Trace metal accumulation efficiency of selected Macroflora associated with the Poovar Estuary (Thiruvananthapuram) Kerala, India

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ABSTRACT

Trace metal contamination is a matter of global concern today and phytoremediation can clean up the contaminated environment. The objective of the study is to examine the metal accumulation efficiency of selected macroflora associated with Poovar estuary. Cyperus tenuispica Steudel, Bacopa monnieri (L.) Pennell, Mariscus javanicus (Houtt.) Merr. & Metc. and Acanthus ilicifolius L. were collected from Poovar estuary and subjected for various elemental analyses such as copper, zinc, cadmium, chromium and lead. The study revealed that all the macrophytes under study were efficient accumulators of all these metals and could be used as bioindicators for metal pollution. Study warrants the analyses of more elements in these species, which could bring the potentiality of the plants as bioindicator for metal pollution.

Keywords: Poovar estuary, macroflora, copper, zinc, cadmium, chromium and lead.
All the binomials are abbreviated in the graphical representation as Ct (Cyperus tenuispica), Bm (Bacopa monnieri), Mj (Mariscus javanicus) and Ai (Acanthus ilicifolius).

1. Introduction

Presence of heavy metals in the aquatic environment is a matter of global concern. Phytoremediation has been widely accepted for its potential to clean up polluted and contaminated sites. The amount of trace elements in plants depends on the concentrations and availability in the medium, the physicochemical properties of the medium, climatic conditions and the amount of accumulation by different species. Use of plants to remove metals from the environment has received increasing attention in recent years. Chakrabarti et al. (1993) investigated trace metal concentration in different macrophytes associated with Sunderbans mangrove area. St. Cyr and Campbell (1994) analyzed the trace metals in submerged plants of St. Lawrence River. Gupta and Chandra (1996) observed copper accumulation and related toxicity in Hydrilla verticillata. Thomas and Fernandez (1997) analyzed trace metal accumulation in mangrove flora of Kumarakom, Quilon and Veli. Munshi et al (1998) studied the heavy metal accumulation in various macrophytes associated with Subernarekha River. Rama and Rajeswari (2001) observed the application of water hyacinth to assess cadmium pollution in Chennai city. Ashfaq and Saadia (2011) examined the potential of algae as a biosorben for the removal of heavy metals. De Luccia (2012) analyzed the determination of heavy metals in the bioindicator plant Tradescantia pallida var. purpurea. Parmar and Patel (2012) evaluated the effect of chromium and amendments on yield and heavy metal contents in different parts of rice. Prasannakumari et al (2012)
examined the distribution and abundance of copper, zinc, cadmium, chromium and lead content in *Lagenandra ovata* associated with Neyyar River. Saxena et al (2012) analyzed the potentiality of Marigold for lead phytoextraction from artificially contaminated soil. Yadav et al (2012) determined the effect of cyclic use of sewage water on growth, yield and heavy metal accumulation in cabbage. The present study is an attempt to delineate the accumulation and abundance of trace metals namely copper, zinc, cadmium, chromium and lead in four selected macrophytes - *Cyperus tenuispica* Steudel, *Bacopa monnieri* (L.) Pennell, *Mariscus javanicus* (Lam.) Dom. and *Acanthus ilicifolius* L. collected from Poovar estuary.

2. Materials and methods

Neyyar, the southernmost river of Kerala with a length of 56 Km (latitude 8° 16’ to 8° 40 ’N and longitude 77° 5’ to 77° 16 ’E) originating from the Agasthyamala, flows towards the midland and lowland, finally joins the Lakshadweep Sea at Poovar, Thiruvananthapuram district of Kerala state. *Cyperus tenuispica* Steudel, *Bacopa monnieri* (L.) Pennell, *Mariscus javanicus* (Lam.) Dom. and *Acanthus ilicifolius* L. associated with Poovar estuary were collected once a month for a period of one year. Thoroughly washed plants were dried in shade at room temperature for 5 days and oven dried for 48 hours. The dried and powdered plant samples were used for the analyses, following APHA (1992). Results were subjected to monthwise, seasonwise and annual average basis.

3. Results and discussion

3.1. Copper

Monthwiase data on copper content ranged from 17.00 to 48.00 µg g⁻¹, 7.00 to 19.00 µg g⁻¹, 7.00 to 22.00 µg g⁻¹ and 5.00 to 20.00 µg g⁻¹ in *Bacopa monnieri* (L.) Pennell, *Cyperus tenuispica* Steudel, *Mariscus javanicus* (Lam.) Dom. and *Acanthus ilicifolius* L. respectively. Annually it ranged from 11.33 µg g⁻¹ (*Acanthus ilicifolius* L.) to 34.07 µg g⁻¹ (*Bacopa monnieri* (L.) Pennell). Seasonal data are shown in figure 1.

![Figure 1](image_url)

**Figure 1:** Seasonal distribution of copper content in the macroflora

Comparatively higher concentration was observed in *Bacopa monnieri* and lower in *Acanthus ilicifolius*. Thomas and Fernandez (1997) recorded the copper concentration varying between 29.80 and 190.20 µg g⁻¹ in *Avicennia officinalis*, between 6.20 and 38.00 µg g⁻¹ in *Brugiera gymnorrhiza*, between 16.1 and 45.2 µg g⁻¹ in *Sonneratia caseolaris* and between 12.70 and 103.50 µg g⁻¹ in *Barringtonia racemosa*. Present findings in *A. ilicifolius* and *M. javanicus*...
remained within the range of the above findings. Prasannakumari et al (2012) detected the copper content in *Lagenandra ovata* (L.) Thwaites and recorded the values between 24.00 and 87.00 µg g\(^{-1}\). Present observations are in agreement with the above report.

Comparatively higher copper concentration than the present observation were detected by Munshi et al. (1998) in different macrophytes collected from the River Subernarekha at Ghatsila that fluctuated between 194.00 and 2055.10 µg g\(^{-1}\) in *Vallisnaria spiralis*, between 221.10 and 661.00 µg g\(^{-1}\) in *Potamogeton pusillus*, between 452.30 and 1194.00 µg g\(^{-1}\) in *P. pectinatus* and between 100.00 and 560.00 µg g\(^{-1}\) in *Hydrrilla verticillata*. Plants normally contain about 5 µg g\(^{-1}\) copper with a range of 4 – 15 µg g\(^{-1}\) and a toxic limit of 30 µg g\(^{-1}\) (Leeper (1978)). Out of the four macrophytes analyzed during the present study, copper concentration in *Bacopa monnieri* exceeds the toxic limit of 30.00 µg g\(^{-1}\) suggesting the copper accumulation efficiency of the species and can be used as bioindicator for copper.

### 3.2. Zinc

Monthwise data on zinc ranged from 32.50 µg g\(^{-1}\) to 106.00 µg g\(^{-1}\) in *Bacopa monnieri*, 15.00 µg g\(^{-1}\) to 42.00 µg g\(^{-1}\) in *Cyperus tenuispica*, 13.00 µg g\(^{-1}\) to 65.00 µg g\(^{-1}\) in *Acanthus ilicifolius* and 13.00 µg g\(^{-1}\) to 58.00 µg g\(^{-1}\) in *Mariscus javanicus* with an annual average value that ranged between 28.48 µg g\(^{-1}\) (*Mariscus javanicus*) and 61.74 µg g\(^{-1}\) (*Bacopa monnieri*). Seasonally (Figure 2) postmonsoon values remained higher in all the four macrophytes studied.

![Figure 2. Seasonal distribution of zinc content in the macroflora](image)

Comparatively higher accumulation of zinc than in the present findings were reported by Munshi et al. (1998) in *Vallisnaria spiralis* (804.20 and 1751.20 µg g\(^{-1}\)), *Potamogeton pusillus* (41.20 and 1065.00 µg g\(^{-1}\)), *P. pectinatus* (63.00 and 176.10 µg g\(^{-1}\)) and *Hydrrilla verticillata* (108.0 and 380.0 µg g\(^{-1}\)) and Prasannakumari et al (2012) in *Lagenandra ovata* (67.00 and 1224 µg g\(^{-1}\)). The present findings are in agreement with the observations of Thomas and Fernandez (1997) in different macrophytes collected from mangrove areas of Kumarakom and Quilon (18.0 and 67 µg g\(^{-1}\)) and St. Cyr and Campbell (1994) in *Vallisnaria americana* (91.00 and 130.00 µg g\(^{-1}\)) collected from St. Lawrence River (Canada). Zinc content in plants normally ranged between 8 µg g\(^{-1}\) and 15 µg g\(^{-1}\) with a toxic limit of 500 µg g\(^{-1}\) (Leeper, 1978) and all the 4 species analyzed during the present study showed higher concentration of zinc than that of the normal range indicating the zinc accumulation efficiency of the species.
3.3. Cadmium

Monthwise data on cadmium content ranged from 13.00 µg g⁻¹ to 119.00 µg g⁻¹ in *Bacopa monnieri*, 9.00 to 116.00 µg g⁻¹ in *Cyperus tenuispica*, 4.30 to 115.00 µg g⁻¹ in *Mariscus javanicus* and 4.00 to 123.50 µg g⁻¹ in *Acanthus ilicifolius*. The respective annual averages are 44.28 µg g⁻¹, 61.16 µg g⁻¹, 36.68 µg g⁻¹ and 41.30 µg g⁻¹. Seasonally (Figure 3) higher concentration was registered during monsoon in all the four macrophytes studied.

![Figure 3. Seasonal distribution of cadmium content in the macroflora](image)

Present result remained in agreement with the findings of Prasannakumari et al. (2012) in *Lagenandra ovata* (29.00 and 96.00 µg g⁻¹) collected from Neyyar River. Observations of Chakrabarti et al. (1993) in various parts of *Avicennia marina* (1.00 and 2.00 µg g⁻¹), *Porteresia coarctata* (0.90 µg g⁻¹), *Cariops decandra* (3.00 µg g⁻¹), *Aegialitis rotundifolia* (2.00 µg g⁻¹) and *A. ilicifolius* (2.40 µg g⁻¹) and St. Cyr and Campbell (1994) in *V. americana* (2.00 and 3.30 µg g⁻¹) remained lower when compared to the present outcome. The monthwise, seasonwise and annual average data on cadmium content remained higher than the common range (0.20 to 1.80 µg g⁻¹) and *Cyperus tenuispica* exceed the toxic limit of 100.00 µg g⁻¹ (Leeper, 1978) for plants. This suggests that all the four species analyzed during the present study can be used as bioindicators for cadmium.

3.4. Chromium

Monthwise chromium content in *Bacopa monnieri* ranged from 22.00 to 77.00 µg g⁻¹ with annual average value of 40.22 µg g⁻¹, in *Cyperus tenuispica* from 22.00 to 65.00 µg g⁻¹ with annual average of 46.92 µg g⁻¹, in *Mariscus javanicus* from 24.50 to 58.00 µg g⁻¹ with annual average of 34.13 µg g⁻¹ and in *Acanthus ilicifolius* from 22.63 to 150.50 µg g⁻¹ with annual average of 42.18 µg g⁻¹. In *Bacopa monnieri*, *Cyperus tenuispica* and *Mariscus javanicus* monsoon values (figure 4) remained higher followed by premonsoon and postmonsoon where as in *Acanthus ilicifolius* the values remained higher during premonsoon. The present findings are in conformity with the reports of Prasannakumari et al. (2012) in *Lagenandra ovata* (17.00 and 57.00 µg g⁻¹). Where as the reported values of Stenner and Nickless (1975) in marine algae (1.00 and 13.00 µg g⁻¹), Keller et al. (1998) in the leaves (0.10 µg g⁻¹) and roots (2.70 µg g⁻¹) of *Phragmites australis* and Sivakumar et al. (2001) in the leaves (1.25 µg g⁻¹) and flowers (1.09 µg g⁻¹) of *Croton banplandianum* remained lower when compared to the present observations. Comparatively higher values of chromium than those in the present inquiry were registered by Bousaka (1981) in crop plants (213.00 and 449.00 µg g⁻¹) from a
coal fired region in Czechoslovakia and Zhu et al. (1999) in the shoot (119.00 µg g⁻¹) and root (395.00 µg g⁻¹) of *Eichhornia crassipus*. Normal composition of chromium in plants is 1.5 µg g⁻¹ (Markert, 1994) and the results obtained during the present study remained higher in all the four macrophytes studied indicating the efficiency of chromium accumulation.

![Figure 4. Seasonal distribution of chromium content in the macroflora](image)

**3.5. Lead**

Lead content in macrophytes ranged from 20.00 to 154.00 µg g⁻¹ in *Bacopa monnieri*, 6.00 to 122.00 µg g⁻¹ in *Cyperus tenuispica*, 3.00 to 154.00 µg g⁻¹ in *Mariscus javanicus* and 4.86 to 42.00 µg g⁻¹ in *Acanthus ilicifolius*. The corresponding annual averages are 61.38 µg g⁻¹, 72.67 µg g⁻¹, 59.95 µg g⁻¹ and 16.44 µg g⁻¹ respectively. All the four macrophytes except *Acanthus ilicifolius* showed monsoon high values (figure 5) of lead accumulation.

![Figure 5. Seasonal distribution of lead content in the macroflora](image)

The present findings are in concurrence with the observations of Untawale et al. (1980) in *Avicennia officinalis* (66.08 µg g⁻¹), Forstner and Wittman (1983) in *Ulva lactusa* (18 µg g⁻¹), Coquery and Welbourn (1995) in the root system of *Eriocaulon septangulare* (2.5 and 62.8 µg g⁻¹), Thomas and Fernandez (1997) in *Avicennia officinalis* (75 to 225 µg g⁻¹), *A. ilicifolius* (25 to 125 µg g⁻¹), *Bruguiera gymnorrhiza* (50 and 75 µg g⁻¹), *Sonneratia caseolaris* (25 to 125 µg g⁻¹) and *Baringtonia racemosa* (25 to 200 µg g⁻¹), Munshi et al. (1998) in *Vallisnaria*...
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**spiralis** (60 to 82.1 µg g⁻¹), *Potamogeton pusillus* (18 to 29 µg g⁻¹), *P. pectinatus* (18.2 to 40.4 µg g⁻¹), and *Hydrilla verticillata* (18.2 to 82 µg g⁻¹) and Prasannakumari et al. (2012) in *Lagenandra ovata* (3.00 122.00 µg g⁻¹).

The findings of Jain et al. (1990) in *Azolla pinnata* (158.00 to 7654.00 µg g⁻¹) during a controlled experiment in laboratory and Cymerman et al. (1991) in *Scapania uliginosa* (464.00 µg g⁻¹) were found higher in comparison with the values observed herein. The present findings remained higher in all the four macrophytes studied than the normal range of lead in plants (0.10 to 10.0 µg g⁻¹ – Leeper, 1978) indicating the lead accumulation efficiency of the species.

4. Conclusion

The uptake and translocation of the element by the plants occurred according to the quantity of the element present in the surrounding. Cadmium, a non-essential toxic element, enters the environment in lesser extent from natural weathering and through various industrial processes. As there are no point sources of cadmium along the estuary, allochthonous inputs may serve as the only possible source of cadmium. Higher concentration of chromium observed may be suggestive of their efficiency in the absorption and accumulation of chromium from the estuarine environment. Surface runoff carrying allochthonous inputs and automobile exhausts account for the accumulation of lead. The monsoon/post monsoon high values recorded may be under the influence of the terrigenous runoff carrying particular metal. The study revealed that all the four macrophytes analyzed in the present investigation were efficient accumulators of different trace metals such as copper, zinc, cadmium, chromium and lead and all the four species could be used as bioindicators of these metals. Study warrants the analysis of more elements of these species which could bring the potentiality of the plants as bioindicator for metal pollution.

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5. References

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