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Original Research Paper

Physico-Chemical and Floristic Studies of Mangalavanam Mangrove Ecosystem in Ernakulam District, Kerala, South India

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ABSTRACT

The present investigation was carried out to study the physical, chemical and biological (biodiversity) characteristics of a mangrove region of Ernakulam district namely Mangalavanam ecosystem. Physico-chemical parameters like pH, temperature, phenolphthalein alkalinity, acidity, free CO_2, chloride, hardness, phosphate, dissolved oxygen, BOD, COD and total alkalinity were analysed. In order to study the quantitative estimation of plant communities in Mangalavanam field, quadrat analysis was done. Frequency, density, abundance and similarity Index were also calculated using standard equations. In the present study five species of true mangroves and a total of 11 mangrove associates were noticed. Among the five true mangrove species, *Acanthus ilicifolius* was found to be abundant, while *Bruguiera cylindrica* and *Bruguiera sexangula* were the least represented mangrove species in this area. The leaf anatomy of four species of mangrove plants was also investigated to determine the taxonomic value of their leaf anatomical and micromorphological characters.

INTRODUCTION

Mangroves are salt tolerant plants of tropical and subtropical regions of the world along the estuarine sea coasts and river mouths, mainly in the intertidal zone. The ecosystem is also considered as dynamic, productive and biodiverse providing significant functions in the coastal zones as buffer against erosion, storm surge and tsunamis. In Kerala, mangroves are distributed in all districts except Idukki, Pathanamthitta, Palakkad and Wayanad. Maximum mangroves areas are occupied in Kannur district. The total extent of mangrove forests in the state is estimated to be less than 50 sq. km. Basha (1991) reported that only 1671 ha of mangroves exist in Kerala coast, out of these Ernakulam district occupies 260 ha. Mangrove ecosystem shows biodiversity richness too. With regard to the plants and animal diversity of mangroves, the ecosystem harbours both typical mangrove species, more accurately termed as mangals and also mangrove associates in adjacent aquatic or wetland formations. The present paper deals with the physico-chemical and floristic studies made in Mangalavanam mangrove ecosystem in Ernakulam district.

MATERIALS AND METHODS

Study site: The present investigation was carried out on a mangrove region namely Mangalavanam ecosystem in Ernakulam district of Kerala located at 90°59' N latitude and 76°16' E longitudes (Fig. 1). It is only a small patch of greenery with a tidal wetland with an extent of 2.74 ha. It has been declared as a protective area on 31st August, 2004.

Methods of study: The physico-chemical analysis of water was conducted and parameters like pH, temperature, phenolphthalein alkalinity (PA), acidity, free CO_2, chloride, hardness, phosphate, DO (dissolved oxygen), BOD (biochemical oxygen demand), COD (chemical oxygen demand), and TA (total alkalinity) were analysed as per standard methods (APHA 1998, Trivedy & Goel 1986). Water samples were collected during Oct. 08, Dec. 08 and Feb. 09 from the mangrove areas. Primary productivity was also determined and NPP, GPP and CR were calculated as per the light and dark bottle method pioneered by Gaarder & Gran (1927).

Quantitative estimation of Mangalavanam vegetation in the form of frequency, abundance, density and similarity index was done during Dec. 08 and Feb. 09. Mangrove flora and associated species of the region were identified by using published floras by Gamble (1915-1934) and Mathew (1983). Leaf anatomy of mangroves was also studied to determine morpho-anatomical adaptations.

RESULTS AND DISCUSSION

Physico-Chemical Characteristics of Water Samples

The results of the water analysis are given in Table 1.

pH: It is influenced by metabolic activities of aquatic vegetation. The pH varied from 6.6-6.9 in the mangrove waters in the three collection periods. It was 6.6 during October and 6.9 in the month of February. Much lower values ranging from 6.1 to 6.9 have been reported by Verma et al. (1984) due to acidic wastes.

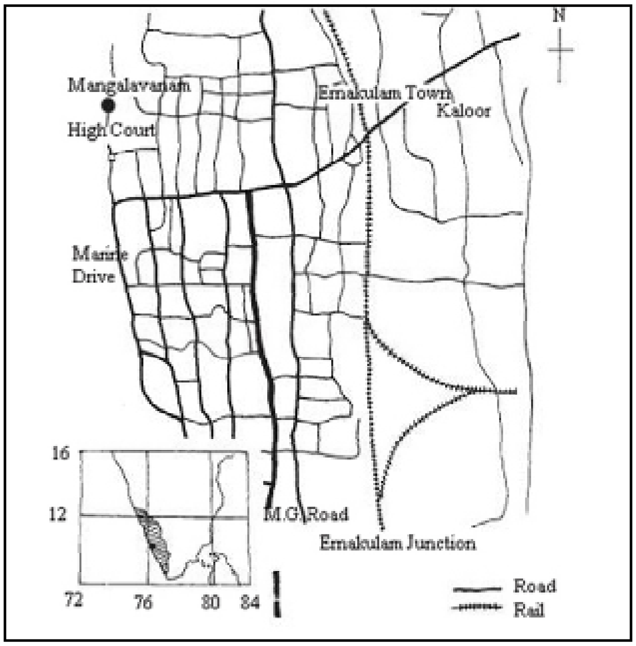

Fig.1: Map showing location of Mangalavanam in Ernakulam District.

Temperature: In general, the temperature is higher during the summer months and lower during the post monsoon season. In the present study also, temperature showed such variation according to seasons. The temperature fluctuated from 28°C-32°C. The minimum temperature was recorded during October, while the maximum during February. Vass (1989) considered water temperature as an important physical factor which influenced the chemical changes in water.

Phenolphthalein alkalinity (PA): Alkalinity of the water source is more significant than its pH because it takes into account the principal constituents that influence the water's ability to regulate the pH. The presence of phenolphthalein alkalinity is the indication of higher carbon assimilation. The PA was found to be absent throughout the study period. If phenolphthalein alkalinity is present, free CO_2 will be absent. The presence or absence of it was influenced by the pH.

Acidity: Acidity of the water is its capacity to neutralize a strong base to a fixed pH. However, in natural waters most of the acidity is present due to the dissolution of CO_2 which forms carbonic acid. Determination of acidity is significant as it causes corrosion and influences the chemical and biochemical reactions. The average value of acidity was 37 mg/L in mangrove water.

Free CO_2: Free CO_2 in water forms carbonic acid (H_2CO_3), which dissociates into H^+ and HCO_3^- ions. This brings a change in pH of water as H+ ions set free. HCO_3 reacts with calcium to form calcium bicarbonate, which is soluble in water. If free CO_2 is not available at this stage calcium bicarbonate gets converted into insoluble calcium carbonate. Thus, free CO_2 is dependent on the temperature and controls the pH and concentration of bicarbonates, carbonates and calcium. The CO_2 was 26.7 mg/L in the mangrove waters.

Chloride: Chloride is often associated with sodium since sodium chloride is a common constituent of many water resources. The levels above 140 ppm are considered to be toxic for plants (Flood 1996). The average value of chloride was 65.2 mg/L in mangrove water.

The chloride concentration increases during summer in water samples collected from nonmangrove areas. According to Gonzalves & Joshi (1946) the chloride concentration increases in summer when the water level is low. The increased value of chloride during summer is due to lower quantity of water and increased excreta from various aquatic fauna (Mishra & Yadav 1978, Pandey & Mishra 1991).

Hardness: The value of hardness in the mangrove water was 405.6 mg/L. It is an important parameter as it indicates the quantity of some dissolved salts, especially of calcium and magnesium. Magnesium is an important constituent of chlorophyll, its higher concentration increases the hardness in water and rejects its utility for drinking purposes. Disposal of sewage and industrial wastes are the important sources of calcium.

Phosphate: Phosphate is a nutritional factor, which usually exists in small amount and often limits the biological productivity. The average value of phosphate was 0.17 mg/L in mangrove water. According to Godfrey (1982) increased phosphate concentration causes eutrophication. In the present study the concentration of phosphate was very low, indicating the absence of eutrophication.

Dissolved oxygen: It is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in waters. The DO was 1.75 mg/L in mangrove water.

The amount of dissolved oxygen is an index of productivity in aquatic systems. The photosynthetic and respiratory activities have profound influence on dissolved oxygen concentration. Dissolved oxygen level can also be correlated with the photosynthetic activity (Gonzalves & Joshi 1946, Zafar 1946). Low oxygen concentrations are generally associated with heavy contamination by organic matter. In the value of DO showed negative correlation with temperature. There is an inverse relationship between temperature and dissolved oxygen Desai et al. (1995).

BOD and COD: The value of COD observed in the mangrove water was 638.6 mg/L. Tiwari et al. (1986) established a relationship between COD and BOD for the river Ganga at

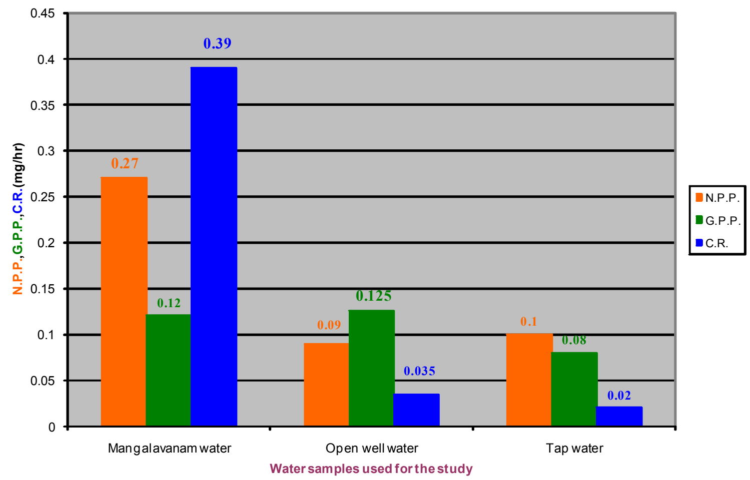

Fig. 2: Productivity and community respiration of water samples from mangrove and non-mangrove regions.

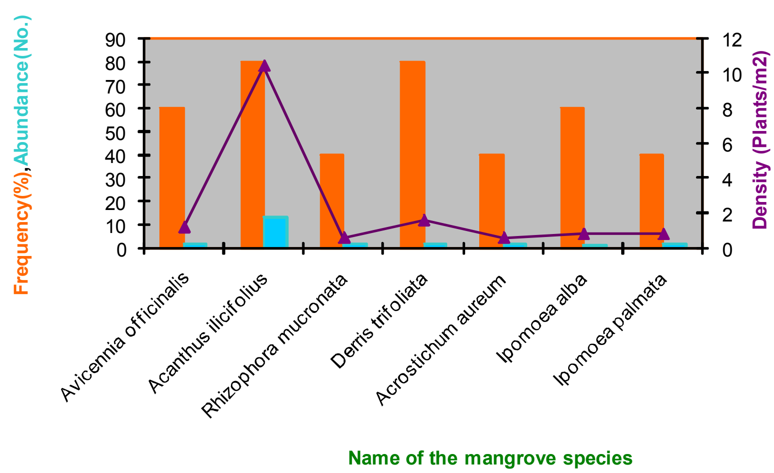

Fig.3(a): Quantitative estimation of mangrove community in Mangalavanam region.

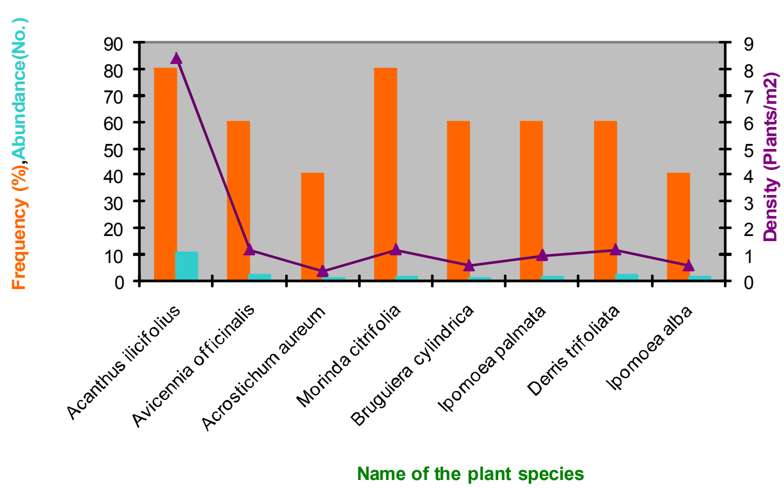

Fig. 3(b): Quantitative estimation of mangrove community in Mangalavanam field.

Table 1: Physico-chemical analysis of water samples from Mangrove and Non-Mangrove region.

S. No.	Water quality parameters studied	Mangrove water sample
1	pH	6.76
2	Temperature (°C)	30.6
3	P.A. (mg/L)	0
4	Acidity (mg/L)	37
5	Free CO_2 (mg/L)	26.7
6	Chloride (mg/L)	65.2
7	Hardness (mg/L)	405.6
8	Phosphate (mg/L)	0.17
9	D.O. (mg/L)	1.75
10	B.O.D. (mg/L)	67.66
11	C.O.D. (mg/L)	638.6
12	T.A. (mg/L)	156.3

Table 2: Details on the name, family and status of Mangalavanam flora.

Sl. No.	Name of Plant	Family	Present status
1	*Rhizophora mucronata, Lamk.*	Rhizophoraceae	+ +
2	*Avicennia officinalis, Linn.*	Verbenaceae	+ + +
3	*Bruguiera sexangula, Lour.*	Rhizophoraceae	+
4	*Bruguiera cylindrica, (L.)Blume*	Rhizophoraceae	+
5	*Acanthus ilicifolius, Linn.*	Acanthaceae	+ + +
6	*Morinda citrifolia, Linn.*	Rubiaceae	+ + +
7	*Ipomoea alba, Linn.*	Convolvulaceae	+ + +
8	*Urena lobata, Linn.*	Malvaceae	+
9	*Ipomoea palmata, Forsk.*	Convolvulaceae	+ +
10	*Achyranthus aspera, Linn.*	Amaranthaceae	+
11	*Derris trifoliata, Lour.*	Papilionaceae	+ +
12	*Clerodendron infortunatum, Linn.*	Verbenaceae	+
13	*Lantana camara, Linn.*	Verbenaceae	+
14	*Sida acuta, Burm.*	Malvaceae	+
15	*Acrostichum aureum, Linn.*	Pteridaceae	+ +
16	*Cleome burmanni, W.*	Capparidaceae	+
17	*Mikania scandens, Linn.*	Asteraceae	+ +
18	*Colocasia antiquorum, Linn.*	Araceae	+ +
19	*Synedrella nodiflora, Linn.*	Asteraceae	+
20	*Cayratia pedata, Juss.*	Vitaceae	+ +
21	*Commelina nudiflora, Linn.*	Commelinaceae	+
22	*Syzygium jambolanum,DC.*	Myrtaceae	+
23	*Cyperus rotundus, Linn.*	Cyperaceae	+

+ less; ++ frequent; +++ abundant

Kanpur and proposed a linear relationship between BOD and COD.

Low BOD values indicate poor biological activity, whereas low COD values indicate that the water was not organically polluted. In the present study BOD values were lower compared to COD. The BOD values were 66.5-70 mg/L in mangrove water. High COD values indicate the presence of chemically oxidizable carbonaceous matter as well as the inorganic matter such as nitrates, sulphides and reduced metal ions. Singh & Srivastava (1988) noted high value of BOD and COD in Ganga water during summers due to high input of organic pollutants.

Total alkalinity: Alkalinity in natural waters is due to free hydroxyl ions and hydrolysis of salts formed by weak acids and strong bases. Most of the alkalinity is formed due to dissolution of CO_2 in water. Carbonates and bicarbonates thus formed are dissociated to yield hydroxyl ions.

Alkalinity increases as the amount of dissolved carbonates and bicarbonates increases (Flood 1996, Radha Krishnan et al. 2007). Mangrove water shows alkalinity value of 156.3 mg/L. Most of the Indian rivers have been reported to exhibit slight to moderate alkalinity (Bhargava 1985, Venkateshwarlu 1986). Higher values of alkalinity in water indicate pollution of organic and inorganic nature as have been reported by Phillip (1960).

Primary Productivity

The results of the primary productivity studies are shown in Fig. 2. The Net Primary Productivity (NPP) measurements showed that the productivity was 0.27 mg/hr. In case of Gross Primary Productivity (GPP), mangrove water has a productivity of 0.12 mg/hr. Community respiration rate was also higher in mangrove water (0.39 mg/hr).

Community respiration was high in mangrove water. It may be due to the presence of large number of decomposers. The phytoplankton growth was found to be low in mangrove habitat, thus affecting the primary productivity (Tripathy et al. 2005).

Quantitative Estimation of Plant Communities

Frequency, density and abundance were studied using quadrat method in Mangalavanam field and the results are summarized in Figs. 3a and 3b. The species *Acanthus ilicifolius* showed maximum frequency, density and abundance.

Similarity index was also calculated for two vegetation strands. In both the strands, six species were found to be common. Similarity index of two vegetation strands of mangrove community obtained from Mangalavanam field was 8.5%.

Mangrove Analysis

Five true mangrove floral species belonging to 3 families were identified from the study area. The true mangroves in Mangalavanam ecosystem are *Acanthus ilicifolius*, *Rhizophora mucronata*, *Avicennia officinalis*, *Bruguiera cylindrica* and *Bruguiera sexangula*. Among the five true mangrove floral species, *Acanthus ilicifolius* was most abun-

Table 3: Comparative leaf anatomy of mangroves plants.

Name of the plant	Cuticle	Epidermis	Hypodermis	Mesophyll	Vascular strand
Rhizophora mucronata	Thick and waxy	Upper-3 layered,lower1-2 layered	Upper-3 layered, lower absent	Palisade 2 layered, thick, Spongy tissue 10-12 layered with intercellular spaces. Idioblast cells are present	Closed, collateral, and endarch xylem
Bruguiera cylindrica	Thick and waxy	One layered thick on both surface	2 layered thick on upper surface, crystals are present	Palisade 2 layered,1-12 layered spongy tissue, crystals present	Closed, collateral, and endarch xylem
Avicennia officinalis	Upper waxy, lower hairy, glandular and non glandular hairs	One layered thick on both surface, Salt glands present	4 layered thick on upper surface	4-layered palisade tissue , 4-5 layered spongy tissue, stone cells present	Surrounded by sclerenchyma cells, closed, collateral and mesarch xylem
Acanthus ilicifolius	One layered thick	One layered on both surface	2 layered thick below upper epidermis	Palisade 2 layered, thick, loosely arranged spongy tissue	Closed, collateral and mesarch xylem

dant, while *Bruguiera cylindrica* and *Bruguiera sexangula* were least represented. *Acanthus ilicifolius* gets dominated at sites that are not completely inundated (Saha & Choudhury 1995).

Bruguiera is largest genus in the family Rhizophoraceae (Hou 1958, Tomlinson 1986, Hogarth 1999). Based on flower size and the pollinating agent, various authors (Tomlinson 1986) generally divided *Bruguiera* into two groups. *Brugueria* species with large, recurved flowers (*B. sexangula*) is considered to be bird-pollinated, while the species (*B. cylindrica*) with comparatively smaller and erect flowers is probably insect-pollinated. In Mangalavanam, *B. sexangula* tree grow mainly in the back mangrove (the landward zone) where there is less frequent tidal inundation and often in association with *B. cylindrica* and *Rhizophora mucronata*.

Several mangrove associated floral species were also identified from the Mangalavanam mangrove ecosystem. Some important mangrove associates were *Acrostichum aureum*, *Derris cylindrica*, *Ipomoea palmata*, *Morinda citrifolia*, *Ipomoea alba*, *Achyranthes aspera*, *Clerodendron infortunatum* and *Cayratia pedata*. The distribution of both the mangroves and mangrove associates at the study site were jointly observed as a picture of 'green cover'. The present status of flora on the Mangalavanam mangrove ecosystem was also analysed and the results were categorized as less, frequent and abundant (Table 2).

Mangrove associated species and true mangroves have no significant relationship among themselves. Basha (1991) observed that no speciality, specificity or relationship between the occurrences of these mangrove associated species and mangrove species.

Leaf Anatomy of Mangroves

Leaf anatomy of 4 species of mangroves, *Avicennia officinalis, Rhizophora mucronata, Bruguiera cylindrica* and *Acanthus ilicifolius* was also analysed and the results are summarized in Table 3.

Generally, mangrove leaves showed leathery texture, thick cuticle and sunken stomata. The lower epidermis of the *Avicennia officinalis* is hairy in nature. The glandular and non glandular hairs are present. Salt gland is another feature and it is covered by hairs. Baker (1915) and Fahn & Shimony (1977) have mentioned that all the species of *Avicennia* show variously shaped hairs to cover salt gland and stomata for reducing water loss through the stomatal pores. Baylis (1940) has reported that all species of *Avicennia* have multilayered thick hypodermal aqueous tissue.

In *Rhizophora mucronata* sclereids are present. Sclereids are reported from *Rhizophora* species by Rao (1957) and Shah & Sundaraj (1965). Generally, single layered epidermis on the upper surface was observed in the members of *Bruguiera* with 1-2 layered thick hypodermal aqueous tissue.

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