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PHOSPHORUS AND IRON DISTRIBUTION IN TWO MANGROVE SPECIES IN RELATION TO ENVIRONMENT

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ABSTRACT

Samples of water, sediment and plants were collected from Pitchavaram mangrove, South India and salinity, dissolved oxygen, pH and various fractions of phosphorus and iron were determined. The dissolved iron concentration showed a significant positive correlation with salinity whereas the particulate iron had a significant negative correlation with salinity. But the relationships between the dissolved, particulate and sediment iron were not linear. The phosphorus content of the area varied irregularly and never showed any clear trend in relation to salinity. The phosphorus and iron content of net plankton showed no significant correlation either with salinity or with dissolved and particulate fractions of these elements. The salt excreting mangrove species *Avicennia marina* was found to accumulate more phosphorus and iron in the leaves than the salt excluding species *Rhizophora mucronata* and a clear seasonal fluctuation was also noted. No clear statistical relation was found between the concentrations of phosphorus and iron in leaves and those in environment of the same. It could be suggested from the observations that the salt transport mechanism is well developed in *A. marina* whereas the ultrafilter mechanism is well developed in *R. mucronata.*

Key-words : Mangrove, phosphorus, iron, Pitchavaram.

INTRODUCTION

Several reports on investigations as well as reviews are available on the distribution and accumulation of minor ions and trace metals in water, particulate matter, sediments and organisms. But these studies have not thrown any light on the accumulation of minor ions by the halophytes of mangrove environment and their seasonal variations. However a few studies were made on the bio-concentrations of the anions PO_4 (Caines, 1965; McMillan, 1974) and NO_3 (Queen, 1974) and some trace metals like Fe, Mn, Cu, Ni, Hg, Co, As, Ur and Pb (Windom, 1975; Ho, 1979b; Murdoch and Capobianco, 1979) by halophytes.

Hence the concentration of phosphorus and iron in the root, stem and leaf of the halophytes *Avicennia marina* and *Rhizophora mucronata* (salt excreting and salt excluding mangrove plants) was studied in relation to the concentration of these elements in the environment.

MATERIALS AND METHODS

Samples were collected at "Peria Kada" in the Pitchavaram mangrove area (Fig. 1) at monthly intervals in 1978. The method of collection of samples

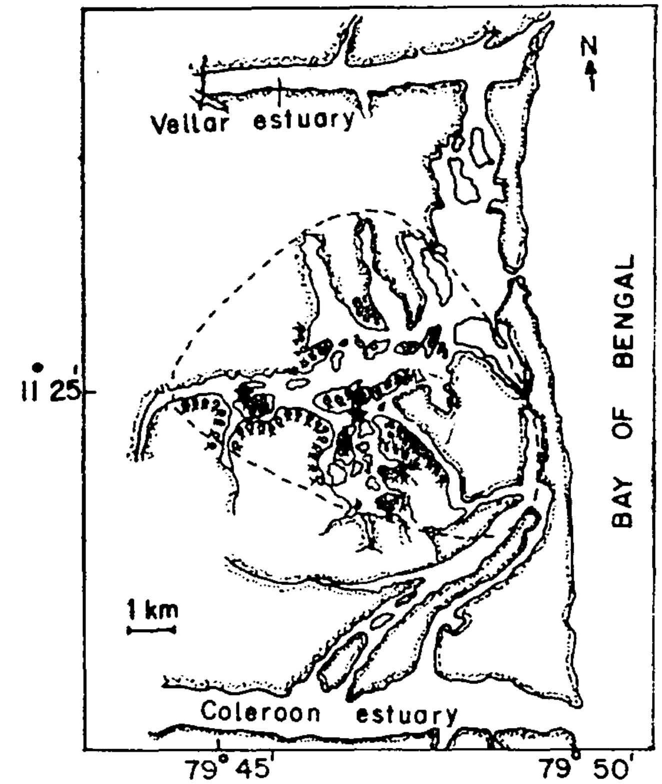

Fig. 1. Sampling area.

was the same as described in a previous paper (Subramanian, Subramanian and Venugopalan, 1981). Salinity, dissolved oxygen and iron were determined as described by Strickland and Parsons (1972). pH was measured in an Elico model Li-10 pH meter. Dissolved phosphorus was estimated adopting the method of Menzel and Corwin (1965). Particulate matter, sediment, plankton (collected using 22 μm pore size Nytex plankton net) and the root, stem and leaf of plants were subjected to acid digestion prior to analysis of iron and phosphorus as suggested by Sandell (1965). The plankton samples collected were presented in analar quality formaldehyde prior to analysis. During analysis the samples were filtered and dried to constant weight. Then the samples were acid digested for the analysis of iron and phosphrous.

RESULTS AND DISCUSSION

Salinity in the study area increased from January to June with a sudden drop in March, due to draining of freshwater from paddy fields (Table 1). With the onset of monsoon in August the salinity was found to decrease and attained low values from August to November. A gradual increase in salinity was noticed subsequently coinciding with the decrease in the monsoon rains.

Dissolved oxygen ranged from 4.5 to 6.1 ml/l. The pH of the water remained higher than that of the sediments. pH of the sediments ranged from

Table I. Hydrographical parameters and concentrations of iron and phosphorus in water, particulate matter, sediment and plankton at Peria Kada. in 1978.

Month	Salinity ‰	Dissolved oxygen ml/l	pH Water	pH Sediment	Iron Dissolved µg/g	Iron Particulate µg/l	Iron Sediment µg/g	Iron Plankton µg/g	Phosphorus Dissolved µg/g	Phosphorus Particulate µg/g	Phosphorus Sediment µg/g	Phosphorus Plankton µg/g
Jan	18.6	6.1	7.6	7.4	386.2	6035.2	28553.3	18675.5	21.5	10.8	283.7	4666.7
Feb	19.3	5.4	8.0	7.7	392.5	2160.6	20356.7	29673.5	12.9	23.5	257.6	3007.6
Mar	12.6	6.2	8.0	7.1	160.6	1999.8	21657.2	4356.3	15.8	30.6	320.8	1987.8
Apr	34.3	5.6	8.1	8.1	123.4	1683.2	9075.2	15675.7	38.8	9.2	263.8	1895.3
May	30.0	5.5	8.0	7.9	1235.3	1235.8	9965.7	29999.5	18.2	7.6	311.8	1999.8
Jun	35.6	6.0	8.2	8.0	390.5	2763.0	7670.2	18361.4	12.7	24.2	209.9	2463.4
Jul	31.3	5.6	7.9	7.7	699.9	1175.6	9993.9	16733.3	26.6	15.0	268.7	2698.7
Aug	8.6	5.0	8.1	7.9	230.5	3125.4	6985.3	35688.7	27.5	25.3	277.7	2467.7
Sep	2.1	4.6	8.0	7.6	185.6	5453.6	15676.8	67831.5	41.8	69.7	266.7	5897.6
Oct	2.6	4.6	7.6	7.1	101.2	6910.1	16007.7	28667.3	16.2	100.3	269.3	4075.7
Nov	5.6	4.6	8.1	7.5	72.6	5465.2	16986.5	7778.7	14.7	93.6	212.2	1679.8
Dec	17.1	4.5	7.6	7.1	268.7	3830.6	13833.3	17788.9	20.6	66.6	310.5	5077.8

Table II. Correlation coefficients (r) of salinity and iron in environment, plankton and plants.

	Dissolved iron	Particulate iron	Sediment iron	Iron in leaf *A. marina*	Iron in leaf *R. mucronata*	Iron in root *A. marina*	Iron in root *R. mucronata*	Plankton iron
Salinity	0.796*	-0.646*	-0.318	0.150	0.636*	—	—	-0.291
Dissolved iron	—	-0.521	-0.224	0.160	0.505	0.546	0.322	0.286
Sediment	—	—	—	-0.158	-0.278	0.168	0.236	—
Particulate iron	—	—	—	—	—	—	—	0.152

* Significant at 5% level r = 0.575 for 10 df.

7.1 to 8.1 whereas pH of the overlying water was between 7.6 to 8.2. The pH never decreased to reducing conditions in the present observation.

The concentrations of dissolved, particulate and sedimentary iron are given in Table I. The lower concentration of dissolved iron at times of low salinity might be due to precipitation of river borne dissolved iron during estuarine mixing as pointed out earlier by Holliday and Liss (1976) and Subramanian, Subramanian and Venugopalan (1981). Similarly the observed higher concentration of dissolved iron when salinity was higher than 15‰, might be due to desorption of iron adsorbed to sediments. Such desorption of iron at higher salinities has been reported by Evans and Chester (1973), Subramanian (1976). This would occur in estuaries having iron rich suspended sediment as seen in the present study. In Vellar estuary the sediments iron concentration ranged from 6.99 to 28.55 mg/g. Such a high concentration might have possibly resulted due to mining operation carried out at the origin of river Vellar. The dissolved iron concentration bears a significant positive correlation with salinity ($r = 0.796$; $p < 0.05$ – Table II).

The particulate iron concentration showed a significant negative correlation with salinity ($r = -0.646$; $p < 0.05$). An insignificant negative correlation was also observed between particulate iron and dissolved iron ($r = -0.521$; $p > 0.05$) and this may be due to precipitation of dissolved iron aided by suspended matter (Aston and Chester, 1973). Alternatively it may be due to the desorption of iron from the sediment at higher salinities, as mentioned earlier.

Even though the sediment iron contributed much to the dissolved iron fraction at least at higher salinities the correlation between the two fractions was insignificantly negative ($r = -0.224$; $p > 0.05$, Table II). This might be because of the very high concentration of iron in the sediment compared to the dissolved fraction and yet even a small change in the sediment iron would cause a sufficiently large change in the dissolved iron (Subramanian, Subramanian and Venugopalan, 1981).

The total dissolved phosphorus ranged from 12.7 to 41.8 μg/l. The seasonal variation observed in the present study was similar to that reported by Ramadhas (1979) for the same study area. The particulate phosphorus ranged from 7.6 to 100.3 μg/l while the sediment phosphorus ranged from 209.9 to 320.8 μg/g (Table I).

Particulate phosphorus showed a highly significant negative correlation with salinity ($r = -0.794$; $p < 0.05$, Table III). In shallow waters the distribution of particulate phosphorus depended on the suspended sediment brought in by river discharge (Matsuda, Endo and Koyama, 1976) and not on the particulate matter formed on estuarine mixing. Because of this, particulate phosphorus was high during low salinity months and hence this negative correlation. The effect of this sediment phosphorus and its exchanges in the system by way of sorptive processes were explained by Carrit and Goodgal (1954), Pomeroy (1963) and Reimold (1974).

When phosphorus and iron content of plankton were considered, no significant correlation either with salinity or with dissolved and particulate fractions of these elements was evident (Tables II and III). Iron concentration in plankton ranged from 4.36 to 67.83 mg/g while phosphorus from 1.68 to 5.90 mg/g (Table I). Both iron and phosphorus concentration in plankton showed insignificant negative correlation with salinity and insignificat on but positive correlation with dissolved and particulate fraction of these elements (Table III). Such insignificant relationship may probably be due to the ommission of nannoplankton during the collection of plankton samples. Ramadhas, Subramanian and Venugopalan (1975) indicated that nannoplankton contributed 57 to 100% to the total chlorophyll *a* values in these waters. Moreover the suspended material collected in the plankton net might have been responsible for the spurious results. The latter reason seems to be true for the higher concentration of iron and phosphorus in plankton observed in monsoon months (Table I).

A comparison of the concentration of iron and phosphorus in the various parts of *Avicennia marina* and *Rhizophora mucronata* (Figs. 2 and 3)

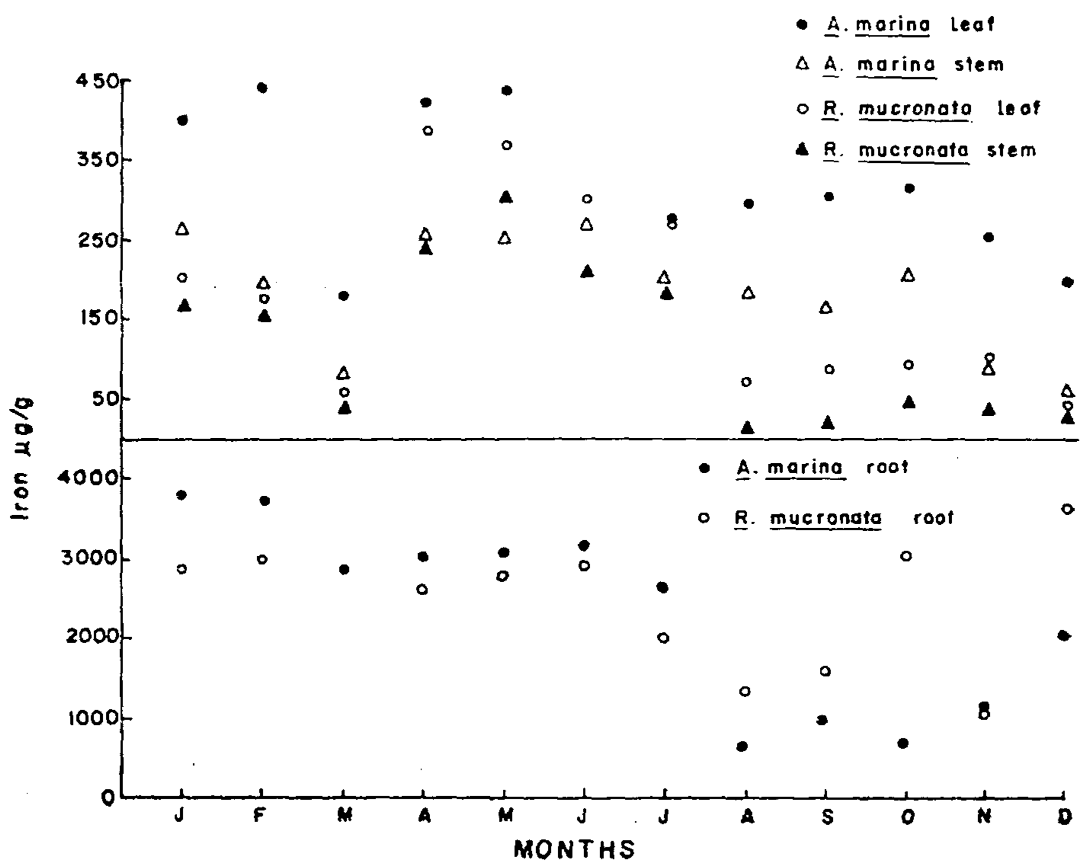

Fig. 2. Concentrations of iron in the leaf, stem and root of *A. marina* and *R. mucronata*.

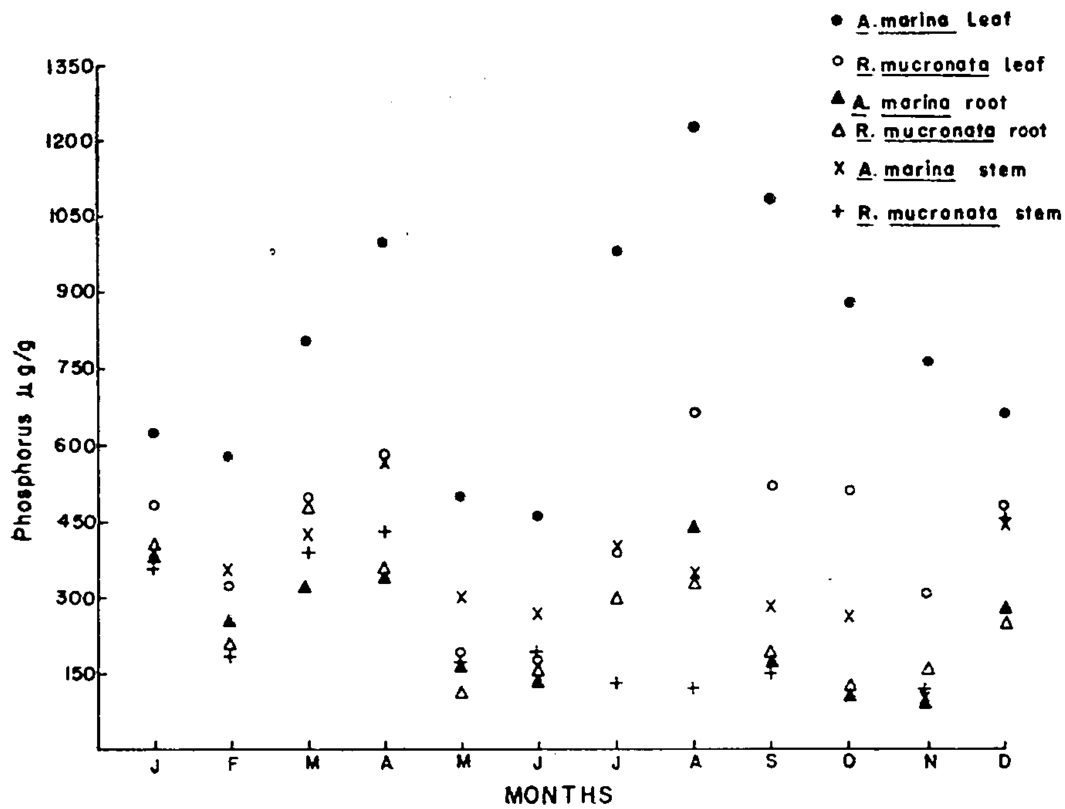

Fig. 3. Concentrations of phosphorus in the leaf, stem and root of *A. marina* and *R. mucronata*.

indicated that the ion transport capacity of the two species were quite different for the two ions and also for both the plants. Smith, Hayasaka and Thayer (1979) observed differences in nutrient uptake efficiencies for different nutrients in *Halodule* and *Zostera*. Higher concentration of iron and phosphorus were observed in the leaves of *A. marina* than in *R. mucronata* which supports the findings of McMillan (1974) and Gulati, Nagpaul and Sayeeda (1979).

McRoy and Barstate (1970) and Ho (1979a) pointed out that sediments were the principal source of phosphorus for eel grass. No such clear relation was observed in the present study between the sediment phosphorus and plant phosphorus. But a significant positive correlation was observed between the concentrations of phosphorus in the dissolved fraction and in the leaves of *A. marina* (Tables II and III). The results of the present study indicated that tidal effect may be more prominent than rain in removing phosphorus from leaves since the leaves which have not come into contact with the water, had higher phosphorus concentration even during the rainy season.

Caines (1965) observed seasonal changes in the concentration of phosphorus in *Myriophyllum alterniflorum* and *Potamogeton praelongus*. Murdoch and Capobianco (1979) observed seasonal changes in trace metal content of

Myriopyllum ventriculatum and *Elodea canadensis.* The present study also revealed that the concentrations of iron and phosphorus in the plants studied fluctuated seasonally. But only iron, in *R. mucronata* leaves showed a significant positive correlation with salinity (r = 0.636; $p < 0.05$, Tables II and III).

McMillan (1974) and Scholander (1968) reported that the ultrafiltration mechanism is better developed in Rhizophoraceae than in Avicenniaceae. The observation of the present study that the percentage of iron in the leaf in comparison to the concentration in the root was more in *A marina* than that in *R. mucronata*, except on two occasions (Table IV) substantiated this view. Ho (1979b) reported that the root iron concentration was much higher than that in other plant parts of freshwater macrophytes. He also found that K, Ca and Mg levels were higher in the above-ground organs than in the below-ground organs. This seemed to be true for phosphorus concentration as well in the present study.

Table III. Correlation coefficients (r) of salinity and phosphorus in environment, plankton and plants.

	phosphorus Dissolved	phosphorus Particulate	phosphorus Sediment	Phosphorus in leaf		Phosphorus in Root		Plankton phosphorus
				A. marina	*R. mucronata*	*A. marina*	*R mucronata*	
Salinity	-0.151	-0.794*	0.062	-0.458	-0.479	—	—	-0.418
Dissolved phosphorus	—	-0.170	0.251	0.729*	0.462	0.587*	0.456	0.268
Sediment phosphorus	—	—	—	0.143	0.405	0.404	0.328	—
Particulate phosphorus	—	—	—	—	—	—	—	0.354

* Significant at 5% level r = 0.575 for 10 d.f.

Table IV. Percentage of iron and phosphorus in leaf in comparison to root concentration in *A. marina* and *R. mucronata*.

Month	Iron		Phosphorus	
	A. marina	*R. mucronata*	*A. marina*	*R. mucronata*
January	10.50	6.86	162.80	120.72
February	11.57	6.03	228.90	149.93
March	6.31	1.86	250.73	103.36
April	13.99	14.68	303.15	176.37
May	14.29	13.17	310.64	170.37
June	15.69	10.34	346.26	116.82
July	10.69	13.81	329.82	132.04
August	46.05	5.35	280.01	201.66
September	31.41	4.10	664.28	294.62
October	47.81	3.05	843.15	462.84
November	21.98	9.36	696.96	200.87
December	9.70	1.27	212.64	141.34

The ultrafilter mechanism suggested by McMillan (1974) would however affect the accumulation of certain essential ions like phosphorus which occur in very low concentration in the environment. This was evident from the fact that phosphorus was accumulated by *A. marina* more in the leaves than in the roots whereas the percentage of accumulation of phosphorus in the leaves of *R. mucronata* when compared with the roots was comparatively low. This also indicates that the salt transporting mechanism is well developed in *A. marina*, suggesting that *A. marina* could transport the excess quantity of ions from roots to the leaves for excertion in the leaves, via salt glands and vascular hairs as pointed out by Queen (1974) and thus withstand salinities upto 118‰.

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