

SEASONAL VARIATION IN HEAVY METAL CONCENTRATION IN MANGROVE FOLIAGE

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ABSTRACT

Seasonal variation in the concentration of some heavy metals in the leaves of seven species of mangrove vegetation from Goa, revealed that maximum concentration of iron and manganese occurs during the monsoon season without any significant toxic effect on the foliage of mangroves. Other metals like copper, nickel, cobalt and lead showed somewhat uniform concentration patterns. Copper and nickel were found to be greater (119.41 $\mu\text{g/g}$) in *Avicennia officinalis*, while *Acanthus ilicifolius* showed high concentration (46.98 $\mu\text{g/g}$) of cobalt. Nickel was found to be greater in *Bruguiera gymnorhiza* (113.66 $\mu\text{g/g}$ average) and *Rhizophora mucronata* (231.06 $\mu\text{g/g}$ average).

INTRODUCTION

Different parts of terrestrial, aquatic and semiaquatic plants have been analysed earlier for their trace metal concentrations (Antonovics, Bradshaw and Turner, 1971; Boyd, 1971; Walsh and Grow, 1973).

Joshi (1976), Gulati, Nagpaul and Bukhari (1979) and Bhosale (1979) have studied the metal concentration in mangrove foliage. Ramadhas, Rajendran and Venugopalan (1974) have described the recycling of minerals in mangrove ecosystem at Pichavaram.

Goa has a network of estuaries with fringing mangroves (Fig. 1). The heavy precipitation during monsoon season washes down the sediments from the hinterland which is well known for mineral deposits of iron and manganese.

The present paper gives the variations in the mineral content of the foliage of mangroves during the seasons of monsoon (June to September), post-monsoon (October to January) and pre-monsoon (February to May).

MATERIAL AND METHODS

Mature (average sized) fresh leaves of mangrove species such as *Derris trifoliata*, *Bruguiera gymnorhiza*, *Bruguiera parviflora*, *Acanthus ilicifolius*, *Sonneratia alba*, *Avicennia officinalis* and *Rhizophora mucronata* were hand plucked every month. The leaves were washed with tap water to remove the adhering matter and dried in hot air oven at 80°C. Dried leaf powder was ignited at 500°C for six hours in muffle furnace. The observations for the month of June could not be included.

A pre-weighed sample of the ash was digested with perchloric acid and concentrated hydrochloric acid. The residue was dissolved in a known volume of distilled water and was used for the estimation of copper, iron, manganese, lead, nickel and

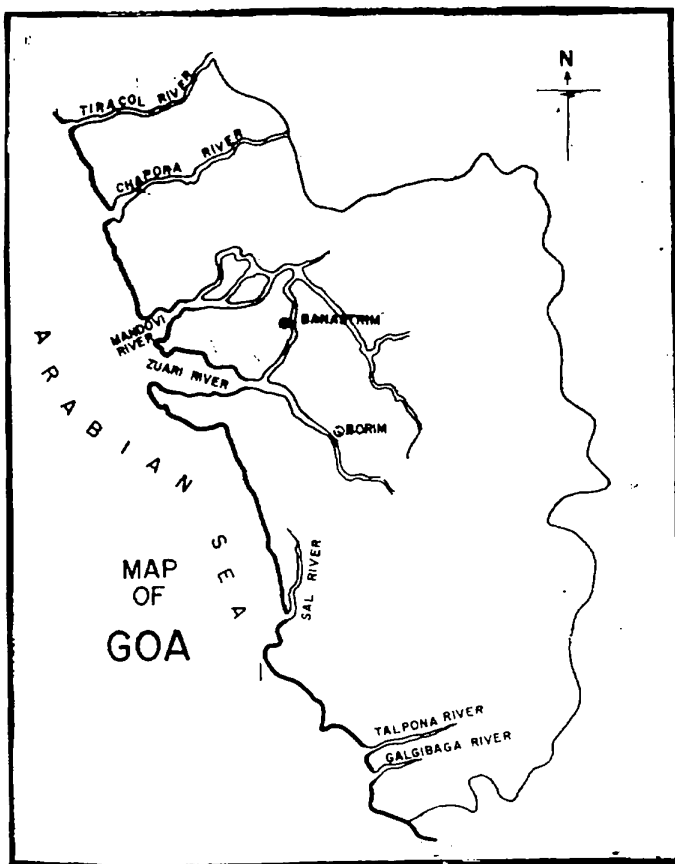


Fig. 1. Map of Goa showing the spots of collection.

cobalt by Atomic Absorption Spectrophotometer (Hilger and Watts Atomispeck H-1550). Standards were also treated in the similar way.

RESULTS

The concentrations of various metals in different mangrove species are discussed below:

1. *Derris trifoliata* (= *D. heterophylla*)

Maximum concentration of iron (7808.7 $\mu\text{g/g}$) was observed in this species during monsoon season. However, the second maxima of 3312.4 $\mu\text{g/g}$ was noticed in February. Manganese was found to be in highest concentration (4325.75 $\mu\text{g/g}$) during September, April (3977.9 $\mu\text{g/g}$) and January to February (3442.75 to 3656.85 $\mu\text{g/g}$). Copper concentration fluctuated with the maximum of 84.65 $\mu\text{g/g}$ during February and minimum of 18.40 $\mu\text{g/g}$ during March. The seasonal fluctuations of cobalt and lead are negligible (Figs. 2, 3, 4, 5).

2. *Bruguiera gymnorhiza*

As in *D. trifoliata*, average values of iron showed two peaks—one reaching to its maximum in May (22009.85 $\mu\text{g/g}$) and another peak during monsoon in the month of August (7837.3 $\mu\text{g/g}$). Manganese was found to be maximum (3184.1 $\mu\text{g/g}$) in February, whereas in July, it was minimum 356.75 $\mu\text{g/g}$. Thus the manganese concentration during premonsoon and postmonsoon months was high, while during monsoon it was low. Cobalt showed no significant seasonal variation during monsoon. The maximum value recorded was 30.11 $\mu\text{g/g}$ in August and minimum in January 6.03 $\mu\text{g/g}$ (Fig. 3).

Seasonal changes in nickel were characterised by the monsoon peak with 759.68 $\mu\text{g/g}$ in August. Unlike other metals, a premonsoon peak was also observed

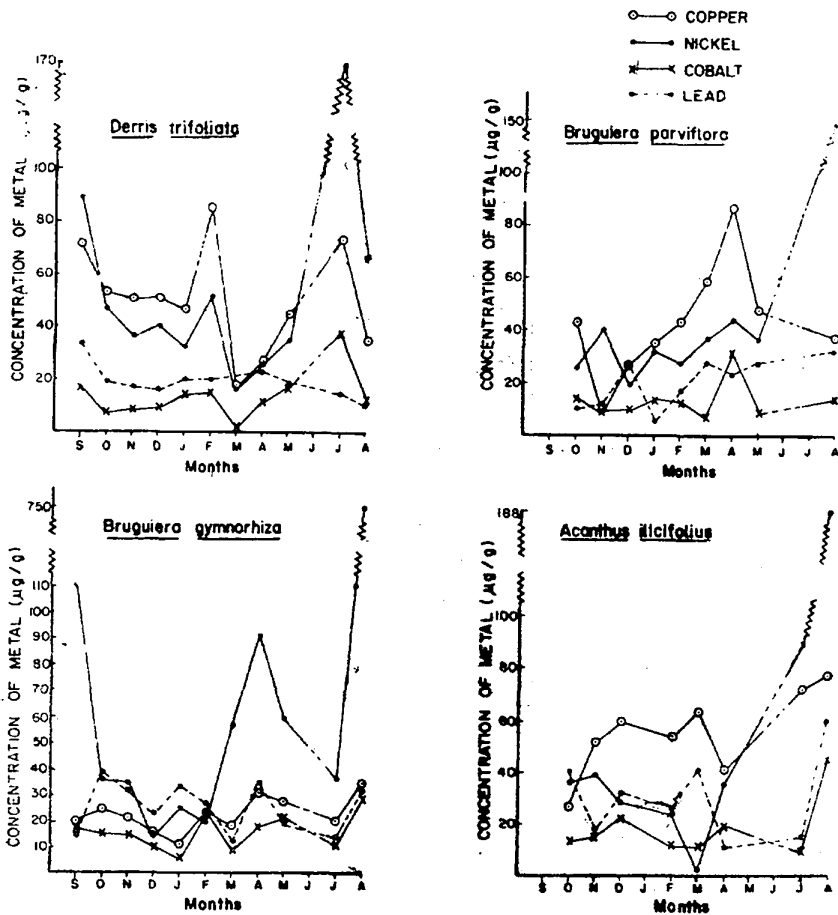


Fig. 2. Seasonal variation of copper, nickel, cobalt and lead in the foliage of *D. trifoliata*, *B. parviflora*, *B. gymnorhiza* and *A. ilicifolius*.

with 91.72 $\mu\text{g/g}$ in April while minimum value of 12.41 $\mu\text{g/g}$ was recorded in January. Maximum concentration of lead was 39.42 $\mu\text{g/g}$ in October and a minimum of 11.59 $\mu\text{g/g}$ in March. Seasonal changes in lead were not of cyclic pattern. In this species the changes did not follow any typical pattern, but the peaks occurred with minor spurts in values during April, August and October (Fig. 2).

3. *Bruguiera parviflora*

As in other mangrove species, the average values of iron and manganese were high respectively, followed by nickel, copper, lead and cobalt. Maximum concentration (4794.3 $\mu\text{g/g}$) of iron was recorded during premonsoon in May and minimum of 2.77 $\mu\text{g/g}$ in November. Manganese values ranged from 428.1 $\mu\text{g/g}$ in December to 3184.1 $\mu\text{g/g}$ in February. Nickel did not show much variation except monsoon peak with 154.52 $\mu\text{g/g}$ in August. Premonsoon peak was absent in all other mangrove species.

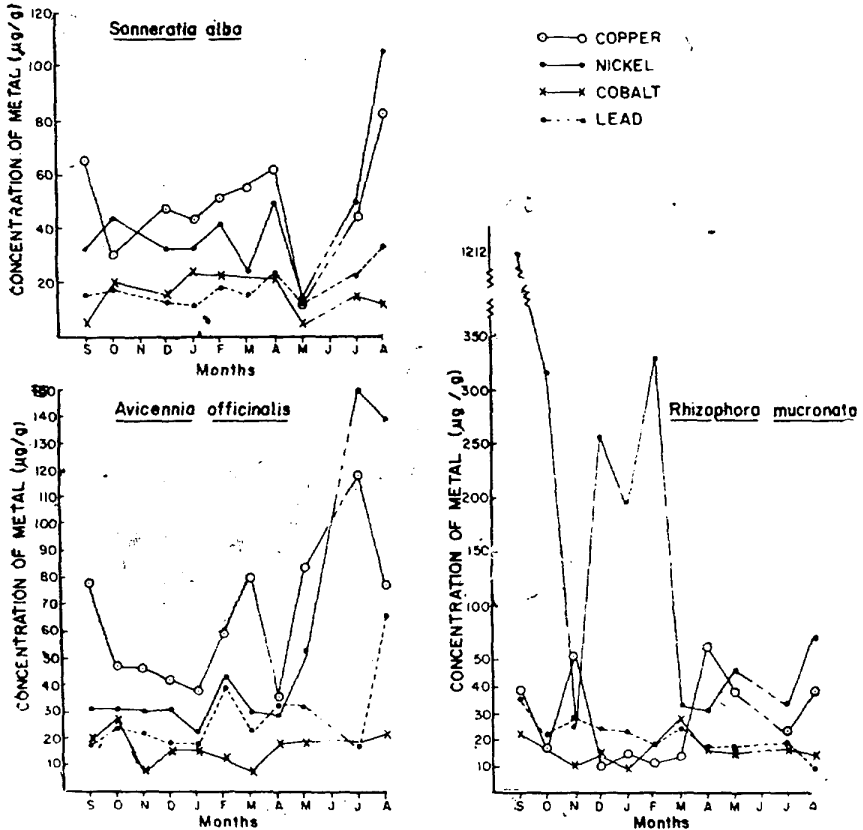


Fig. 3. Seasonal variation of copper, nickel, cobalt and lead in the leaves of *S. alba*, *A. officinalis* and *R. mucronata*.

Maximum cobalt concentration was recorded in April and minimum in March. In general there was not much of the seasonal fluctuation of cobalt and lead, except a slight peak of lead during August with a concentration of 32.46 $\mu\text{g/g}$ and with lowest value of 5.79 $\mu\text{g/g}$ in January (Fig. 2).

4. *Acanthus ilicifolius*

Iron concentration was maximum in August and minimum in November. Iron values were less in premonsoon and postmonsoon period, while manganese did not show distinct seasonal fluctuations except in October. 2657.9 $\mu\text{g/g}$ (Fig. 4). Copper concentration ranged from 27.82 $\mu\text{g/g}$ in October to 77.04 $\mu\text{g/g}$ in August. Seasonal changes in nickel were characterized by the maximum with 188.38 $\mu\text{g/g}$ in August and minimum with 1.84 $\mu\text{g/g}$ in March. Seasonal fluctuations in cobalt and lead concentrations were negligible in this species. However, the average values for both these metals were 18.74 $\mu\text{g/g}$ and 30.47 $\mu\text{g/g}$.

5. *Sonneratia alba*

Monsoon peak of iron was very distinct with highest value of 8111.8 $\mu\text{g/g}$ in July and there was a drop in the concentration of iron during postmonsoon period. Manganese showed the highest concentration of 4432.8 $\mu\text{g/g}$ in February and lowest

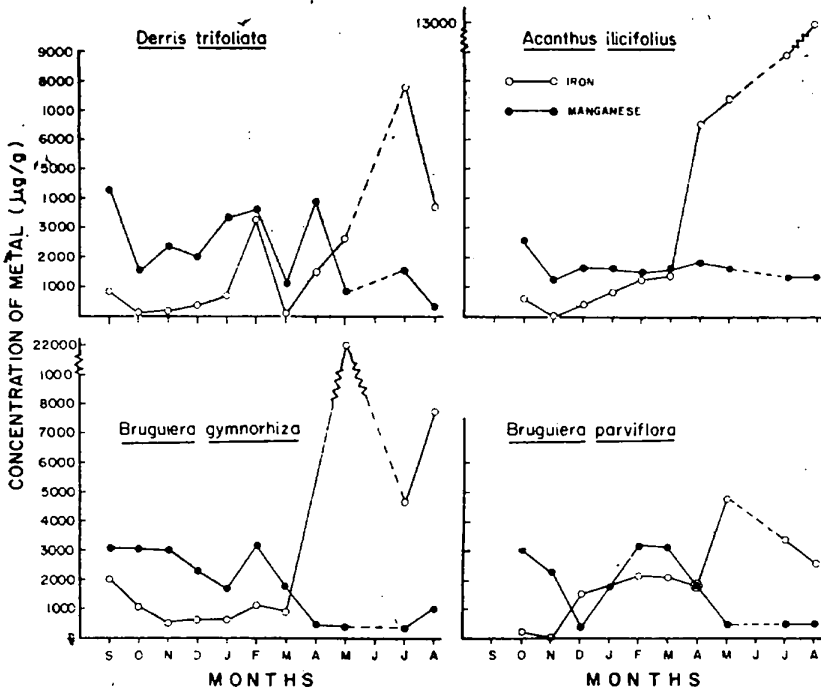


Fig. 4. Seasonal variation of iron and manganese in *D. trifoliata*, *A. ilicifolius*, *B. gymnorhiza* and *B. parviflora*.

value (80.25 $\mu\text{g/g}$) in the month of May (Fig. 5). Typical cyclic pattern of copper accumulation was noted in *S. alba* with lowest value of 11.98 $\mu\text{g/g}$ in May. Secondary peak was observed during premonsoon. No significant seasonal variation of nickel was recorded except for the monsoon peak with highest accumulation in August (105.27 $\mu\text{g/g}$) and the lowest value of 22.78 $\mu\text{g/g}$ in May.

6. *Avicennia officinalis*

The maxima of copper concentration observed during monsoon was 119.41 $\mu\text{g/g}$. However, low values of copper were observed in winter with lowest value of 36.81 $\mu\text{g/g}$ in April. Iron showed maximum concentration of 6343.6 $\mu\text{g/g}$ in August, which dropped down to 281.22 $\mu\text{g/g}$ in January. Manganese unlike all other metals showed a peak of 6600.15 $\mu\text{g/g}$ in November with a sudden decrease to 499.45 $\mu\text{g/g}$ in April (Fig. 5). The seasonal variation of manganese was of the cyclic pattern. Nickel concentration in *A. officinalis* did not show much variation except monsoon peak. There was not of much fluctuation in this trend during postmonsoon period also. Low range of cobalt 7.83–27.70 $\mu\text{g/g}$ from November to October was noticed. Lead showed high values during monsoon with 66.08 $\mu\text{g/g}$ in August (Fig. 3).

7. *Rhizophora mucronata*

Iron values formed a distinct pattern, although a shortlived monsoon peak was not evident. However, the monsoon values were relatively higher (Fig. 5). Unlike

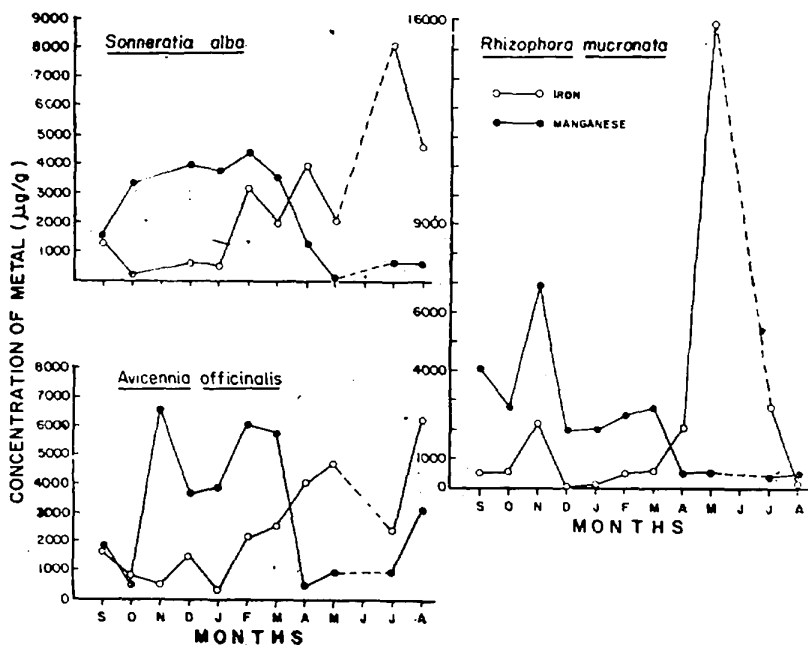


Fig. 5. Seasonal variation of iron and manganese in the leaves of *S. alba*, *A. officinalis* and *R. mucronata*.

iron, manganese showed very low values during monsoon (Fig. 5). Two minor peaks of this metal were seen in August and September. *R. mucronata* differed from all other species under investigation in not having a monsoon peak of copper but instead shifted to postmonsoon, while in other species during this period, lowest values were recorded. Secondary peak was found to occur during premonsoon, particularly in April and minimum values were recorded during the month of December (Fig. 3).

DISCUSSION

The only available records of mineral composition of Indian mangroves are of Sidhu (cited by Walsh, 1974), Joshi (1973) and Bhosale (1979). The values quoted by Sidhu are cobalt-9 ppm, Iron-132 ppm and manganese-387 ppm, whereas in present investigation values for *R. mucronata* for above metals were 16.69 $\mu\text{g/g}$, 2328.49 $\mu\text{g/g}$ and 2286.51 $\mu\text{g/g}$ respectively. Thus the above values recorded in the mangrove foliage of Goa are higher as compared to that of Florida. However, Morton (1965) reported 52.0 $\mu\text{g/g}$ of cobalt in *R. mucronata*. Cobalt and copper values recorded by Bhosale (1979) were found to be low as compared to the present cobalt and copper values of the mangrove foliage of Goa.

In the present studies iron and manganese were found to be much higher, probably because of more availability and accumulating capacity of mangroves for these metals. Secondly, the estuarine sediment of this region, which is very rich in iron and manganese may be responsible for high rate of metal concentration.

Windom (1975) has opined that the precipitate of dissolved iron and manganese accumulate in the sediments. Thus Parker, Gibbs and Lowler (1963) and Pulich, Barnes, and Parker (1976) have described the cycling of trace elements in mangrove areas and the same has been demonstrated for forests, deserts and terrestrial grasslands (Epstein, 1972). Carpenter, Bradford and Grants (1975) noticed substantial release of manganese from the estuarine sediments during summer, but Dunstan and Windom (1975) found no correlation between the concentration of metals in *Spartina* sp., sediment and water from adjoining environment. According to these authors these metal concentrations in plants are either saturated or controlled by the plants.

Wu and Antonovics (1976) showed that the effect of lead pollution was species dependent. In present analysis, iron and copper content varied largely between the foliage of two species such as *Bruguiera gymnorhiza* and *B. parviflora*. However, no significant difference in the accumulation of cobalt, nickel, lead and manganese was observed in the two species. This variation of metal accumulation in the plants, between species to species was supported by Page, Birgham and Nelson (1972) and Rolfe (1973).

According to Woodwell, Whittaker and Houghton (1975), there is not much seasonal variation of metals in herbaceous plants in comparison with woody plants. Marked seasonal variation for the six metals were recorded in seven mangrove species during present investigation.

These species during the studies were found to tolerate high concentrations of some metals, several times of the average concentrations without any harmful effect. It was found that iron and manganese were present in a very high concentrations (22,000 $\mu\text{g/g}$ and 6956.9 $\mu\text{g/g}$) respectively. In the mangrove foliage, however, no toxic effect was seen. This

may be due to the presence of some 'chelating substances', which nullify the harmful effect on plants.

Goucher and Taylor (quoted by Bowen, 1966) are of the opinion that many ions do not occur in the free state inside cells but are chelated by small organic molecules for example, iron and manganese by ADP and ATP. Bowen (1966) has stated that 'porphyrins' form strong chelate complexes with many metals, like chlorophylls in plants. It would be of great interest to find out the chelating substances, which save the marine and marshy plants from harmful effect on high metal accumulation. Any change in metal concentration by way of mineral pollution may not be critical to these mangrove species, unless it is highly toxic. According to Garten, Gentry and Sharitz (1977) variation in elemental composition can arise from numerous sources including environmental variation, biological and environmental differences as well as environment organism interactions. In the present situation, three major sources for metals were identified such as sea water, metal rich upstream region and mineralization process of detritus.

The seasonal peaks in some of the metals were found during monsoon period. This might be because of the easily available minerals due to land runoff coupled with high metabolic activities, resulting into the flowering and fruiting during this season. According to Ramadhas, Rajendran and Venugopalan (1974) sediment of aquatic environment acts as the reservoir for trace metals. Malyuga (quoted by Antonovics, Bradshaw and Turner, 1971) has showed that the plant analysis of metals have been of practical value in outlining ore deposits of variety of metals and also in making new discovery in USSR. The Goa region is well known for mining activities and the high concentration of average iron and manganese in plant material, like mangroves, can be correlated with the mineral deposits in adjacent areas.

From these observations, it is concluded that there is no uniform pattern of trace metal variation in the mangrove species of Goa during different seasons. In general, values of some elements like iron, copper and cobalt in *Derris trifoliata*, *Sonneratia alba* and *Rhizophora mucronata* are higher. During July apparent identical 'seasonal' trends indicated for the different elements in *Derris* sp. *Bruguiera gymnorhiza* and *B. parviflora*, a pattern with minor variation was noteworthy. Higher iron values, when compared to manganese were evident in *Acanthus ilicifolius*. But the behaviour of annual variation between the four elements like nickel, copper, lead and cobalt was more or less identical in all plants except *Acanthus ilicifolius* to some extent. In *Sonneratia alba* and *Derris trifoliata* the pattern was almost uniform with marginal elemental variation in *Avicennia* sp.

ACKNOWLEDGEMENTS

The authors wish to express their sincere thanks to Dr. S. Z. Qasim, Director, NIO for going through the manuscript and for helpful suggestions. They are also grateful to Dr. T.S.S. Rao for offering valuable suggestions.

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