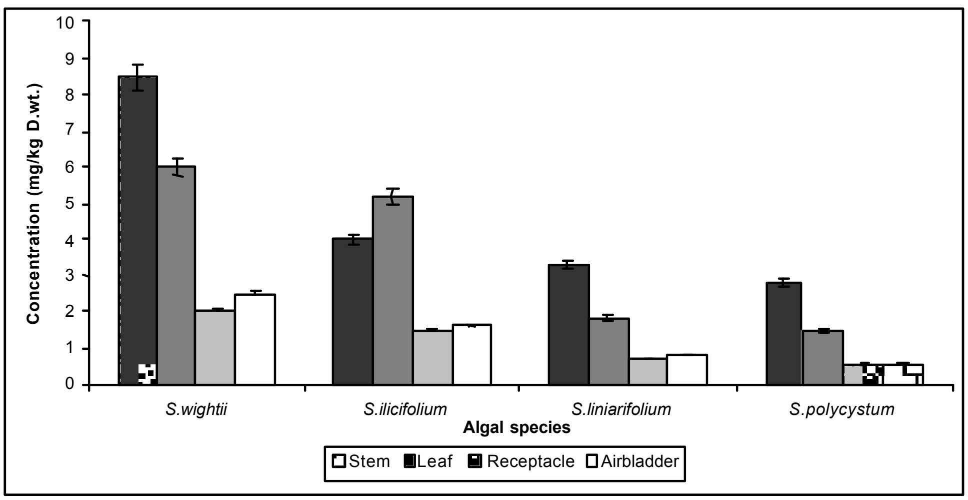

Fig. 3: Accumulation of cobalt content in different parts of *Sargassum* species

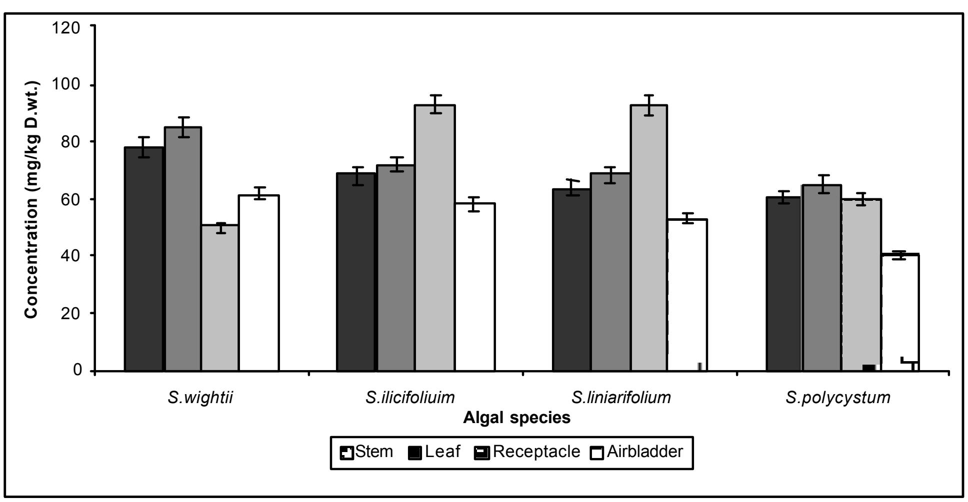

Fig. 4: Accumulation of manganese content in different parts of *Sargassum* species

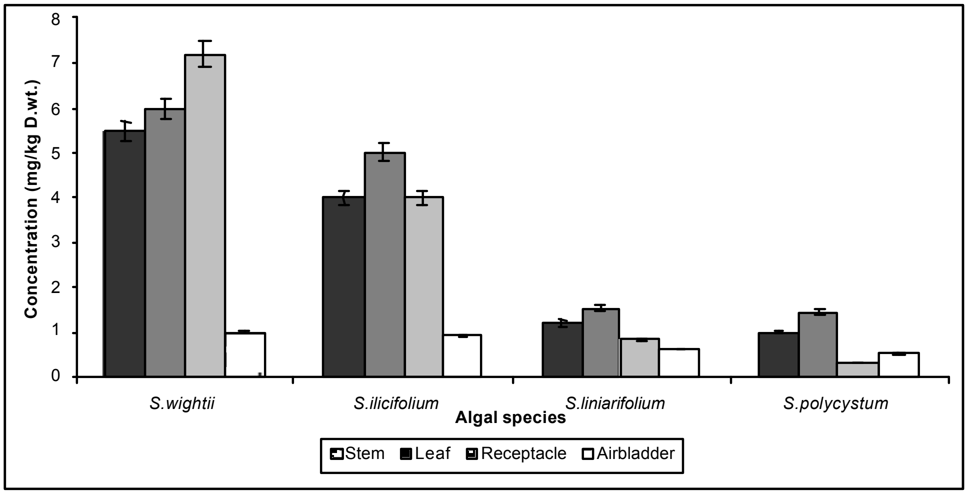

Fig. 5: Accumulation of cadmium content in different parts of *Sargassum* species

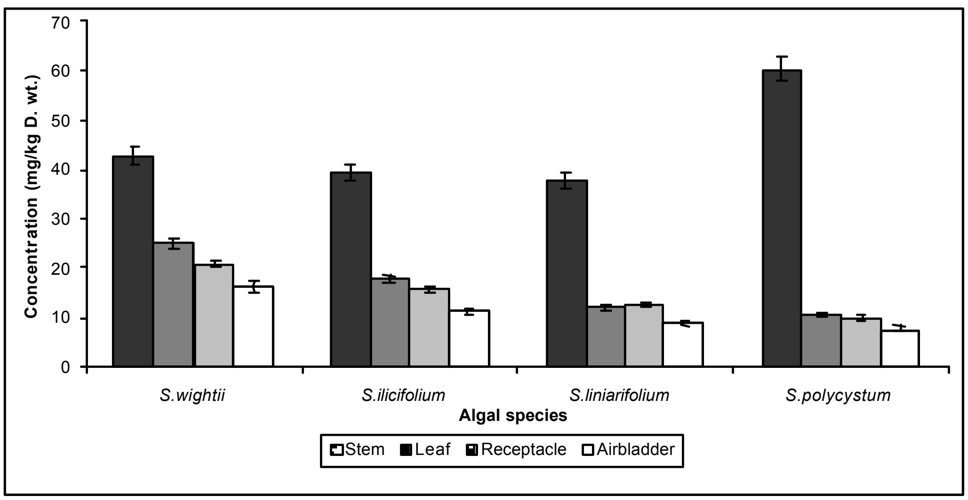

Fig. 6: Accumulation of zinc content in different parts of *Sargassum* species

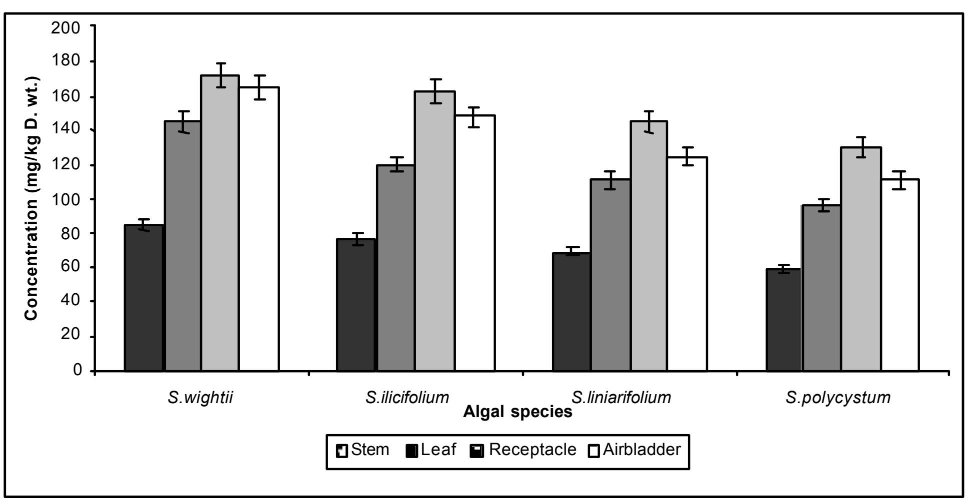

Fig. 7: Accumulation of chromium content in different parts of *Sargassum* species

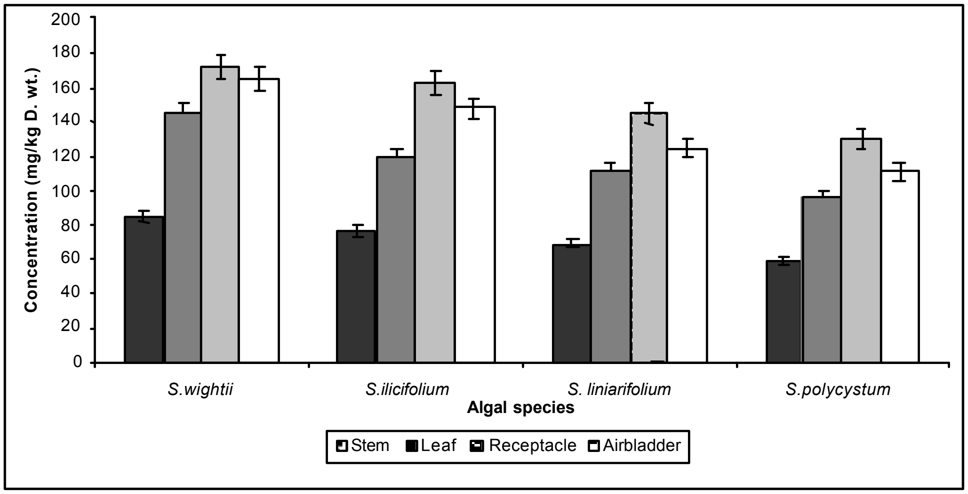

Fig. 8: Accumulation of nickel content in different parts of *Sargassum* species

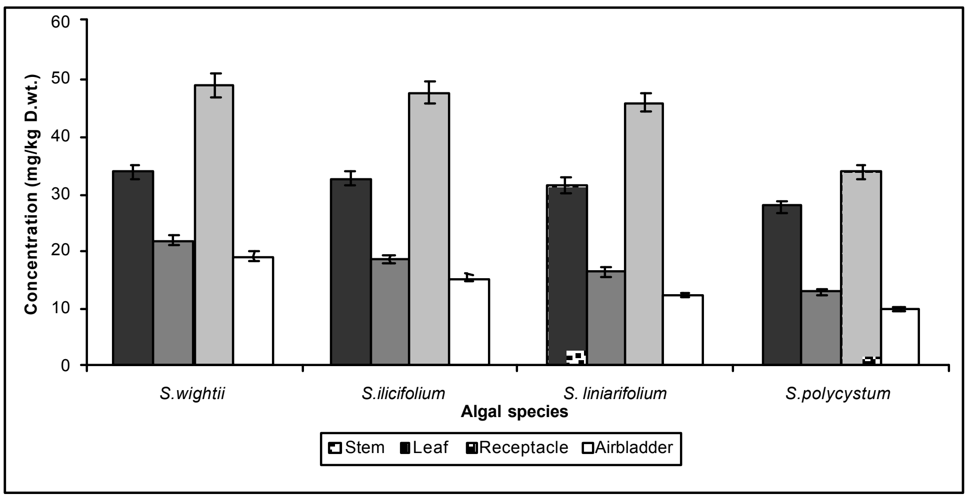

Fig. 9: Accumulation of iron content in different parts of *Sargassum* species

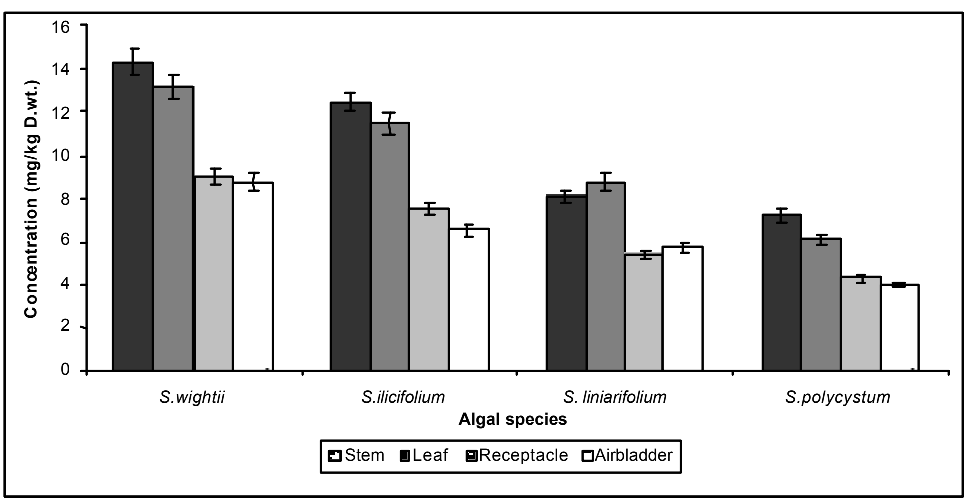

Fig. 10: Accumulation of lead content in different parts of *Sargassum* species

DISCUSSION

The accumulation of heavy metals varied significantly in different parts of the species in a previous study conducted in the Turkish Coast of the Black sea, 1998-2000 for heavy metal monitory of marine algae [4]. Seaweeds are the best material for biosorption because their macroscopic structures offer a convenient basis for the production of biosorbent particles suitable for sorption process [5-8]. This may reflect competition among metals for binding or uptake sites in the seaweed [9]. Comparing metal concentrations in algae among the species clearly indicates that the degree of accumulation depends not only on the human activities but also on the geology of the specific area.

The first phase of chromium biosorption is attributed to the surface adsorption due to the action of ion exchange with the participation of the carboxyl groups of uronic acid present in the cell structure which are known metal requesting sites. Similarly the metal concentrations were higher in the species collected from nearby industrial zone. It is well known that the heavy metals are introduced via rivers or direct discharge of industrial wastes into the sea.

The high levels of some heavy metals in the plant reflect firstly the high bioavailability of the metals in the study area and secondly the capacity of the alga to take them up [10]. Many factors may influence the bioavailability of metals in algae. With regard to the physico-chemical parameters, the main factors are pH, salinity, temperature, light, particulate matters and organic matters [10]. Besides the variations in the available metal concentrations in the ambient water, other factors such as water conditions, the stage of development and variation in growth and chemical composition of the algae may influence the pattern of accumulation [11-13].

Biomonitors may reflect the levels of metals in the environment, but they do not provide information on the source of the elevated concentrations, natural or anthropogenic. It also reflects that the species which accumulate higher metals may contain the metal tolerate genes.

The macroalgae were found to contain a high concentration of cadmium (Cd) when collected along the Urban coastlines because of input of these metals from sewage, metals product manufacturing, leather tanning, electroplating, the use of fertilizers and petroleum refining [12].

Phytoplankton studies on the influence of major nutrients on heavy metal bioaccumulation demonstrated that nutrient enrichment increased concentrations of cadmium uptake [14]. The enriched macroalgae have a higher Cd accumulation rate than the nitrate starved macroalgae [15].

Copper is an essential micronutrients but at toxic levels it depresses growth, pigment content and photosynthesis and respiration states [16-19].

The presence of high concentration of Cu in marine plants can be attributed to the fact that they are important micronutrients for various metabolic functions of the plant [20]. The wide range of metal concentrations in different algae species reflects the importance of biochemical factors in affecting the relative tendency of different tissue to concentrate pollutants.

The uptake of cobalt by *Laurencia corollopsis* appears to be active transport [9]. The Cobalt concentrations accumulated by *U. rigida* exceeded those observed in the algae in 1982 [21].

The presence of high concentration of Fe in marine plants can be attributed to the fact that they are important micronutrients for various metabolic functions of the plants [20]. The high level of Fe in all algal groups is consistent with the food chain magnification hypothesis [22].

The high levels of Fe are the result of enhanced photosynthesis and respiration, so increasing algae metal uptake [23-24]. Iron plays an important role in plant processes.

Lead (Pb) may be directly toxic to algae or might indirectly affect algal growth by forming lead-mineral complexes and thereby depleting supplies of an essential nutrient (i.e., phosphate) or nutrients [25].

Species of *Padina* and *Sargassum* were reported to be the best species for biomonitoring and phytoremediation of Zinc (Zn) from coastal tropical environment. However, the bioaccmulations of Zn in these genera were low. Probably in such cases species differences of the same genera may have different ability concentrate same metal ion [26].

The accumulation of Zn in nitrate starved macroalgae was lower than that in nitrate replete macroalgae. The accumulation Zn due to their weak affinity with binding ligands [15].

According to Lobban and Harrison [9], Ca and Mg concentrations in brown seaweeds are largely the result of an ion exchange between seawater and alginate (an acid polysaccharide) in the cell walls by a process of cation adsorption.

Co, Ni, Cr, in *U. rigida* in the study area exceeded those regarded as normal in marine macrophytes and the maximum concentrations were detected to exceed those in algae from a Ni-polluted area [27].

CONCLUSION

The results showed that all the metals are lower in airbladders than in receptacle, stem and leaf. Chromium, iron and manganese content were higher in all the parts than in other metals studied. According to these findings the species of *Sargassum* were effectively used as the bioaccumulation study from the polluted sites.

ACKNOWLEDGEMENT

I am extremely thankful to Professor and Head, Department of Botany, Annamalai University, Annamalai Nagar-608 002 for providing laboratory facilities. Also I am grateful to the UGC authorities for providing Rajiv Gandhi fellowship during the period of study.

REFERENCES

1. Leusch, A., Z.R. Holan and B. Volesky, 1995. Biosorption of heavy metals (Cd, Cu,Ni, Pb, Zn) by chemically reinforced biomass of marine algae. J. Chemical Technol. Biotechnol., 62: 279-288.
2. Holan, Z.R., B. Volesky and I. Prasetyo, 1993. Biosorption of cadmium by biomass of marine algae. Biotechnol. Bioengineering, 41: 819-825.
3. Brown, M.T. and M.H. Depledge, 1998. Determinants of trace metal concentrations in marine organisms. In: W.J. Langston, M.J. Bebianno, Eds. Metal metabolism in aquatic environments. London: Chapman and Hall., pp: 185-217.
4. Topcuoglu, S., K.C. Guven, N. Balkis and C. Kirbasoglu, 2003. Heavy metal monitoring of marine algae from the Turkish coast of the Black Sea, Chemosphere Biomaterials, 52: 1683-1688.
5. Figueira, M.M., B. Volesky, V.S.T. Ciminelli, 2000. Biosorption of metals in Brown seaweeds biomass. Water Research., 34: 196-204.
7. Volesky, B., J. Weber and R.H. Holan, 1995 Biosorption of heavy of Cd and Cu by different types of *Sargassum* biomass. In: Biohydrometallurgy and the Environment towards the mining of the 21st century (part B), Amils R. and Ballester A (eds). International Biohydrometallurgy symposium-proceedings. Elsevier. Amsterdam, pp: 473-482.
8. Yang, J. And B. Volesky, 1999. Biosorption and recovery of uranium by seaweed biomass. In Biohydrometallurgy and the environmental towards the mining of the 21st century (part B), Amils R and Ballester A (eds.). International Biohydrometallurgy Symposium-proceedings, Elsevier, Amsterdam, pp: 483-492.
9. Lobban, C.S. and P.J. Harrison, 1994. Seaweed ecology physiology. Cambridge University Press, New York, pp: 366.
10. Karez, C.S., V.F. Magalhaes, W.C. Pfeiffer and G.M. Amado Filho, 1994. Trace metal accumulation by algae in Sepetiba Bay. Brazil. Environ. Pollution, 83: 351-356.
11. Ho, Y.B., 1990. *Ulva lactuca* as bioindicator of metal contamination in intertidal waters in Hong Kong. Hydrobiologia., 203: 73-81.
12. Wong, M.H., T.T. Kwok and K.C. Ho, 1982. Heavy metals in *Ulva lactuca* collected with Tolo Habour an almost landlocked sea. Hydrobiol. Bulletin, 16: 223-230.
13. Carlson, L. and B. Erlandsson, 1991. Seasonal variation of radionuclides in *Fucus vesiculosus* L. from the oresund. Southern Sweden. Environmental Pollution., 73: 53-70.
14. Wang, W.X. and R.C.H. Dei, 2001. Effects of major nutrient additions on metal uptake in marine phytoplankton. Environ. Pollution III, pp: 233-240.
15. Wai-Yin Lee and Wen-Xiong Wang, 2001. Metal accumulation in the green macroalga *Ulva fasciata*: Effects of nitrate, ammonium and phosphate. Sci. Total Environ., 278: 11-22.
16. Davies, A.G., 1978. Pollution studies with marine plankton. Part II. Heavy metals. Advanced marine Biology., 15: 381-508.
17. Visuiki, I. and J.W. Rachlin, 1991. The toxic action and interaction of copper and cadmium to the marine alga *Dunalialla minuta* in both acute and chronic exposure. Archives of Environ. Contaminant and Toxicol., 20: 271-275.
18. Robinson, M.G., L.N. Brown, M.L. Quenneville and B.D. Hall, 1992. Aspects of copper tolerance and toxicity in *Amphom coffeaformis*. Biofouling, 5: 261-276.
19. Raj, L.C. and N. Mallick, 1993. Heavy metal toxicity to algar under synthetic microcosm. Ecotoxicol., 2: 231-242.
20. Donat, J. and C. Dryden, 2001. Transition metals and heavy metal speciation. In: Encyclopedia of ocean sciences. Academic, Elsevier Science, J. Steele, S. Thrope, K. Turekian, (Eds.) New York., pp: 3027-3035.
21. Malea, P. And S. Haritonidis, 2000. Use of the green alga, *Ulva rigida* C. Agardh as an indicator species to reassess metal pollution in Thermaikos Gulf, Greece after 13 years. J. Appl. Phycol., 12: 169-176.
22. Laws, E., 2000. Aquatic pollution. An introductory text. 3rd edn. Wiley, New York, pp: 369.

23. Wabbeh, M., 1984. Levels of Zn, Mn, Mg, Fe and Cd in three species of seagrasses from Agaba (Jordan). Aquatic Botany, 20: 179-183.
24. Catsiki, V.A. and E. Papathanassiou, 1993. The use of the chlorophyte *Ulva lactuca* (L.) as indicator organism of metal pollution. Proc. of the cost-48 symposium of sub. Group II. Macroalgae. Eutrophication and trace metal cycling in Estuaries and Lagoons. Thessaloniki., Sep., pp: 24-26.
25. Monahan, T.J., 1976. Lead inhibition of chlorophycean microalgae. Phycol., 12: 358-362.
26. Jadeja, R.N. and A. Tewari, 2007. Effect of soda ash industry effluent on bioaccumulation of metals by seaweeds of coastal region of Gujarat, India. Hazardous materials 147: 148-154.
27. Haritonidis, S. and P. Malea, 1995. Seasonal and local variation of Cr, Ni and Co concentrations in *Ulva rigida* C. Agardn and *Enteromorpha linza* (Linnaeus) from Thermaikos Gulf, Greece. Environmental pollution., 89: 319-327.