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Diversity study of predominant fungi from the sediments of mangroves at Mahanadi delta and its adjoining areas

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ABSTRACT

Microorganisms in mangrove areas perform complex interactions for nutrient and ecological balances. Marine fungi play an important role in nutrient regeneration cycles as decomposers of dead and decaying organic matter. Since a very little is known about fungal populations in Mahanadi delta mangroves, the present study has been conducted to analyze the fungal diversity in relation to soil physico-chemical properties in the Mahanadi delta and its adjoining areas, a tropical mangrove ecosystem in India. In the study, ten sediment samples have been collected from different mangrove areas and the physico-chemical as well as fungal diversity study has been carried out. The physico-chemical parameters varied significantly among all sites. The pH was maximum (pH=8.3) at MHS-2 and minimum (pH=4.3) at DVS-1, organic carbon content was maximum (48.48mg/gm soil) and minimum (14.1 mg/gm soil) at MHS-5, salinity was maximum (3.84 PSU) at DVS-1 sediments. The fungal diversity was maximum ($8.56\pm0.48 \times 10^5$ cfu/gm soil) at DVS-4 sediment sample. The most dominant genera among all the fungi was *Aspergillus*. The occurrence of other genera such as *Trichoderma, Penicillium, Acremonium, Fusarium* etc. were also found in the different sampling sites. This study revealed the presence of diverse fungi in the mangroves of Mahanadi delta which provides information regarding better utilization of the industrially potent marine fungal groups for valuable product formation such as antibiotics, surfactants, antioxidants, industrial enzymes, metal-tolerant enzymes, stress proteins, food preservatives etc.

1. Introduction

Mangrove forests are among one of the world's most productive tropical ecosystems (Kathiresan, 2000). The mangrove ecosystem is composed of various organisms such as bacteria, fungi, actinomycetes, microalgae, invertebrates, birds, mammals etc. Mangrove forests are biodiversity "hotspots" for marine fungi (Shearer *et al.,* 2007). Mangrove trees are fascinating study objects for the mycologist because the bases of their trunks and aerating roots are permanently or intermittently submerged. Thus, terrestrial fungi and lichens occupy the upper part of the trees and marine species occupy the lower part (Kohlmeyer, 1969). At the interface there is an overlap between marine and terrestrial fungi (Sarma and Hyde, 2001). Mangrove fungi constitute the second largest ecological group of the marine fungi (Sridhar, 2004). The latest estimate of marine fungi is 1,500 species, which excludes those form lichens, and many of them are new or inadequately described species (Hyde *et al.,* 1998, Zhong-shan *et al.,* 2009). Fungi play important role in the ecological processes occurring in mangroves and which are also involve in organic matter decomposition pathways, despite the fact that a large fraction of the carbon processing in mangroves happens in the anoxic bulk sediment. Mangrove communities are recognized as highly productive ecosystems that provide large quantities of organic matter to adjacent coastal water in the form of detritus. Microbial activity is responsible for major nutrients transformations within a mangrove ecosystem. The biochemical versatility and diversity of rare microorganisms represent an enormous variety of genes that are still unknown. So it is open up new areas of

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biotechnological explorations, which drive the necessity to isolate and culture these organisms. The objectives of the present study include the study of physico-chemical characterization and fungal diversity of mangrove sediments of Mahanadi delta and its adjoining areas of Odisha which is less explored.

2. Materials and method

2.1 Study area

Samples have been collected from Mahanadi delta and its adjoining areas located at Long. 20^0 17' N to Lat. 86^0 42' E occupying an area of 9,000 sq. km. The mangrove vegetation is luxuriant near the estuaries of the Devi river situated at Long. 19^0 58' N and Lat. 86^0 22' E which are the adjoining areas of Mahanadi and in the Protected Forest along the creeks of Boman nadi of Bitikolia estuary. Since the mangrove forest of the Mahanadi delta receives freshwater from three rivers such as Mahanadi, the Brahmani and Baitarani, they are rich in species diversity and dense. The sediment is generally sandy clay in the adjoining areas.

2.2 Collection of samples

The sediment samples were collected in sterile condition with the help of a borer. Samples were collected in big zipper polythene bags. Two sets of sample for physico-chemical and microbiological analysis were collected from each site. After collection the samples were labled properly, marked well and kept in ice box and carried to the laboratory immediately. In the laboratory the samples were stored at a temperature of 4^0C till the time of analyses/study. Samples were collected from Kansardi (MHS-1), near light house (MHS-2 & MHS-3), Ghangholia jora site (MHS-4) and MHS-5 of Mahanadi estuary whereas Machamachikuda (DVS-1), Bandar (DVS-2), Nadiakhia (DVS-3), Nentai (DVS-4) and Kiakhala (DVS-5) of Devi mangrove estuary of Odisha (Fig.1).

2.3 Analysis of physicochemical parameters

pH and conductivity of the sediment samples were measured by using a digital pH and conductivity meter. Salinity, alkalinity and total phosphorous were analyzed following the methodology of APHA (1998). The oven dried sediment samples were powdered with grinder (Tetsch, model, RM 100). Then required amount of grounded sample was taken for total OC analysis following the methodology by Wakely and Black (1934).

2.4 Isolation and identification of fungi

The sediments were air dried aseptically for 7-10 days. Isolation of fungi from mangrove sediments was carried out by spread plate method. The samples were plated on different solid medium i.e. Potato Dextrose Agar for the isolation fungal colonies and kept in incubator for growth at 28-30^0C for 48-72 hrs. After enumeration by counting the Colony forming units (CFU) of the microbes, the isolates were sub-cultured repeatedly for isolation of pure culture and maintained in agar slants at 4^0C. After isolation, the fungal colonies were identified by studying their morphological and microscopical characteristics. Morphological characterization was done by studying the upper and lower surface of the culture plate whereas microscopical study has been done by using Lactophenol cotton blue (LPCB) staining.

3. Results and discussion

Different physico-chemical parameters of the mangrove sediments were investigated such as pH, conductivity, salinity, OC, alkalinity and TP of the sediments (Fig. 2). The pH of DVS-1 was least 4.32±0.12 and maximum i.e. 7.36±0.21 in DVS-4; conductivity was minimum i.e. 1327±113 at DVS-2 and highest i.e. 1675±138 µS/cm in DVS-5; temperature

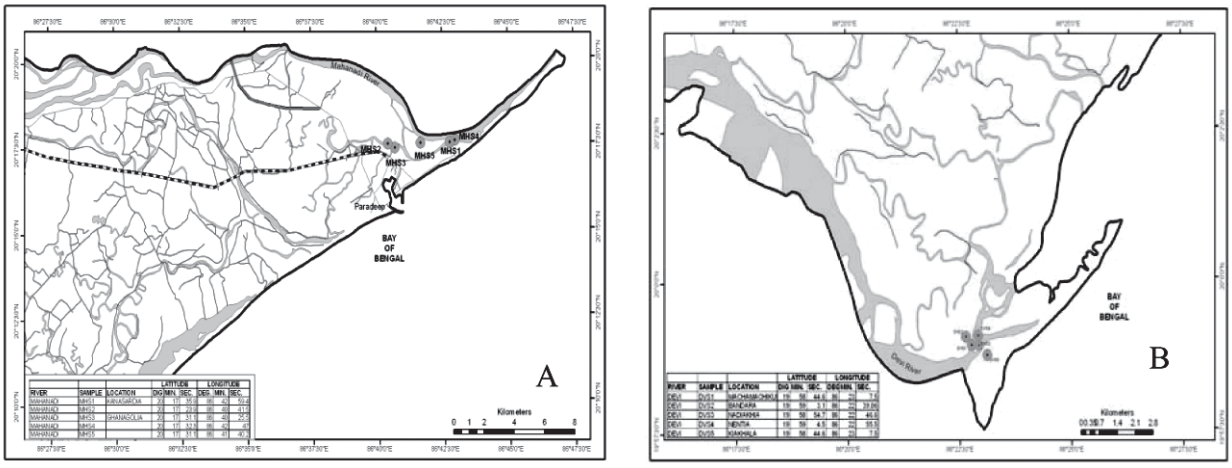

Fig.1. Sampling sites of Mahanadi delta (A) and its adjoining areas (B) of mangrove estuary

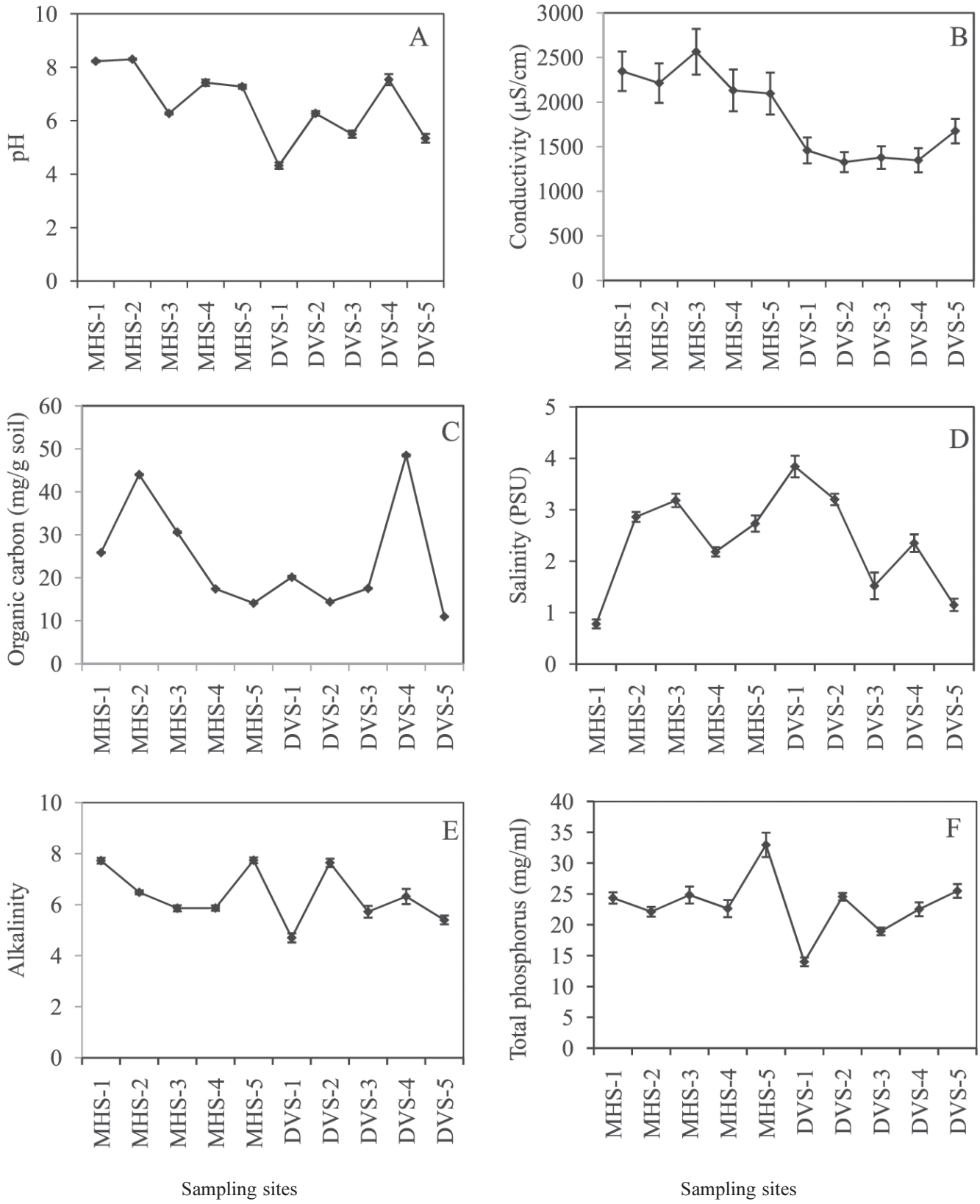

Fig.2. Physico-chemical characterization of sediment samples ; A-pH, B-Conductivity, C-Organic carbon content, D-Salinity, E-Alakalinity, F-Total Phosphorus content

ranged from 22±1.05 to 24±0.98 ^{0}C at DVS-1 and DVS-3 respectively; salinity varied between 1.15 ±0.12 PSU at DVS-5 to 3.84±0.21 PSU at DVS-1; organic carbon varied from 10.98±0.055 at DVS-5 to 48.48±0.05mg/gm at DVS-4; alkalinity was maximum at DVS-1 i.e. 4.7±0.18 to 7.64±0.16 at DVS-2; total phosphorus varied from 14.23±0.61 to 25.5±1.11 mg/ml at DVS-1 and DVS-5 (Fig.2). The total colony forming unit varied a lot in five different sampling sites of Devi. The total CFU was 3.56±0.39, 6.76±0.29, 5.14±0.11, 1.42±0.36, 0.92±0.02, 5.12±0.33, 1.84±0.26, 4.18±0.26, 8.56±0.48 and 0.94±0.03 (x 10^5) at sediments of MHS-1, MHS-2, MHS-3, MHS-4, MHS-5, DVS-1, DVS-2, DVS-3, DVS-4 andDVS-5 respectively (Fig.3). The fungal diversity study has been carried out for the collected sediments. The fungal diversity of sediments of MHS-2 and DVS-4 were maximum. Among all the fungi the most dominant were found to belong to the genus

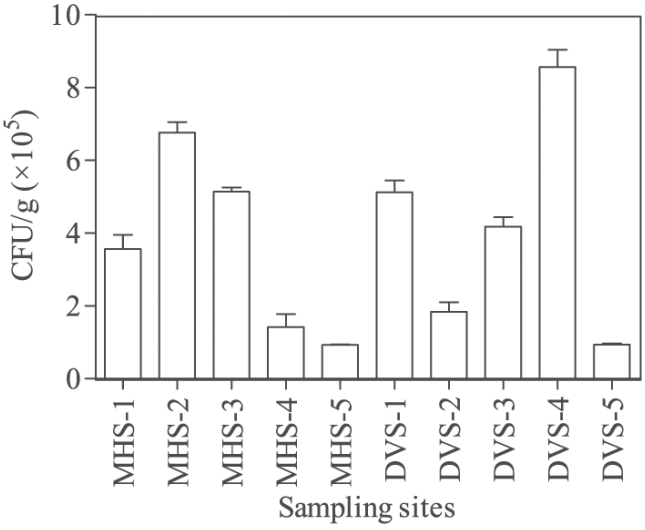

Fig.3. Total CFU (x 10^5/g) of sediment fungi from sediments

Table 1
Predominant fungal diversity in different sampling sites of mangrove area of Mahanadi delta

Sl. No.	Name of the strains	MHS-1	MHS-2	MHS-3	MHS-4	MHS-5	DVS-1	DVS-2	DVS-3	DVS-4	DVS-5
1.	*Aspergillus niger*	+	+	+	++	+	+	-	+	++	+
2.	*Aspergillus fumigatus*	+	+	+	++	-	+	+	+	++	-
3.	*Acremonium kiliense*	+	-	-	+	+	++	-	-	+	+
4.	*Penicillium citrinum*	+	-	+	-	+	+	-	+	-	+
5.	*Trichoderma viride*	++	+	-	+	-	++	+	-	+	-
6.	*Aspergillus oryzae*	+	+	-	+	-	+	-	-	+	-
7.	*Penicillium chrysogenum*	+	+	+	-	+	+	+	-	-	+
8.	*Aspergillus flavus*	-	+	-	-	+	-	-	-	+	-
9.	*Trichoderma* sp.	-	+	+	+	-	+	-	+	-	-
10.	*Aspergillus* sp.	+	-	+	-	+	-	+	-	-	-
11.	*Aspergillus* sp.	-	+	+	+	-	-	-	-	-	-
12.	*Aspergillus flavus*	-	-	-	+	-	+	-	-	+	+
13.	*Penicillium* sp.	+	+	+	-	+	-	-	+	-	+
14.	*Fusarium oxysporum*	-	+	-	-	-	+	-	-	-	-
15.	*Trichoderma virens*	-	+	-	-	-	+	-	+	-	-

Aspergillus. Other fungi belonging to the genera *Penicillium, Trichoderma, Acremonium, Fusarium* were also observed in the mangrove sediments which may be due to the presence of different nutrients in the sediments (Table 1).

Mangrove ecosystem environmental parameters affecting the community of soil fungi have been studied over many years (Holguin *et al*., 1999). Microbial activity is responsible for major nutrient transformations within a mangrove ecosystem (Alongi *et al.*, 1993; Holguin *et al.,* 1999). 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 pH and salinity. Despite inherent limitations, viable count of fungal population in our study as it would reflect relatively abundant and functionally dominant microbial communities (Nannipieri *et al.,* 2003, Das and Dangar, 2008). 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 (Alongi *et al.,* 1993; Boto *et al.*, 1989). Microbial diversity comprises a wide range of microbes than any other living group of organisms of the world. Average fungal population in mangrove sediments was maximum at Nentai of Devi mangrove sediments i.e. $8.56\pm0.48x10^5$ cfu/g soils (Das and Dangar, 2008). However, Gonzalez-Acosta *et al*. (2006) have recorded more microbes (10^9- 10^{11}cfu/ml water) in a Mexican mangrove forest. Out of microbial populations fungal diversity 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.

4. Conclusion

A range of fungi occur frequently in the mangrove ecosystem, although these differ as to their location. Some fungi certainly occur more frequently than others. Many factors will have an effect on species/frequency of occurrence either individually or synergistically. This could be attributable to the geographical proximity and similar climatic factors prevailing in both the delta systems. However, minor differences could be due to subtle local environmental factors. However this study is a preliminary study of fungal diversity in Mahanadi and its adjoining areas of Odisha. Correlation study showed that microbial diversity is strongly related to organic carbon. The most dominant fungi belong to the genus *Aspergillus*. It requires further study to establish relation between microbes and plants which is very much essential for conservation point of view as well as to protect the coastal areas against cyclones, storm and also tsunami.

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