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Structure and species distribution in Coringa mangrove forest, Godavari Delta, Andhra Pradesh, India

Jayapaul Azariah, Hilda Azariah,* S. Gunasekaran & V. Selvam
*Department of Zoology, University of Madras, Guindy Campus, Madras – 600 025, India; *CAS In Botany, University of Madras, Guindy Campus, Madras 600 025, India*

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Abstract

Coringa mangrove forest is located in the Godavari delta, Andhra Pradesh, India. The mangrove community consisted of more than 13 species of mangrove and other plants in the present study area. The following three dominant mangrove plants, *Avicennia marina*, *Excoecaria agallocha* and *Sonneratia apetala* were found to be present on the banks of a major channel of the Godavari river running through the forest. The structure and species distribution of mangrove, in the Channel Nagathana Kalava has been described. The area behind the belt consisting of *Acanthus ilicifolius* and *Myriostachya wightiana* is generally colonized by *E. agallocha* and *A. marina*. The zone has been called the *Avicennia* and *Excoecaria* zone. Adjacent to this zone species like *Aegiceras corniculatum* and *A. officinalis* were the common species. In the flat clayey soil, *Suaeda maritima* was found to grow. In areas of high elevation, devoid of inundation of tidal seawater during the high tidal period, species such as *M. wightiana* and *Acanthus* were found to colonize both the banks of the channels.

An analysis of species diversity, indicated a definite trend in the distribution of mangrove from the mouth of the estuarine region to the inland waters.

The levels of atmospheric pollutants such as sulphur dioxide (SO_2), oxides of nitrogen (NO_x), ammonia (NH_3) and suspended particle matter (SPM) were within the legal limits.

Introduction

A survey of the global status of mangroves may show that vast areas are being destroyed either intentionally or as a secondary result of other activities (Saenger *et al.*, 1983). The mangrove of India also is no exception to such an uncontrolled exploitation. The mangrove vegetation of India have an area of approximately 356 500 ha of which Krishna-Godavari mangrove complex comprises an area of approximately 12 800 ha (Sidhu, 1963). The Coringa mangrove forest, which is a part of the Godavari mangrove forest, is located on the southern coast of the Kakinada town in Andhra Pradesh, where the present investigation was carried out. The Kakinada port is a natural harbour and an all weather port which can provide protection from severe weather conditions. Hence, it is possible to handle ships for more than 300 days per year. Currently, loading and unloading are carried out around the clock. Recently, the Government of Andhra Pradesh has developed a master plan to convert the Kakinada port into a major port so as to make it a gateway for trade and export. The proposed developmental plan involves the construction of three deep

water berths, extension of break water to 3.35 km, dredging of access canal and provision of ancillary facilities such as road, approach bridges and other navigational aids. The project, costing Rupees 1335.8 million, is expected to be completed by April 1995 (Indian Express, 1990).

A second major developmental activity is the building of the fertilizer complexes namely, Godavari Fertilizers and Chemicals Ltd (Capital cost of Rupees 1080 million, work completed) and the Nagarjuna Fertilizer and Chemicals Ltd (capital cost of Rupees 6700 million-work nearing completion). These two fertilizer factories are expected to meet the fertilizer demands within a 200 km range from the factory. In view of such a rapid pace of industrialization in the coastal zone of Kakinada, a detailed study on the environmental impact assessment was made on a multidisciplinary basis. In an earlier paper the results of the analysis of the mangrove vegetation within a 15 km radius of the fertilizer complex have been given (Azariah *et al.*, 1990). The present paper examines the structure of the mangrove community and its distribution in the Coringa forest, which is located on one of the deltaic branches of the northern zone of the Godavari delta, so as to provide quantitative baseline information on the current status of the ecosystem together with a survey of the current levels of atmospheric pollutants such as sulphur dioxide, oxides of nitrogen, ammonia and suspended particulate matter.

Description of site

Mangrove forests are seen in places like Coringa, Yanam, Kandikuppa, Kakinada and Sacramento which are in the East Godavari delta. The Coringa river originates at Yanam which is about 6 km on the upper reach of Godavari river. This tributory along with Gadeur forms a part of the Godavari estuarine system. Both the tributaries open into the southern side of the Coringa bay. The bay is named after Coringa (Koriangi, a well known ancient port). A group of islets are located in the vicinity of Coringa bay. Among these, Hope Island, Bhairavapalend series and Coringa and tributaries, Gaderu and Vasavakalava are noteworthy (see Fig. 1).

Materials and methods

The present study was carried out in the Nagathana Kalva (canal) which extends for a distance of 10 km from the Coringa river. The area is swampy with knee deep mud.

A series of quadrats of 5 x 5 m (Sidhu, 1963) were laid at an interval of 1 km along the 10 km long canal. The number of trees in each quadrat was counted and the data were tabulated. Using certain indices of species structure in community, data on the index of dominance, species diversity, richness of species were calculated. Besides, data on the relative density, relative frequency and relative dominance were calculated. Details of the formulae used are given in an earlier paper (Azariah *et al.*, 1986). A few micrometereological assessments were carried out to obtain baseline information on the level of sulphur dioxide, oxides of nitrogen, ammonia and suspended particulate matter. The details of the analysis are given in an earlier paper (Azariah *et al.*, 1990).

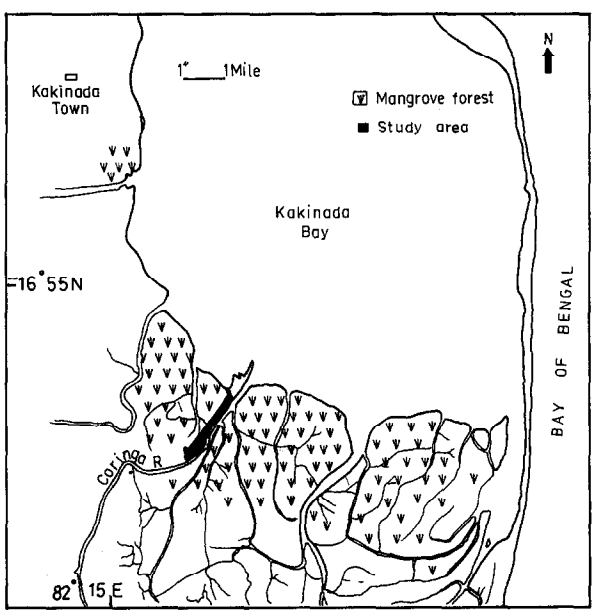

Fig. 1. Map showing the location of the Coringa mangrove forest and the study site.

Results

Concentration of atmospheric pollutants

A biweekly sampling of atmospheric pollutants were made using a high volume sampler. The studies were carried out from December 1988 – May 1989 (Table 1).

The SO_2 concentration varied from zero to 10 $\mu g\ m^{-3}$ over a period of 6 months. The values didn't exceed the maximum admissible limit of 80 $\mu g\ m^{-3}$. The NO_x values varied from zero to 98 $\mu g\ m^{-3}$. The maximum value was observed during the month of September 1988, which may indicate that there were occasional outburst of oxides of nitrogen. It may be seen that the levels of NO_x exceed the maximum admissible limit (80 $\mu g\ m^{-3}$). The concentration of ammonia varied from zero to 28 $\mu g\ m^{-3}$ against the admissible limit of 30 $\mu g\ m^{-3}$. It can be seen that the levels of ammonia were nearing the critical concentration. The total suspended particulate matter (SPM) varied between 31 and 137 $\mu g\ m^{-3}$, which is well below the admissible limit of 200 $\mu g\ m^{-3}$. The dust fall is low, the value being 9.8 metric tonnes km^{-2} per month.

A comparison of data between Coring village and Kakinada neighbourhood was made. It can be seen that the levels of the SO_2 were higher in the Coringa mangrove forest than at Kakinada neighbourhood during the summer season, i.e., March to May. It can be noted that the level was higher at Kakinada during the post monsoon season (December to February). A similar pattern may be seen with respect NO_x. The concentration of ammonia and SPM was higher during both the summer and post monsoon months. A similar pattern was observed with respect to SPM (See Fig. 2).

Nature of environmental pollutants in the vicinity of Kakinada (Table 1)

Level of sulphur dioxide

In an earlier study, it has been found that the SO_2 concentration did not exceed the limit throughout the year (Azariah *et al.*, 1990). Notable variations in its concentration were found between the summer and North East monsoon (June to August) seasons at Kakinada township with the values of 1.9 and 4.4 $\mu g\ m^{-3}$ respectively. During the summer the concentrations of was minimal in the entire vicinity of Kakinada, the value being 1.9 $\mu g\ m^{-3}$ (Table 1).

NO_x

The concentration of NO_x exceeded the admissible limit in the Kakinada town but it remained within the admissible limit in the coastal zone during the summer (March to May) season. A relationship between NO_x and human activity

Table 1. Concentration of atmospheric pollutants ($\mu g\ m^{-3}$) in Coringa forest and Kakinada neighbourhood

Period	SO_2	NO_x	NH_3	SPM
Coringa:				
Dec 88–Feb 89	1.3 ± 2.4 (0–3.0)	10.6 ± 5.7 (2–20.2)	14.4 ± 8.1 (0–28)	64.9 ± 23.8 (31–97)
Mar 89–May 89	3.6 ± 2.9 (0–10)	36.0 ± 27.0 (0–98)	13.0 ± 4.7 (0–19)	80.5 ± 31.6 (38–137)
Kakinada neighbourhood:				
Dec 88–Feb 89	2.76 ± 2.83 (0–20)	46.9 ± 30.5 (0–330)	31.0 ± 17.3 (0–180)	104.03 ± 52.8 (24–294)
Mar 89–May 89	1.9 ± 2.26 (0–12)	45.1 ± 36.2 (0–276)	9.3 ± 9.46 (0–81)	106.86 ± 56.8 (28–302)
Maximum admissible limit	80 $\mu m\ m^{-3}$	80 $\mu g\ m^{-3}$	30$\mu g\ m^{-3}$	200 $\mu g\ m^{-3}$

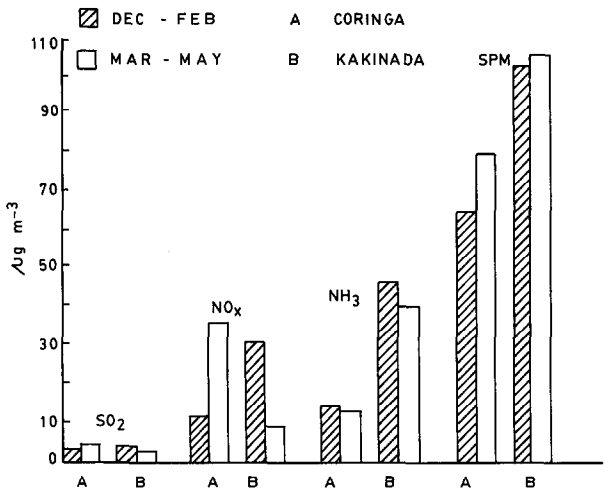

Fig. 2. Concentration of atmospheric pollutants in the Kakinada town and Coringa mangrove forest.

was found. The concentration was higher in places where there were more human activities in terms of handling nitrogen based fertilizers (loading and unloading). During the summer months, the coastal zone registered a value ranging between zero and 40 $\mu g\ m^{-3}$ and it varied from 2 to 330 $\mu g\ m^{-3}$ during the post monsoon season i.e. December to February.

NH_3

The ammonia concentration exceeded the admissible limit, at all times, except in the coastal zone during the summer season. The maximum concentration, 180 $\mu g\ m^{-3}$, was found during the post monsoon season in the Kakinada and lower levels (0 to 8.2 $\mu g\ m^{-3}$) were recorded during the summer season in the coastal zone.

SPM

The concentration of suspended particulate matter exhibited a direct relationship with human activity. It's level was high both during the post monsoon and summer seasons, the values being 24 to 294 $\mu g\ m^{-3}$ and 28 to 302 $\mu g\ m^{-3}$ respectively.

Analysis of mangrove ecosystem

The number of plants recorded in 10 quadrats along the distance of 10 km are given in Table 2. The vegetation in the mangrove swamp consisted

Table 2. Structure of Coringa Mangrove Community, East Godavari

Sl. no.	Species	Quadrat number										Total number of individuals	Frequency (%)	Relative density (%)	Relative frequency (%)
		1	2	3	4	5	6	7	8	9	10				
		Number of individuals													
1.	*Excoecaria aquallocha*	25	9	38	28	8	17	22	24	8	9	188	100	30.62	17.54
2.	*Avicennia marina*	6	27	7	14	4	11	4	12	11	6	102	100	16.61	17.54
3.	*Avicennia officinalis*	–	–	–	–	2	6	7	3	9	7	34	60	4.4	8.77
4.	*Aegiceras corniculatum*	–	14	3	4	–	2	–	–	4	–	27	50	5.54	10.53
5.	*Acanthus ilicifolius*	–	–	–	–	–	–	6	17	17	23	63	40	10.26	7.02
6.	*Sonnaretia apetala*	–	–	–	–	–	–	–	4	8	9	21	30	3.42	5.26
7.	*Derris trifoliata*	–	–	–	–	–	–	4	6	2	3	15	40	2.44	7.02
8.	*Ipomea tuba*	–	–	–	–	–	–	3	4	3	6	16	40	2.61	7.02
9.	*Cyperus rotundus*	–	–	–	–	–	–	33	22	–	–	55	20	8.96	3.51
10.	*Clerodendrum inerme*	–	–	–	–	–	–	–	–	2	3	5	20	8.96	3.51
11.	*Ceasalpinia nuga*	–	–	–	–	–	–	–	–	1	3	8	20	0.81	3.51
12.	*Myriostachya wightiana*	–	–	–	–	–	–	–	–	4	2	6	20	1.30	5.26
13.	*Suaeda maritima*	62	12	–	–	–	–	–	–	–	–	74	20	12.05	3.51
	Total	93	62	48	46	14	36	79	93	71	72	614			

of 13 species of plants out of which 11 species belonged to the mangroves. Secondly, their distribution varied in a distinct pattern from the mouth of river towards the inland water.

The distribution of *Avicennia officinalis* Lam. was restricted towards inland waters whereas *Excoecaria agallocha* Lam. and *Avicennia marina* (Forsk.) Vierh. were found along the entire stretch of the river i.e. from the coast to the inland waters. Between *E. agallocha* and *A. marina* the dominance of the former was seen throughout the study area. However, *E. agallocha* was more thickly distributed towards the mouth of the river. On the other hand for the latter species, although distributed throughout the study area, the magnitude of colonization was relatively less than *E. agallocha*.

The zone of mangrove can be divided into two areas. First, the *Avicennia* area which is located near the inland water and the second region dominated by *E. agallocha*. This region was found more towards the ocean front. A feature of interest is that, when the number of *E. agallocha* increased the number of *Avicennia* decreased. It is also interesting to note that *Avicennia officinalis* was not distributed within the area of 4 km from the mouth of the river. It is likely that this species may prefer a inland habitat with lesser magniture of salinity variation. Whereas *A. marina* did not exhibit such a relationship. A non mangrove species *Ipomaea tuba* Linn. which was closely associated with mangroves showed a discontinuous distribution. Nine species (item No. 5 to 13 in Table 2) showed a salinity related distribution in that they were represented in regions the river, where there may be wide fluctuations in salinity, and were recorded only in quadrat numbers 6 to 12. The quadrats 1 to 3 were located near the mouth which was characterised by the presence of neritic waters throughout the year due to its proximity to the sea whereas quadrat numbers 7 to 12 were located in the inland area where fresh water condition existed during the monsoon season and brackish water regime found during the post monsoon and summer seasons (Sarma & Ganapti, 1971). *Myriostachya wightiana* Hook was found in habitats which were located more toward the inland waters. On the other hand, *Suaeda maritima* Dumort was recorded in the first two quadrats which were laid very close to the sea coast.

In general, the following three distinct zones of distribution can be made.

Zone I: *Excoecaria agallocha – Suaeda maritima* zone, which extends 1 to 2 km from the river mouth.

Zone II: A middle zone in which a mixed community of *Excoecaria*, *Avicennia* and *Aegiceras corniculatum* L. may be found. This zone extends upto about 6 km from the river mouth.

Zone III: Was represented by *Excoecaria*, *Avicennia* and *Cyperus* which were found at a distance of 7–8 km from the sea. In this zone a mixed community of *Excoecaria*, *Avicennia* and *Acanthus* may be recognized.

It is interesting to note that *Suaeda maritima* was found only near the swampy regions of the coastal zone along with *Excoecaria* and *Avicennia*. Another interesting feature is the occurrence of the *Rhizophora apiculata* Blume and *Lumnitzera racemosa* Willd. But these were not present within the 10 quadrats. *Rhizophora apiculata* was represented by a single tree, which was located in the middle stretch of the study area. Whereas *L. racemosa* was found to be sparingly distributed.

The species diversity varied from 0.92 to 3.13 with the highest level towards the inland waters. Similarly, an ascending value in species richness was recognized from the mouth of the river towards the inland water. Where *Excoecaria* and *Avicennia* dominated, as in the case of first 3 km, the richness index was poor (1.02 to 1.67) whereas it ranged between 4.85 and 5.4 in the region of freshwater regime. The species evenness index was relatively high in areas of low salinity (Table 3).

Discussion

Figure 2 compares the concentration of atmospheric pollution between Kakinada town and its neighbourhood and the Coringa forest. The variation in the atmospheric pollution is a function of

Table 3. Species diversity, species richness and species eveness values in different quadrats

Indices	Quadrat number									
	1	2	3	4	5	6	7	8	9	10
		Coast line					Inland water			
Species diversity	1.15	1.81	0.92	1.26	1.42	1.69	2.52	2.69	3.13	2.95
Species richness	1.02	1.67	1.19	1.20	1.75	1.93	3.16	4.05	5.40	4.85
Species eveness	0.73	0.90	0.58	0.76	0.90	0.84	0.90	0.85	0.90	0.89

the influence of monsoon accompanied by the direction of wind speed. The behaviour of SO_2 and NO_x was similar in that the concentration of these components were higher in Coringa during the summer season when the wind was blowing in the SE and SW directions. It is likely that wind borne SO_2 and NO_x may be concentrated at the Coringa reserve forest. On the other hand, the concentration NH_3 and SPM was higher at the Kakinada town which is due to wide spread human activity and the use of nitrogenous fertilizers.

The species structure in the mangroves of Coringa appears to vary from site to site. Rao *et al.* (1963) and Venkatesan (1966) reported the occurrence of 26 species in the neighbourhood of Kakinada. Of which *Suaeda maritima*, *Heliotrophium curassaricum* L., *Fimbristylis cymosa* R. Br. and *Aeluropus lagopoides* (L.) Trin. occur in considerable numbers. In the Coringa forest, Blasco (1975) recorded the occurrence of *Excoecaria agallocha*, *Avicennia officinalis*, *Phoenix paludosa*, *Derris* sp., *Dalbergio* sp. and *Ceasalpinia* sp. Later Sidhu (1963) recognized three major forest communities. They are tidal ever green, semi-evergreen and tidal decidous. He recognized pure *Avicennia* community, mixed *Avicennia* community and *Aegiceras* mixed community. He also recognized a total number of 20 species in his studies carried out the at Coringa Coup No. 2 and 4 (coup = area alloted by forest authorities for clear felling) and various region within the Coringa reserves such as Gundhuhalla, Varavacalea and Padavakpalam. An interesting and contradictory feature between the earlier and the present study is the variation and the dominance of species within the community. In the above areas of study, *Avicennia* was the dominant species, whereas in the present study, *Excoecaria* was found to be the dominant species and no pure stand of *Avicennia* was recognized at any place. Another feature of difference is the association of *Avicennia* with *Acanthus*.

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