SEDIMENT QUALITY, METAL BIOACCUMULATION AND ANTIMICROBIAL PROPERTIES OF MANGROVES OF SUNDARBAN, INDIA

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Introduction

Mangroves host estuarine salt tolerant plants that have a wide range of applications in folk medicine because of their anthelmintic, antimicrobial, anti-inflammatory and other therapeutic properties. Trace elements and metals in mangrove habitats are highly significant mainly because of their toxicity, persistent nature, bioaccumulation capacity and potential ecotoxicological risk which may arise due to anthropogenic interference (Liu et al. 2009). The bioaccumulated trace elements along with bioactive metabolites are characteristics of the plants having several pharmacological attributes (Xie et al. 2004). Considering the importance of trace metals, the present study was aimed to determine the metal bioaccumulation and sediment quality of a mangrove dominated habitat of Indian Sundarban (in terms of bioconcentration factors, element enrichment, contamination, geo-accumulation and potential ecological risk), and their relation with antimicrobial property of ten mangrove plants of this region. The study of bioaccumulation of elements in various parts of mangrove and their consequent biotic response can also provide an insight to the plant-sediment interactions (Chaudhuri et al. 2014).

Methods

The elemental distribution of mangrove leaves, their subsequent fractions and habitat sediments were analyzed using Energy dispersive X-ray fluorescence spectroscopy. The antimicrobial activity of the solvent fractions (hexane, ethyl acetate, acetone, methanol) of mangrove leaves were assessed against six different microorganisms (*Escherichia coli, Agrobacterium tumefaciens, Streptococcus mutans, Staphylococcus aureus, Tricophyton rubrum*, *Aspergillus flavus)* and correlated with the plant metal concentration and bioaccumulation.

Results

The highest antimicrobial activity was found using ethyl acetate and acetone fractions of *Avicennia alba* against *Staphylococcus aureus* (11.9 mm and 15.6 mm zone of inhibition respectively). Biological Concentration Factors (BCF) for different elements (0.002-1.442) indicates gradual metal bioaccumulation in leaf tissues. Analysis of variance (one-way ANOVA) results confirm the wide variation in elemental concentrations in mangroves, even in case of the leaves collected from the same site. Various sediment quality indices suggest the surface sediments are moderately contaminated and suffering from progressive deterioration. Cu, Cr, Zn, Mn and Ni showed higher Enrichment Factors (0.658-1.469), Contamination Factors (1.02-2.7) and Geo-accumulation Index (0.043-0.846) values. The Potential Ecological Risk Index (PERI) values based on Cu, Cr, Pb and Zn was found within 'low ecological risk' category (20.04-24.01) where Cr and Ni are of more concern in terms of Effect Range Low (ERL) and Probable Effect Level (PEL) in the Sundarban mangroves (Figure 1). Strong correlation of Zn with Fe and K was established, suggesting their similar transportation and accumulation process in both sediment and plant system. The plant–sediment elemental correlation is highly non-linear suggesting role of some physiological and edaphic factors in the accumulation process. Pearson's correlation analysis depicts both positive and negative correlations between the antimicrobial activities and metal

concentration of mangroves. Mn showed a range of significant correlation with almost all the fractions whereas Cu had correlation with ethyl acetate, acetone and methanol fractions. Zn and Fe expressed correlation with hexane fractions only. The BCF of Mn and Cu mostly show correlation with the antimicrobial activities of acetone and methanol fractions of mangroves whereas Fe and Zn exhibits correlation with the hexane and ethyl acetate fractions. The entire study can be summed up in the three dimensional relationship where Mn, Fe, Cu and Zn concentrations of *Acanthus ilicifolius* and *Avicennia alba* leaves and surface sediments found to have the strongest association ($p<0.05$) with their antimicrobial activity as also suggested in correlation and cluster analysis studies (Figure 2).

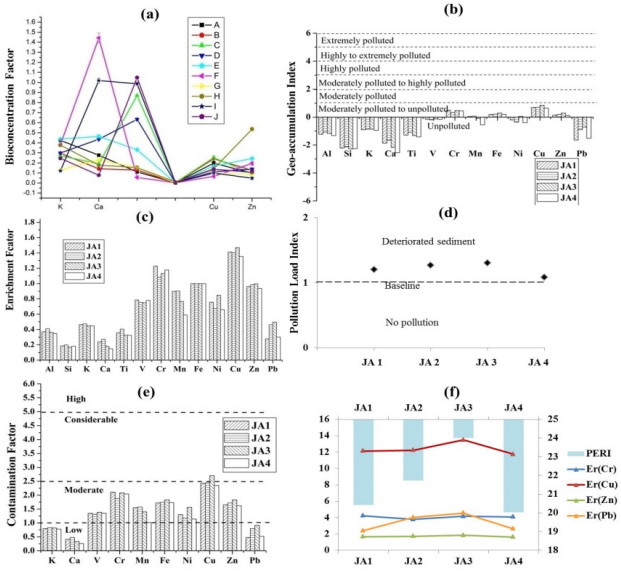

Figure 1: Plant and sediment indices: (a): Bio-concentration factors of the elements in mangrove leaves, (b): Geo-accumulation Index, (c): Enrichment Factor, (d): Pollution load index, (e): Contamination factor, (f): Potential risk of individual metal & Potential Ecological Risk Index in habitat sediments.

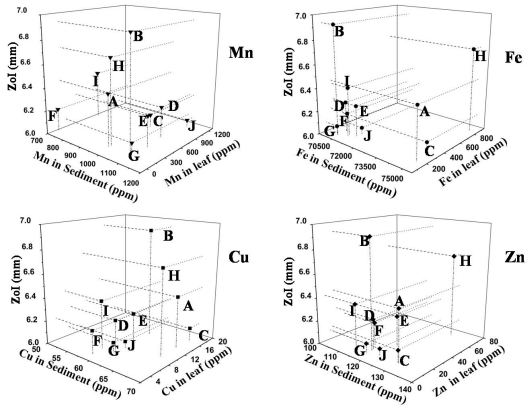

Figure 2: 3D representation of metals in sediment and plant along with their antimicrobial activity (A: A. marina, B: A. alba, C: A. officinalis, D: S. apetela, E: S. caseolaris, F: E. agallocha, G: A. corniculatum, H: A. ilicifolius, I: C. decandra, J: N. fruticans)

Conclusion

This study has potentially assessed the influence of sediment quality and metal bioaccumulation on the bioactivity of mangrove leaves of Indian Sundarban. The various indices (EF, Igeo, Cf, PLI) indicate the surface sediment quality to be moderately contaminated and suffering from progressive deterioration of estuarine quality. The study area which is a part of Indian Sundarban is currently facing anthropogenic interference in form of tourism, domestic sewage, vehicular emission etc. Change in the sediment quality can certainly influence and affect the metal concentration of the surrounding biotic community by bioaccumulation and biomagnifications. Positive role of metals found with respect to antimicrobial activity of mangroves where the strongest association found in case of *Acanthus ilicifolius* and *Avicennia alba* with trace metals.

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