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Floral and microbial dynamics in relation to the Physico-chemical constituents of the Devi-estuary of Odisha Coast of the Bay of Bengal, India

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The floristic and microbial diversity, were assessed with respect to the prevailing physico-chemical composition of the mangrove forest of the Devi estuary, Odisha, India. Floristic composition showed that *Avicennia officinalis* L., *Avicennia alba* Bl., *Sonneratia apetala* Buch.-Ham. and *Acanthus ilicifolius* L. were dominant plant species. Microbial population dynamics was more i.e. 3.34×10^6 CFU/gm at Bandara and lower i.e. 2.96×10^5 CFU/gm at Machamachikuda region of the mangrove sediments. *Aspergilus* and *Streptomyces* spp. were most abundant microbes in the five sampling sites. Organic carbon content and *p*H were significantly correlated with microbial dynamics, whereas salinity had negative relation. A positive correlation was found among the physico-chemical character viz. pH, organic carbon and salinity.

[Keywords: Biodiversity assessment; Devi estuary; Floristic composition; Microbial dynamics; Physico-chemical parameters]

Introduction

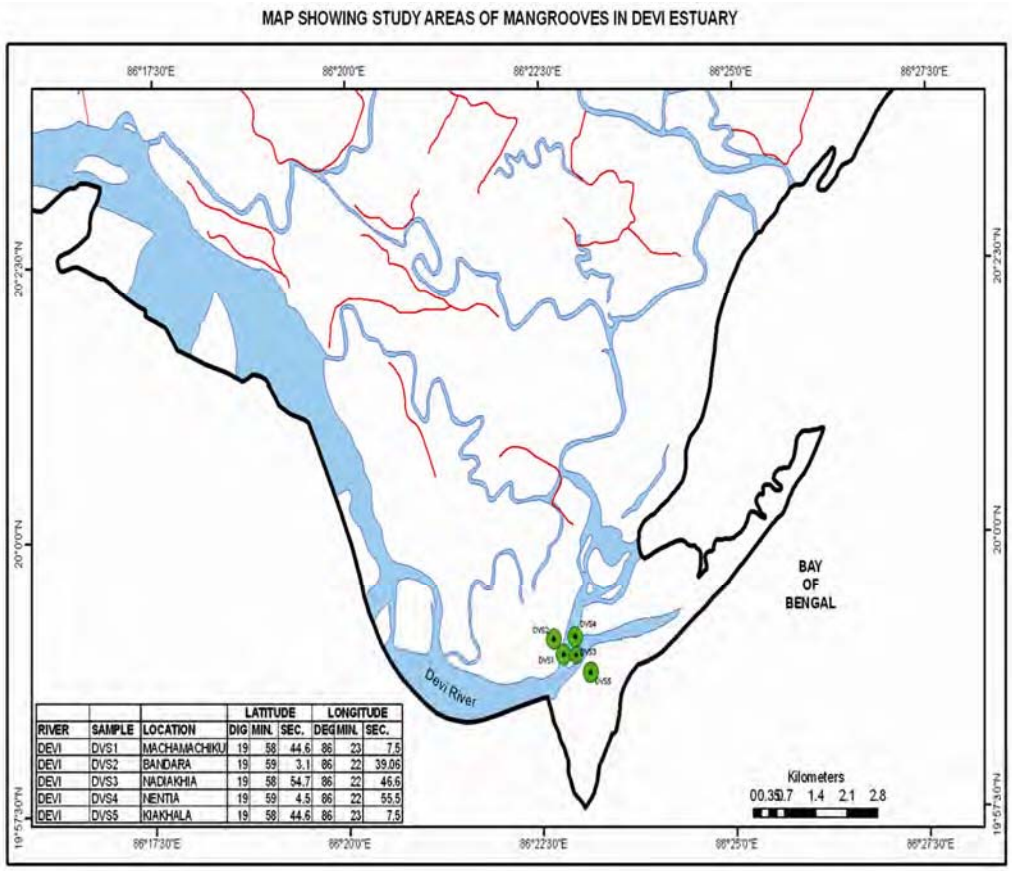
Mangroves are taxonomically diverse group of salt-tolerant, mainly arboreal, lower stature plants that grow primarily in tropical and sub-tropical regions[1]. Dynamic mangrove ecosystems support diverse soil micro, meio, and macro organisms such as bacteria, fungi, actinomycetes, microalgae, invertebrates, birds, mammals etc[2,3]. The soil organisms, especially microbial flora, play a very active role in the degradation of foliage litters. It nurses diverse microbes such as nitrogen fixing, phosphate solubilising, sulfate reducing, photosynthetic anoxygenic, methanogenic bacteria, wood degrading fungi, enzyme and antibiotic producing actinobacteria etc.[4] which could be important sources of industrially important molecules. Though several studies on physico-chemical constituents and microbial diversity have been done[5,6,7,8] in various mangrove ecosystems of India, limited investigations has been undertaken on the interrelations among the microbial and floral diversity with sediment properties of the mangrove ecologies. In Odisha, probably, similar studies on floristic and microbial diversity in relation to the physico-chemical constituents in the Devi estuary have not been envisaged. Therefore, an attempt has been undertaken to assess the floristic and microbial dynamics with respect to prevailing physicochemical constituents of the mangrove soil.

Materials and Methods

Devi river (a distributary of the Mahanadi river) mouth mangrove wetland is located in the southernmost part of the Mahanadi delta in the district of Jagatsinghpur district lies between 20° 05' and 20° 10' N latitude and 86° 15' and 86° 25' E longitude (Fig.1). It is a sporadic nesting ground of the olive ridley turtle, a reserved mangrove forest and natural resources of dependant villages from its protected *Casuarina* plantations.

Regular surveys at three months intervals were made at different localities across the entire area throughout the year. Plants were collected and detailed field notes were recorded on the spot which included field number, date of collection, locality, habit, habitat, phenology, and plant species, pattern of distribution, abundance/rarity and their characters. The specimens were identified referring the regional flora[9,10,11,12] and preserved in the herbarium (RRL-B) at IMMT, CSIR, Bhubaneswar.

Sediment samples were collected from five different localities such as Machamachikuda (DVL-1), Bandar (DVL-2), Nadiakhia (DVL-3), Nentai (DVL-4) and Kiakhala (DVL-5) for physico-chemical and microbial analysis. Two sets of samples were collected from each site at different locations from 5 to 10 cm depth removing 2-3 cm top soil by using a presterilized borer, put in polythene



RIVER	SAMPLE	LOCATION	LATITUDE DIG	MIN.	SEC.	LONGITUDE DEG	MIN.	SEC.
DEVI	DVS1	MACHAMACHIKU	19	58	44.6	86	23	7.5
DEVI	DVS2	BANDARA	19	59	3.1	86	22	39.06
DEVI	DVS3	NADIAKHIA	19	58	54.7	86	22	46.6
DEVI	DVS4	NENTIA	19	59	4.5	86	22	55.5
DEVI	DVS5	KIAKHALA	19	58	44.6	86	23	7.5

Fig. 1—Study area

bags, labelled appropriately, kept in an ice box, carried to the laboratory and at 4±1°C for further study. The individual samples were air dried at room temperature for first. One set of sample was oven-dried at 60±5°C to constant weight for phyisico-chemical parameters analysis and other set was used for microbial analysis.

*p*H of each oven dried sediment sample was measured through a digital pH meter. Salinity, alkalinity and total phosphorous were analysed following the methodology of APHA (1998)[13] whereas the total organic carbon was analysed following Walkely and Black method[14].

The sediment samples were air dried aseptically at a less exposed area (having moisture content 50%). The individual soil samples (soil suspension) were plated on different solid growth medium such as starch casein agar (SCA in gm/lt: starch-10, casein-0.3, KNO_3-2, NaCl-2, K_2HPO_4-2, $MgSO_4.7H_2O$-0.5, $CaCO_3$-0.02, $FeSO_4$-0.01, agar-agar-15; *p*H-7.2) and Potato Dextrose Agar (PDA in gm/lt: Potatoes infusion from-200, dextrose-20, agar-agar-15, *p*H-7.2) for isolation of actinobacterial and fungal colonies respectively by spread plate method and kept in incubator (37°C and 28°C for 7-8 and 2-3 days) respectively for growth Fig. 2&3. The actinobacterial and fungal colonies were counted as colony forming units (CFU) and isolated colonies were picked up, purified and maintained as pure cultures in slants of respective isolation medium for further study.

Correlation analysis

Pearson correlation analysis was performed among the studied parameters and microbial diversity with the help of statistical software SPSS-ver 10.0.

Results and Discussion

Mangrove ecosystem of Devi mouth region is a storehouse of variety of fauna and flora with great ecological and economical significance. All together 35 angiosperms belonging to 32 genera and 26 families were recorded from the Devi mangrove forest (Table 1). Out of the 35 species, 2 species were monocot plants and remainder 33 species were dicot

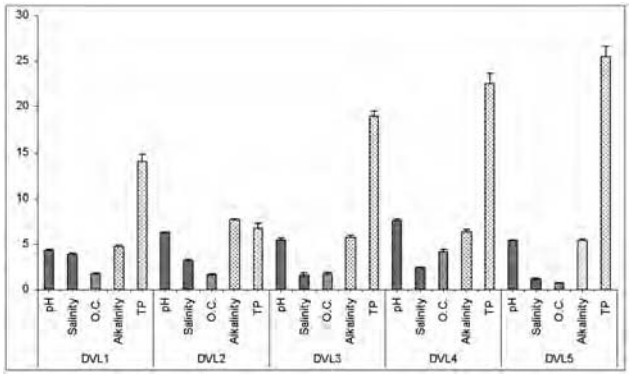


Fig. 2—Total organic carbon content of different sampling sites

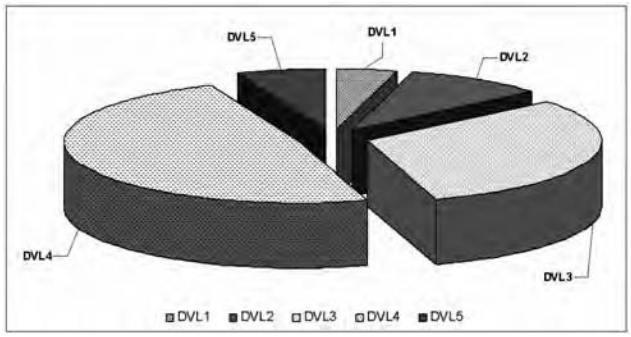


Fig. 3—Total microbial diversity of different sampling sites

Fig. 4—Biotic interference inside estuary region

plants; only 5 species belonged to true mangroves Fig. 4 and other 28 species were mangrove associates and sand dunes species (Table 1). The predominant true mangrove species were *Avicennia alba*, *A. officinalis*, *Sonneratia apetala,* whereas other species were *Pandanus foetidus, Acanthus ilicifolius, Porteresia coarcata, Calotropis gigantea, Casuarina equisetifolia* which dominated the whole estuary region. Comparison records of previous[15] and the present study revealed the extinction of *Heritiera fomes, Excoecaria indica* and *Kandelia candel* which would be due to conversion of mangrove wetland into agriculture and aquaculture, cutting down of mother plants restricting regeneration, random fishing through drag net damaging seedlings of the mangrove species and natural disasters. Comparison study with Bhitarkanika mangroves implies that true mangroves like *Kandelia candel, Heritiera fomes,* are having good population status in Bhitarkanika which is very rare in our study site[16]. The results envisage conservation of the natural resources of the mangrove ecology.

The soil of the mangrove forests had more clay content as compared to non-mangrove soils. The mangrove ecosystems of the Devi estuary had significant variation of *p*H and salinity (Fig.5 & Table 2). The sediment *p*H was higher at Nentai (7.54) and at Machamachikuda (4.32) (Fig. 2). Fluctuations of the *p*H might be due to anthropogenic activities, sewage deposition, pollution etc. Salinity was more at Machamachikuda (3.84 PSU), whereas, lower at Kiakhala (1.15 PSU) (Fig. 2). Sediment alkalinity varied from 4.702 to 7.638 at Machamachikuda and Bandar, whereas the total phosphorus varied from 6.68 to 25.5 mg/g at Bandar and Kiakhala, respectively (Fig. 2). Organic carbon content in the sediment samples was more i.e. 4.13% and lower i.e. 0.69% at Nentai and Kiakhala region, respectively (Fig. 6). Total microbial population dynamics was higher i.e. 3.34×10^6 CFU/g at Bandara and lower i.e. 2.96×10^5 CFU/g at Machamachikuda (Fig. 2). The microbial load increased with the increase in organic carbon content of sediments of different localities (Fig. 7). Most dominant fungi were *Aspergillus niger* (8.0×10^5 CFU/gm), *A. fumigatus* (4.44×10^4 CFU/gm), *A. oryzae* (1.3×10^4 CFU/gm), *Penicillium citrinum* (3.34×10^4 CFU/gm), whereas most dominant actinobacteria was *Streptomyces sampsonii* (5.1×10^6 CFU/gm), *S. flavogriseus* (1.29×10^6 CFU/gm) Fig. 8&9. In the correlation study, the organic carbon content (r = 0.672) and *p*H (r =0.533) were significantly correlated with microbial diversity whereas salinity (r = -0.312) had negative relation with microbial diversity (Table 3). However, a positive relationship was found between *p*H, organic carbon and salinity.

Table 1—List of plant species in the Devi estuary region

Botanical Name	Local Name	Form	Distribution
Acacia auriculoformis A.Cunn.ex Benth.	Akasia	Tree	India and Australia
Acanthus ilicifolius L.	Harakancha	Herb	Sea-coasts of India, Sri Lanka, Malaysia, Java, Indonesia, Australia etc.
Aristolochia indica L.	Panaairi	Climber	India, Sri Lanka, Nepal, Bangladesh
Avicennia alba Bl.	Bani	Tree	Eastern coast of India, Malaya peninsula, S.E. Asia, North Australia
Avicennia officinalis L.	Kalabani	Tree	Sea shores of India, Bangladesh, Myanmar, Sri Lanka, Thailand, Malaysia etc.
Azadirachta indica A.Juss.	Limba	Tree	India, Myanmar, China
Borassus flabellifer L.	Tal	Tree	India, Africa, Madagascar, Sri Lanka, New Guinea etc.
Calotropis gigantea R.Br.	Arakha	Under shrub	India, Pakistan, Nepal to Sri Lanka, S. China & Malaysia
Casuarina equisetifolia L.	Jhaun	Tree	India, Myanmar, Australia
Ceriops decandra (Griff.) Ding Hou	Gorani	Shrub	India, Sri Lanka, Myanmar, Thailand, Malaysia, New Guinea etc.
Chromolaena odorata (L.) R.King & H.Robins	Gandhuri	Under shrub	India, South America, Nepal, Myanmar, Malya and Thailand
Crotolaria juncea L.	Chanapata	Herb	Native India and now spread to most tropical countries
Croton bonplandianus Baill.	Ban mirchi	Herb	India, South America
Cuscuta reflexa Roxb.	Nirmuli	Climber	India, Afghanistan, Sri Lanka, China, Malaysia etc.
Dalbergia spinosa Roxb.	Kanta sisoo	Shrub	India, Bangladesh, Myanmar, Malaysia
Derris trifoliata Lour.	Khatei lata	Climber	India, Andaman and Nicober, South Africa, Madagascar etc.
Excoecaria indica (Willd.) Muell.-Arg.	Ghigidi	Tree	South and East India, Andaman and Nicober, Southeast Asia and Malaysia to Solomon Island
Ficus benghalensis L.	Baro	Tree	India, Sri Lanka, Pakistan
Flacourtia indica (Burm.f.) Merr.	Baincho	Shrub	India, Africa, S.E. Asia, Polynesia
Hedyotis corymbosa (L.) Lam.	Gharpodia	Herb	Through out India, Pantropic
Ipomoea pes-caprae (L.) R.Br.	Kansari lata	Creeping Herb	Sea-shores of India, Pantropical
Lantana camara L.	Naguari	Under shrub	India, West Indies and widely distributed in sub tropical and tropical regions of the earth
Opuntia stricta (Haw.) Haw.	Nagphani	Shrub	Native to America and naturalised in India
Pandanus fascicularis Lam.	Kia	Shrub	India, Myanmar, Java, Malaysia, China, Polynesia
Pandanus foetidus Roxb.	Kia	Shrub	India, Myanmar
Pongamia pinnata (L.) Pierre	Karanja	Tree	India, Sri Lanka, Myanmar, Pakistan, Malay, North Australia etc.
Porteresia coarcata (Roxb.) Tateoka	Dhani harakata	Herb	India, Myanmar, Malaysia
Prosopis juliflora (Sw.) DC.	Kabuli kikkar	Shrub	India, Soth America, West Indies, Pantropic
Sida acuta Burm.f.	Bajramuli	Herb	Through India, Pantropical
Sonneratia apetala Buch-Ham.	Kerua	Tree	W. Bengal, Deccan Peninsula, Bangladesh, Myanmar, Sri Lanka
Spondias pinnata (L.f.) Kurz	Amta	Tree	Through India and Tropical Asia
Triumfetta annua L.	Bichhua	Herb	India, Pakistan, Madagascar, Tropical and South Africa
Vitex negundo L.	Begunia	Shrub	India, Sri Lanka, Pakistan, Myanmar, Asia, North America, West Indies etc.
Ziziphus mauritiana Lam.	Bara koli	Shrub	India, Sri Lanka, now cultivated in most parts of the world
Ziziphus oenoplia (L.) Mill.	Kantei koli	Herb	India, Tropical Asia and Australia

Table 2—Variation of the physico-chemical compositions in the Devi estuary

Stations	*p*H	Salinity (PSU)	O.C. (%)	Alkalinity (mg/l)	TP (mg/l)
DVL 1	4.32 ± 0.12	3.84 ± 0.21	1.70 ± 0.08	4.70 ± 0.18	14.00 ± 0.72
DVL 2	6.27 ± 0.09	3.20 ± 0.11	1.62 ± 0.12	7.64 ± 0.16	6.68 ± 0.61
DVL 3	5.49 ± 0.13	1.52 ± 0.26	1.75 ± 0.12	5.72 ± 0.23	18.94 ± 0.63
DVL 4	7.54 ± 0.21	2.35 ± 0.17	4.13 ± 0.24	6.32 ± 0.30	22.52 ± 1.13
DVL 5	5.34 ± 0.16	1.15 ± 0.12	0.67 ± 0.13	5.40 ± 0.17	25.50 ± 1.11

PSU- Practical Standard Unit,OC-organic carbon, TP-total phosphorus

Fig. 5—In-situ view of Mangrove forest

Fig. 6—Microscopic structure of Aspergillus

Table 3—Correlation of different components to the sediment

	Microbial dynamics	Organic Carbon	*p*H	Salinity
Microbial dynmics	1			
Organic carbon	0.672**	1		
*p*H	0.533*	0.49	1	
Salinity	-0.312	0.231	0.185	1

** significant at 0.01 level.
* significant at 0.05 level.

Fig. 7—Microscopic structure of Streptomyces

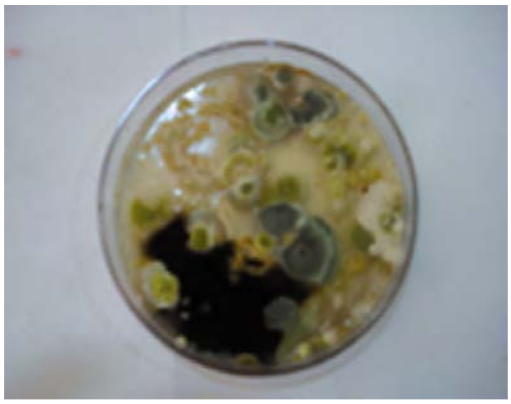


Fig. 8—Mixculture plate of fungi

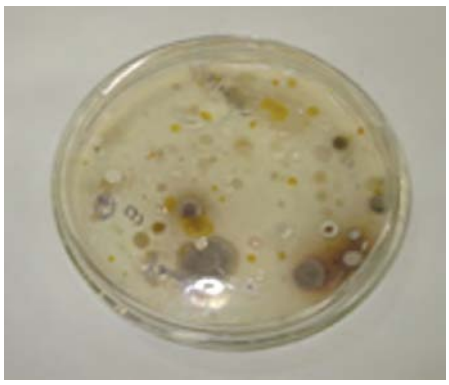


Fig. 9—Mixculture plate of actinomycetes

Microbial activity is responsible for major nutrient transformations within a mangrove ecosystem[17,18]. By consuming the dissolved organic carbon present in interstitial waters, microbial population in mangrove sediments prevent the export of this form of carbon to adjacent ecosystems, such as pelagic food or adjacent coastal areas[19,20]. Microbial diversity comprises a wide range of microbes than any other living group of organisms of the world. Microbial populations in the estuarine and marine sediments vary in density with varying regions and also among various sites. Thus, they have worldwide distribution which indicates adaptability to extremely varied environmental conditions. The distribution of actinobacterial and fungal species within the mangrove habitat may reflect physical conditions and/or habitat preference such as temperature, salinity, humidity, organic contents of the Sunderbans mangroves of India[21]. It was observed from the present study that the fluctuation in *p*H values may be due to sewage deposition, pollution etc. Estimation of organic carbon can serve as an important tool in determining the status of food available to benthic fauna and indicates the extent to which the bottom is fertile for the sustenance of microbes[22,23]. Organic carbon represents the organic matter in the sediments and this is of potential significance for aquatic productivity. The mangrove ecosystem of the study area had shown significant variation in *p*H and salinity.

Conclusions

The preliminary study on microbial and floristic diversity in the Devi estuary indicated the biotic and abiotic status, and anthropogenic activities inside the estuary. Steps should be taken to protect the mangroves from the ongoing threats like climate change and biotic interference. Correlation study showed that microbial dynamics is strongly related to organic carbon and *p*H whereas salinity has negative relation. It requires further study to establish the relations between microbes and plants to develop strategy for sustenance of the coastal ecologies.

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