ABSTRACT

Heavy metals are essential for proper functioning of the biological systems and their deficiency or excess could lead to a number of disorders. Aquatic environment is contaminated by heavy metals; mainly originate from mining activities, intensive agricultural practices, discharge of untreated industrial effluents and application of sewage sludge and indiscriminate disposal of domestic and municipal wastes. The objective of the study is to analyze the absorption potential for heavy metals by selected ferns associated with Neyyar River. *Acrostichum aureum* Lam, *Adiantum latifolium* L., *Blechnum orientale* L. and *Pityrogramma calomelanos* (L.) Link were collected from four different locations along Neyyar River and analyzed different trace metals such as copper, zinc, cadmium, chromium and lead for a period of one year. The study revealed that all the four species analyzed were with high absorption potential for these metals and can be used as bioindicators for trace metal pollution.

**Keywords:** Neyyar River, Ferns, Copper, Zinc, Cadmium, Chromium, Lead.

1. Introduction

Heavy metal pollution is an issue of international distress at present. The discharge of untreated and contaminated sewage and industrial effluent is one of the most significant reasons for heavy metal pollution of ecosystems and irrigated lands. Today phyto-remediation has been received much attention for its potential to clean up the contaminated sites by absorbing the trace metals. Application of water hyacinth to assess cadmium pollution in Chennai city (Rama and Rajeswari, 2001), potential of algae as biosorbent for removal of heavy metals (Ashfaq and Saadia, 2011), determination of heavy metals in the bioindicator plant *Tradescantia pallida* var. *purpurea* (De Luccia, 2012), effect of chromium and amendments on yield and heavy metal contents in different parts of rice (Parmar and patel, 2012), distribution and abundance of copper, zinc, cadmium, chromium and lead content in *Lagenandra ovata* (Prasannakumari et al., 2012), Potentiality of Marigold for lead phytoextraction from artificially contaminated soil (Saxena et al., 2012), effect of cyclic use of sewage water on growth, yield and heavy metal accumulation in cabbage (Yadav et al., 2012), trace metal accumulation efficiency of selected macroflora associated with Poovar estuary (Prasannakumari et al., 2014), distribution and abundance of trace metals in the macroflora of an aquatic system (Arathy et al., 2014) etc are few among them. The objective of the present study is to analyze heavy metal absorption potential of four selected ferns.
Acrostichum aureum Lam, Adiantum latifolium L., Blechnum orientale L. and Pityrogramma calomelanos (L.) Link collected along the sides of Neyyar River.

2. Materials and method

The state of Kerala, popularly known as God’s Own Country is blessed with 44 rivers, among them Neyyar River is the southernmost one. It has 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 through the midland and lowland and finally joins the Lakshadweep Sea at Poovar. Acrostichum aureum Lam, Adiantum latifolium L., Blechnum orientale L. and Pityrogramma calomelanos (L.) Link were collected from four different locations along Neyyar River for a period of one year. Voucher specimens were identified by Dr. Raju Antony, Pteridologist, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, Kerala. Thoroughly washed, dried and powdered plant samples were used for different elemental analyses such as copper, zinc, cadmium, chromium and lead following the methods in APHA (1992).

3. Results and discussion

3.1 Copper

Among the four species analyzed the maximum seasonal value (Figure 1) of copper (27.25 µg g⁻¹) was registered in Acrostichum aureum Lam. during postmonsoon season. Results obtained during the present study remained well within the observations of Thomas and Fernandez (1997) in Avicennia officinalis (6.20 and 38.00 µg g⁻¹) and Sonneratia caseolaris (16.1 and 45.2 µg g⁻¹) and Prasannakumari et al (2014) in selected macroflora associated with the Poovar Estuary (8.07 and 42.75 µg g⁻¹).

![Figure 1: Seasonal variation of copper content in selected ferns](image-url)

Comparatively higher concentrations were reported by Thomas and Fernandez (1997) in Barringtonia racemosa (12.70 and 103.50 µg g⁻¹), Munshi et al. (1998) in Vallisneria spiralis (194.00 and 2055.10 µg g⁻¹), Potamogeton pusillus (221.10 and 661.00 µg g⁻¹), P. pectinatus (452.30 and 1194.00 µg g⁻¹) and Hydrilla verticillata (100.00 and 560.00 µg g⁻¹) and Prasannakumari et al (2012) in Lagenandra ovata (24.00 and 87.00 µg g⁻¹). The major source of copper contamination is industrial effluents, waste products, mining and mineral leaching. Comparatively lower values observed in the present study than the above findings may be due to the absence of industrial effluents and mineral leaching. 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). In the present findings postmonsoon values of all the four species, monsoon values of Blechnum orientale L. and Adiantum latifolium L. and premonsoon value of Pityrogramma calomelanos...
(L.) Link remained higher when compared to the above findings indicating the copper absorption potential of the species.

3.2 Zinc

Seasonal values of zinc (Figure 2) ranged from 17.60 in *Pityrogramma calomelanos* (monsoon) to 47.63 µg g⁻¹ in *Adiantum latifolium* L. (postmonsoon). Present observations remained lower when compared to the findings of 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), *Hydrilla verticillata* (108.0 and 380.0 µg g⁻¹), St. Cyr and Campbell (1994) in *V. americana* (91.00 and 130.00 µg g⁻¹) in Lawrence river (Canada) and Prasannakumari et al (2012) in *Lagenandra ovata* (67.00 and 1224 µg g⁻¹) collected from Neyyar river. The present findings are more or less in agreement with the observations of Thomas and Fernandez (1997) in mangroves (18.0 and 67 µg g⁻¹) collected from Kumarakom and Quilon and Prasannakumari et al (2014) in selected macrophytes (20.10-88.13 µg g⁻¹) associated with the Poovar Estuary. Zinc content in plants normally ranged between 8 and 15 µg g⁻¹ with a toxic limit of 500 µg g⁻¹ (Leeper, 1978). In the present study all the four species showed higher concentration of zinc than the normal range but within the toxic limit irrespective of season and can be used as bioindicators for zinc.

![Figure 2: Seasonal variation of zinc in selected ferns](image_url)

3.3 Cadmium

Seasonal data (Figure 3) on cadmium ranged from 19.70 in *Acrostichum aureum* to 123.50 µg g⁻¹ in *Adiantum latifolium* during premonsoon and monsoon respectively. Comparatively lower concentration than the present findings were reported by St. Cyr and Campbell (1994) in *V. americana* (2.00 and 3.30 µg g⁻¹), Heydt (1977) in *Potamogeton pectinatus* (0.13 and 1.29 µg g⁻¹) and *P. crispus* (0.21 and 1.25 µg g⁻¹) and Chakrabarti et al. (1993) in *Avicennia marina* (1.00 and 2.00 µg g⁻¹), *Portersea coarctata* (0.90 µg g⁻¹), Cariop decandra (3.00 µg g⁻¹), *Aegialitis rotundifolia* (2.00 µg g⁻¹) and *Acanthus ilicifolius* (2.40 µg g⁻¹).

Present results are in agreement with the reports of Prasannakumari et al (2012 & 2014) in *Lagenandra ovata* (29.00 and 96.00 µg g⁻¹) and various other macrophytes (17.52 and 111.00 µg g⁻¹). Cadmium content in all the four species recorded during the present study remained higher when compared to the common range of cadmium in plants (0.20 to 1.80 µg g⁻¹) suggested by Leeper (1978) and exceed the toxic limit of 100.00 µg g⁻¹ in *Blechnum orientale* and *Adiantum latifolium* during monsoon season. This indicated the absorption potential for cadmium by the particular species and can be used as bioindicators for cadmium toxicity.
Absorption potential for heavy metals by selected ferns associated with Neyyar River (Kerala), South India

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3.4 Chromium

Seasonal values (Figure 4) of chromium varied from 11.38 to 66.00 µg g\(^{-1}\) in *Blechnum orientale* L. during postmonsoon and monsoon seasons. Values obtained during the present study remained higher when compared to 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*.

Whereas higher values than the present observations were reported by Zhu et al. (1999) in the shoot (119.00 µg g\(^{-1}\)) and root (395.00 µg g\(^{-1}\)) of *Eichhornia crassipinnis*. Present results are in unison with the findings of Prasannakumari et al (2012 &2014) in *Lagenandra ovata* (17.00 and 57.00 µg g\(^{-1}\)) and selected macrophytes from Poovar Estuary (30.75 and 59.50 µg g\(^{-1}\)). All the four species studied revealed higher accumulation of chromium than their normal composition in plants (1.5 µg g\(^{-1}\)) as suggested by Markert (1994) indicating the efficiency of chromium accumulation.

3.5 Lead

Seasonal value (Figure 5) of lead ranged from a minimum of 13.38 in *Acrostichum aureum* Lam. (postmonsoon) to a maximum of 116.00 in *Blechnum orientale* L. (monsoon). More or less similar results were reported by Untawale et al. (1980) in *Avicennia officinalis* (66.08 µg g\(^{-1}\)) at Goa region, Forstner and Wittman (1983) in *Ulva lactuca* (18 µg g\(^{-1}\)), Coquery and Welbourn (1995) in *Eriocaulon septundulare* (2.5 and 62.8 µg g\(^{-1}\)), Thomas and Fernandez (1997) in *Avicennia officinalis* (75 to 225 µg g\(^{-1}\)), *Acanthua ilicifolius* (25 to 125 µg g\(^{-1}\)), *Bruguiera gymnorrhiza* (50 and 75 µg g\(^{-1}\)), *Sonneratia caseolaris* (25 to 125 µg g/g) and...
Baringtonia racemosa (25 to 200 µg g\(^{-1}\)), Munshi et al. (1998) in Vallisnaria 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 & 2014) in Lagenandra ovata (L.) Thwaites (3.00 122.00 µg g\(^{-1}\)) and selected macrophytes from Poovar Estuary (7.46 and 116.00 µg g\(^{-1}\)).

Figure 5: Seasonal variation of lead in the selected ferns

Comparatively higher values than the present observations were reported by Jain et al. (1990) in Azolla pinnata (158.00 to 7654.00 µg g\(^{-1}\)) during a controlled experiment in lab and Cymerman et al. (1991) in Scapania uliginosa (464.00 µg g\(^{-1}\)) in streams in Poland, Belgium and Germany. Lead content in all the four species analyzed in the present study remained higher than the normal range in plants (0.10 to 10.0 µg g\(^{-1}\) – Leeper, 1978) indicating the lead accumulation efficiency of the species.

4. Conclusion

On the basis of above findings, it can be concluded that all the 4 species analyzed during the present study revealed higher absorption potential for all the five metals than their normal concentration in plants suggesting to exploit these plants as bioindicators for metals. The uptake and translocation of the element by the plants happened according to the quantity of the element present in the surrounding. Surface runoff carrying allochthonous inputs and automobile exhausts also account for the accumulation of lead. This may be the reason for higher levels of lead accumulation in the entire four species analyzed. Natural weathering and industrial processes are responsible for the entry of cadmium in the environment. The monsoon high values recorded in the present study may be under the influence of the terrigenous runoff carrying particulate metal. However the results demand the inquiry of other elements in these species which could bring the potentiality of the species as bioindicator for metal pollution.

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5. References


