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Bacterial and Fungal Microorganisms Diversity of Machilipatnam Coast (India)

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ABSTRACT

The present study on the Microorganisms Diversity of Machilipatnam Coast in the mangrove region leads to findings of several species of Bacteria and Fungi belonging to various genera. These microorganisms are taxonomically diverse and genetically special. Mangroves are an important part of the coasts acting as an intermediary zone between land and water. In the present study Field Collection trips were undertaken at Station I (Pedapatnam) and Station II (Polatitippa) for a period of one year spanning between January 2017 and January 2018. Sediment Sampling was done at regular intervals. Water samples were collected from the stations just below the surface, Sediment samples were analysed for concentration of organic matter, Nitrogen, Phosphorous, Potassium, Zinc, Copper, Iron and Manganese. This helped in determining the ecological factors for the growth of microorganisms. Mangroves are rich in bacterial flora. The bacterial population is huge and greater than Fungi. In the marine environment 90% of the bacteria are Gram negative as their cell wall is better adapted for survival. The open sea is a fungal desert where yeast or lower Fungi are attached to planktonic organisms or pelagic animals. The higher marine Fungi occur as parasites on plants and animals or as symbionts in marine lichens and algae. Samples were collected using Grabs, the central portion of the sediment sub samples were collected aseptically by alcohol rinsed polyvinyl core with 3 cm diameter. The top fraction of the sediment samples were used for analysis.

Keywords: Mangroves, Bacteria, Fungi, Diversity

INTRODUCTION

Among the Asian countries, India is perhaps the only country that has a long record of inventories of coastal and marine biodiversity dating back to at least two centuries. (Mora *et al.*,2011) predicted the presence of about 64000 fungal taxa, 36400 protists and 9680 bacteria on earth which includes the oceans. Until recently the role played by the microorganisms in the control of microbial biodiversity has been largely ignored in literature (Mihaljevic,2012: Saleem,2015 : Li *et al*.,2016). Marine microorganisms are found in several environments such as hydrothermal vents, hot springs, salty lakes and deep sea floors (Dalmaso *et al*., 2015). Starting from the discovery of deep sea hydrothermal vents up to the study of marine biodiversity, new microorganisms have been isolated from marine environments. Thermophiles, Halophiles, Alkalophiles, Psychrophiles and Polyextremophile microorganisms have been isolated from these marine environments (Poli *et al*.,2017).

The marine environment is an enormous reservoir of novel sources of biologically active metabolites, many of which display unique structural skeletons that can be used in the development of new drugs (Deshmukh *et al*., 2018 : Blunt *et al*., 2018). Mangroves in India are found along the coastline of 9 states and 4 union territories (Ragavan and Mandal 2018). Apart from this, they also often provide various niches for diversified flora and fauna including microbes such as Bacteria, Fungi, Actinobacteria and Microalgae. Advances in molecular techniques and ecological genomics have greatly improved our understanding of the processes mediated by bacteria in the marine environments including marine sediments, oligotrophic open sea, coastal temperature (Treusch *et al*., 2009). Communities found in surface and maximum oxygen samples are dominated by heterotrophic bacteria likely consuming the phytoplankton derived organic matter. Gamma proteobacteria are known to play an important ecological role in the degradation of organic carbon by producing extra cellular hydrolytic enzymes such as amylases, proteases, lipases and DNAases (Dang *et al*., 2009) although some oceanospirillales have also shown to possess genes for carbon fixation (Calvin cycle) and they have the potential to grow as chemo autotrophs (Swan *et al*., 2011). Kiranmai and Anima (2017) isolated bacteria from the marine waters of Visakapatnam coastal area in relation to degradation of oil and grease. In recent years Coliform bacteria have been used as indicator microorganisms to determine the quality of surface waters. Their distribution can also change depending on environmental parameters (Lindstorm *et al*., 2005). *Streptomyces* were the major isolates in Most of the marine samples collected in the south east coastal region of India (Sahu *et al*., 2006). Investigations on the subsea floor environments have shown that different properties separated by a few tens of kilometres also have distinct communities (Inagaki *et al*., 2006 : Hewson *et al*.,2007 : Schauer *et al*.,2010).

Bacterial communities can be found living freely in mangrove sediments (Roy *et al*., 2002:Dias *et al*., 2009, 2010) or as endophytes associated with the natural flora (Garcias-Bonet *et al*.,2012: Janarthine et al.,2010; Liu *et al*.,2010; Feng *et al*.,2009).(SriRamkumar et al., 2011) studied variations in heterotrophic bacteria and phosphate solubilising bacteria from Karangadu and Devipattinam coast of Palk Strait. Fungi are eukaryotic, spore producing, achlorophyllous, heterotrophic organisms with absorptive nutrition, reproducing both sexually and asexually and whose filamentous branched somatic structure known as 'hyphae' typically surrounded by cell wall. Marine derived fungi exhibit morphological characteristics similar to their terrestrial counterparts (Mejanelle *et al*., 2000). (Hyde *et al*., 2000) reported 444 species of marine fungi. Fungi such as *Pestalotiopsis* and *Cladosporium* have been often recovered from mangrove leaves (Raghukumar *et al*., 2004). The diversity and abundance of fungal microbes in marine environments has been studied.(Kis and Papo ,2005) reported 467 marine species of fungi from 244 genera. Temperature, salinity, dissolved oxygen levels and the availability and diversity of substrates are factors which may also influence fungal composition in a given environment. Culture/morphology – based analyses have recovered fungi from marine samples (Damare and Raghukumar ,2008: Burgaud *et al*., 2009).

Cultivation-dependent and molecular studies demonstrate that marine macro organisms such as sponges and algae are a rich source for fungi (Debbab *et al*., 2010). Marine fungi have a broad diversity in terms of species richness, phylogenetic distribution and their natural products (Marlis and Antje., 2017). Molecular techniques are being emphasised to investigate microbial diversity from marine environments (Miloslavich *et al*.,2010: Singh *et al*.,2012).Marine fungi are known to play an important role as primary degraders in coastal waters (Massana and Logares 2013). Aspergillus and Penicillium represent the best studied fungal genera as depicted in marine contexts (Nicoletti and Andolfi,2018). Many of the fungi collection practices are proven techniques used by mycologists for the isolation of a broad diversity of fungi, while others, such as the construction of marine baiting stations and the collection and processing of sea foam using dilution to extinction plating techniques are methodological adaptations for specialized use in marine / aquatic environments (Overy *et al*., 2019).

True marine fungi are defined on the basis of their ability to grow and sporulate exclusively in sea water, whereas facultative marine fungi are forms from land, which are capable of growing in sea water (Kohlmeyer and Kohlmeyer, 1979). Fungal diversity in the marine ecosystem is important to study the fungal evolutionary history as early fungal divergence is known to have taken place in the marine realm (Calvez *et al*.,2009). Marine derived fungi exhibit morphological characteristics similar to their terrestrial counterparts (Mejanelle *et al*., 2000). (Hyde and Ponting, 2000) reported 444 species of marine fungi. Information on the isolation of marine derived fungi is given by (Nakagiri ,2012). Enrichment methods were applied by (Mohan *et al*., 2012) for the isolation of marine Actinobacteria. (Monem *et al*.,2013) : Sette and Santos ,2013) mention the use of specific nutrients or compounds with particular toxicity levels for the selection of slow growing fungi. Marine fungi are known to play an important role as primary degraders in coastal waters (Massana and Logares, 2013). Fungi are an important consumer of plant and animal residues as well as chemical pollutions of the marine environments (Haas *et al*.,2011; Richards *et al*.,2012). Mangrove swamps are considered an important niche repository for fungi (Nambiar and Raveendran, 2008) which play an important role in the organic matter decomposition process present in the ecosystem (Jones *et al*., 2009). Current estimates of global marine species suggest up to 5.1 million (Hawksworth and Colwell, 2012) but only 100,000 are described (Kirk *et al*., 2008). Fungal diversity in the marine ecosystem is important to study the fungal evolutionary history as early fungal divergence is known to have taken place in the marine realm (Calvez *et al*.,2009).

MATERIALS AND METHODS

Sediment samples were collected employing a well-rinsed and air-dried Peterson grab. The central portion of sediment samples for bacteriological analyses were transferred aseptically employing an alcohol dipped and flamed metal spatula into unused polythene bags. The upper layer of sediment samples for estimation of physical and chemical parameters were transferred employing a scoop into unused polythene bags. Approximately 40-50 gm. of sediment sample was aseptically weighed and transferred into a sterilized 1000 ml beaker. An appropriate volume of sterile 50% aged seawater was added so as to yield a 1:10 dilutions and the sediment-seawater mixture was agitated employing magnetic stirrer. The mouth of the beaker was covered with aluminium foil to prevent air-borne contamination during the mixing process.

Isolation of total aerobic heterotrophic bacterial load in the samples was done by 10-fold serial dilution technique followed by spread plating. Diluents were prepared with sterilized phosphate buffer having pH 7.2 to avoid osmotic shock to the bacteria. From each dilution tube, 100 µl of samples were used for spread plating on pre sterilised Zobell Marine Agar (ZMA) (E 4123, Hi-media, Mumbai) plates. Three replicates of each dilution were used for spread plating to minimize the error. All the plates were incubated at 30 ±2 °C for 24-48 hrs. Plate shaving viable colony count (30-300 colonies per plate) were selected for the enumeration of bacteria from the sediment samples. Selected bacterial colonies showing different morphological features were picked up from the ZMA plates and were re streaked several times on pre sterilized ZMA plates to obtain pure culture of the isolates. The pure cultures of the isolates were preserved by sub culturing on ZMA slants at 4°C for future use.

The isolated bacterial strains from the coastal waters of Machilipatnam were identified by following various morphological and biochemical methods. Identification was done on the basis of their colony characteristics on different media, Gram's reaction, and biochemical tests, various sugar utilization tests, halophilic nature, pH tolerance capacity, growth at different temperatures and enzymatic activities shown by the isolates. All the bacterial isolates were subjected to various biochemical tests for their identification (Oliver and Smith, 1982: Hansen and Sorheim, 1991: Holt *et al*., 1994).

For the Fungal isolation: From the samples collected using the grab, the central portion of the sediment sub samples were collected aseptically by alcohol rinsed polyvinyl core with 3 cm diameter. Then the collected sediment was cut into 3 sections of 0-3 cm (surface), 3-6 cm (middle) and 6-9 cm (bottom). The 0-3 cm (top) fraction of the sediment samples alone were used for fungal population analysis. One gram of the sediment was serially diluted in sterile sea water (10^{-3} -10^{-6}).

From the dilutions 0.1 ml was transferred aseptically into the 50% sea water corn meal agar medium (corn meal powder 20 g, dextrose 20 g, peptone 20 g, agar 20 g and 50% sea water 1000 ml) and incubated at room temperature (28 ± 2°C) for 5 days. The plates were observed for the development of fungi from third day onwards. The number of colonies in each plate was counted. Growing edge of each colony was isolated and sub cultured in 50% sea water corn meal agar medium.

Semi-permanent slides of all the fungi encountered were prepared using lacto phenol cotton blue mount from the growing edge of the colonies and sealed with DPX mountant. The fungal species were photographed using Nikon photomicroscope (Japan). The identification of fungal taxa was made based on Hyphomycetes (Subramaniyan, 1971); Dematiceous and More Dematiceous; Hyphomycetes (Ellis, 1971) and Marine Mycology (Kohlmeyer and Kohlmeyer, 1979).

RESULTS AND DISCUSSION

In the present study, the environmental (physical and chemical) characteristics and assessment, the quantification of total heterotrophic bacteria (THB) in the sediment samples of two different marine locations, Pedapatnam (sea shore ecosystem) and Polatitippa (mangrove ecosystem) of the Machilipatnam coast were made. The total bacterial population densities in the two samples are given in Table-1. In order to understand the distribution of heterotrophic bacteria at two collection sites, the bacteria were isolated and identified from the sediment samples. The distribution of bacteria as per Gram reaction indicates the dominance of Gram-negative bacteria. Of the total isolates, 70% was found to be of Gram-negative and the remaining 30% belonged to Gram-positive (Table-2).Totally 13 species of bacteria belonging to 12 genera viz. *Bacillus*, *Corynebacterium*, *Enterobacter, Escherichia, Flavobacterium*, *Klebsiella*, *Micrococcus, Pseudomonas*, *Salmonella, Shigella*, *Streptococcus* and *Vibrio* were recorded from both stations. These genera were falling under 8 families belonging to 6 orders such as Actinomycetales, Bacillales, Enterobacteriales, Lactobacillales, Pseudomonadales and Vibrionales. Among the genera and species identified, 10 species were common to both stations ; species of *Corynebacterium, Flavobacterium* and *Micrococcus* were recorded only at station II.

The Pearson correlation studies revealed that the bacterial population at station I showed a significant positive correlation at 0.01 level ($P>0.01$) for atmospheric temperature, surface water temperature, pH, salinity and electric conductivity while the organic matter registered a significant positive correlation at 0.05 level ($P>0.05$). On the other hand, nutrients such as zinc, iron and manganese showed a significant negative correlation at 0.01 level ($P>0.01$) where as nitrogen and potassium recorded a significant negative correlation at 0.05level ($P>0.05$). The negative correlation recorded for rainfall, dissolved oxygen, copper and phosphorus did not show any statistical significance in the present study .

Table 1. Bacterial population isolated from marine (station I) and mangrove (station II) zones of Machilipatnam coast during January 2017 - January 2018

S. No	Month	Population density (CFU/gm) (Station I)	Population density (CFU/gm) (Station II)
1	January 2017	141×10^4	121×10^4
2	February 2017	142×10^4	122×10^4
3	March 2017	138×10^4	121×10^4
4	April 2017	139×10^4	82×10^4
5	May 2017	132×10^4	85×10^4
6	June 2017	127×10^4	94×10^4
7	July 2017	125×10^4	139×10^4
8	August 2017	131×10^4	135×10^4
9	September 2017	134×10^4	138×10^4
10	October 2017	162×10^4	142×10^4
11	November 2017	176×10^4	158×10^4
12	December 2017	178×10^4	162×10^4

Table 2. Cultural and biochemical characteristics of bacterial species isolated from sediment samples at station I & II

S. No	Name of the bacteria	Shape	Size	Gram Reaction	Motility	Optimum Temp.	Indole	MR	VP	Citrate	Urea Hydrolysis	Catalase	Oxidase	H2S
1	*Bacillus* sp.	Rod	0.5-2.5 1.2-10µm	+	Motile	37°C	-	-	+	+	-	+	-	-
2	*Corynebacterium* sp.	Straightor Slightly curved	0.3-0.8× 1.5-8.0 µm	+	Non motile	35-37°C	-	+	-	+	-	+	-	-
3	*Enterobacter aerogens*	Straight rod	0.6-1.0× 1.2-3.0µm	-	Motile	30-37°C	-	-	+	+	-	+	-	-
4	*Escherichia coli*	Straight rod	1.1-1.5× 2.0-6.0µm	-	Non motile	37°C	+	+	-	-	+	+	-	-
5	*Flavobacterium* sp.	Rod	0.5 × 1.0-3.0µm	-	Non motile	37°C	+	-	-	-	-	+	+	-
6	*Klebsiella pneumoniae*	Straight rod	0.3-1.0× 0.6-6.0µm	-	Non motile	37°C	-	-	+	+	+	+	-	-
7	*Micrococcus* sp.	Cocci	0.5 × 3.5µm	+	Non motile	25-37°C	-	+	-	+	-	+	-	-
8	*Pseudomonas aeruginosa*	Straightor Slightly curved	0.5-1.0× 1.5-5.0 µm	-	Motile	41°C	-	-	-	+`	-	+	+	-
9	*Salmonella* sp.	Straight Rod	0.7-1.5× 2-5 µm	-	Motile	37°C	-	+	-	+	-	+	-	+
10	*Shigella dysenteriae*	Straight rod	0.5-1.4× 2-4.5µm	-	Non motile	37°C	+	+	-	-	-	+	-	-
11	*Streptococcus faecalis*	Cocci	0.6-2.0× 0.6-2.5 µm	+	Non motile	10-42°C	-	+	-	-	-	-	-	-
12	*Vibrio cholerae*	Straight or curved rod	0.5-0.8× 1.4-2.6 µm	-	Motile	30°C	+	+	-	+`	-	+	+	-
13	*V. parahaemolyticus*	Curved rod	0.5-0.8 × 1.2-2.6 µm	-	Motile	37°C	+	+	-	-	-	+	+	-

Table 3. Fungal population isolated from marine (station I) and mangrove (station II) zones of Machilipatnam coast during January 2017 - January 2018

S.No	Month	Population density(CFU/gm) (Station I)	Population density(CFU/gm) (Station II)
1	January 2017	20×10^3	$23\ 10^3$
2	February 2017	18×10^3	21×10^3
3	March 2017	17×10^3	19×10^3
4	April 2017	16×10^3	13×10^3
5	May 2017	13×10^3	14×10^3
6	June 2017	11×10^3	11×10^3
7	July 2017	14×10^3	19×10^3
8	August 2017	13×10^3	18×10^3
9	September 2017	16×10^3	21×10^3
10	October 2017	23×10^3	23×10^3
11	November 2017	23×10^3	25×10^3
12	December 2017	21×10^3	30×10^3

At station II, the total bacterial population is positively correlated with atmospheric temperature showed statistical significant at 0.05 level (P>0.05), pH and salinity at 0.01 level (P>0.01) while the organic matter and nutrients such as zinc, iron and manganese registered a significant negative correlation at 0.05 level (P>0.05). The remaining nutrients including nitrogen, potassium, copper, iron and phosphorus showed a significant negative correlation at 0.01 level (P>0.01). On the other hand, positively correlated surface water temperature and electric conductivity and negatively correlated rainfall and dissolved oxygen did not show any statistical significance in the present investigation.

The sediment samples obtained from two different stations were investigated to determine the Mycofloral diversity in the Machilipatnam coast. Fungal population density and the species composition were determined and recorded for two stations individually. The present study reveals that there was alternate increase and decrease in fungal diversity during different seasons at two different stations in the year of January 2017 to January 2018. The maximum population density was recorded during June 2017 in the station at Pedapatnam and minimum during December2017 in the station at Polatitippa (Table-3).
From the two stations totally 29 species belonging to 10 genera of fungi were recorded. The higher diversity 20 species at station I and 22 species at station II was recorded during post-monsoon in January 2018 (Table-4).

A qualitative study of the mycoflora of the Pedapatnam station revealed a total of 22 species assignable to 8 genera were recorded. Among the total isolates, 6 genera / 20 species belonged to Deuteromycetes and 2 genera / 2 species belonged to Phycomycetes. The Ascomycetes were not recorded in this station.

The fungal diversity at the station Polatitippa revealed a total of 28species belonged to 9 genera. Among the total species, 6 genera /20 species belonged to Deuteromycetes, 1 genus/1 species belonged to Phycomycetes and 2 genera / 2 species belonged to Ascomycetes. The genus *Aspergillus* was found to be dominant; it was represented with 8 species at station I and 10 species at station II.

Among the fungal genera isolated, *Aspergillus* was found to be dominant with 10 species followed by *Fusarium* and *Penicillium* with 4 species, *Curvularia*with 3, *Trichoderma* with 3 and the remaining genera such as *Chaetomium*, *Mucor*, *Rhizopus* and *Thielavia* with single species each. Of the species isolated *Aspergillus niger, Aspergillus candidus, Aspergillsu flavus and Aspergillus terreus* were recorded during all the seasons in both stations from January 2017 to January 2018.

Table 4. Fungal species recorded in the sediment samples of station I & II collected during January 2017- January 2018

S.No	Name of the Fungi	Station – I				Station –II			
		Pre monsoon	Monsoon	Post monsoon	Summer	Pre-monsoon	Monsoon	Post-monsoon	Summer
1	**Deuteromycetes** Aspergillus candidus	+	+	+	+	+	+	+	+
2	A. clavatus	-	-	+	+	-	-	+	-
3	A. flavus	+	+	+	+	+	+	+	+
4	A. fumigates	+	-	+	+	+	+	+	+
5	A. gigantus	-	+	-	+	+	-	-	+
6	A. niger	+	+	+	+	+	+	+	+
7	A. terreus	+	+	+	+	+	+	+	+
8	A. unguis	-	-	-	-	-	+	+	+
9	A. ustus	-	-	-	-	-	-	+	-
10	A. versicolor	+	+	+	+	-	+	-	+
11	Alternaria alternate	-	+	+	+	-	-	+	-
12	Curvularia pallescens	+	-	+	+	-	-	+	+
13	C. tuberculata	+	+	+	-	-	-	+	-
14	Curvularia sp.	-	+	+	+	+	+	+	+
15	Fusarium oxysporum	+	+	+	+	+	-	+	+
16	F. semitectum	-	-	-	-	+	-	+	+
17	F. solani	-	-	-	-	-	-	+	+
18	Fusarium sp.	+	+	+	+	+	-	+	+
19	Penicillium citrinum	+	+	+	+	-	+	+	-
20	P. funiculosum	+	+	+	-	+	-	+	+
21	P. javanicum	+	+	+	+	+	-	+	+
22	Penicillium sp.	+	+	+	+	+	+	-	+
23	Trichoderma harzianum	+	+	+	+	+	-	-	-
24	T. koningi	-	+	+	+	+	-	-	+
25	T. viride	-	-	-	-	+	+	+	-
26	**Phycomycetes** Mucor sp.	+	+	+	-	-	-	-	-
27	Rhizopus sp.	+	+	-	+	+	+	+	-
28	**Ascomycetes** Chaetomium globosum	-	-	-	-	-	-	+	-
29	Thielavia terricola	-	-	-	-	+	-	-	+
	Total	17	19	20	19	18	12	22	19

+Species present, -Species

The Pearson correlation studies revealed that the fungal population at station I showed a significant positive correlation at 0.01 level (P>0.01) for atmospheric temperature, surface water temperature, pH, salinity, electric conductivity and organic matter. On the other hand, nutrients such as nitrogen, zinc, iron and manganese showed a significant negative correlation at 0.01 level (P>0.01) whereas potassium, copper and phosphorus recorded a significant negative correlation at 0.05 level (P>0.05). The negative correlation recorded for rainfall and dissolved oxygen did show any statistical significance in the present study.

At station II, the total fungal population is positively correlated with atmospheric Temperature, surface water temperature, pH, salinity and electric conductivity showed statistical significant at 0.01 level (P>0.01) while the copper, manganese and phosphorus registered a significant negative correlation at 0.05level (P>0.05). The remaining parameters including organic matter, nitrogen, potassium, zinc and iron showed a significant negative correlation at 0.01 level (P>0.01). On the other hand, negatively correlated rainfall and dissolved oxygen did not show any statistical significance.

DISCUSSION

Contemporary selection refers to the ability of a given microbial species to thrive in a set of local environmental and biological conditions (Lima-Mendez, 2015). Hydrographic features play an important role in controlling the microbial community structure at the regional level (Baltar and Aristegui, 2016 : Morales *et al*., 2017 : Venkatachalam *et al*., 2017). Free living and particle associated bacterial communities have been analysed in shrimp farms attached to marine waters (Hou et al., 2017). In the present study, the bacterial populations were also high at station I which received heavy load of prawn farm effluent.

The intensive growth of the bacteria in the coast may be due to relatively high organic carbon and nutrient concentration caused by river inputs and discharge of waste. Statistical analysis also revealed a significant positive correlation with nutrients and there was no significance with other physicochemical features. Likewise, total heterotrophic bacterial population density was high at station I and II during summer. A large amount of organic matter is available for bacterial decomposition and utilization during summer plankton blooms. Heterotrophic bacteria play an important role as decomposers of particulate organic matter and regenerate the primary nutrients by utilizing various organic compounds produced by the phytoplankton. In the present study, in general, high densities of total heterotrophic bacterial population coincided with high value of particulate organic carbon (POC). This suggests that bacterial degradation of particulate organic matter leads to mineralization whereby the nutrients are made available to primary producers. This is in agreement with views of (Adeyemo *et al*., 2008 and Kamaruzzaman *et al*., 2009).

The organic carbon content in marine sediments is a key component in a number of chemical, physical and biological processes and contributes significantly to acidity through the formation of organic acids. The highest value of organic matter was recorded in post monsoon season as natural processes and human activities have resulted in elevated content of organic carbon. Further, land drainage and discharge of industrial effluents may enrich the near shore waters with particulate matters which in turn increase the bacterial production. The study revealed that the physical and chemical factors viz., temperature, pH, salinity and Electric conductivity were positively correlated with bacterial population and nutrients such as nitrogen, potassium, zinc, copper, iron, manganese and phosphorus registered a negative correlation .The above study gives an insight into the types of marine bacteria present in the coastal waters as well as their potential use as a biotechnological tool for the production of enzymes and other bioactive substances.

In the present investigation, initially a survey was conducted to find out the fungal community that are harbouring the soils along the Machilipatnam coast. Species composition of Machilipatnam coast soil Mycoflora revealed the presence of 29 species belonged to 10 genera. Among them, 25 species belonged to Deuteromycetes, 2 belonged to Phycomycetes and 2 belonged to Ascomycetes.

Fungi play an important role in the biogeochemical cycle and also produce active metabolites which in turn suppress other organisms. Lack of luxuriant shoreline vegetation and continual surface run off of the inland waters and subsequent soil leachates may be the possible reason which influenced the occurrence of common terrestrial fungi in the coastal marine system in contrast to true-marine forms. Aspergillus is ubiquitous in marine environment (Koh *et al*., 2000). Its high salt tolerance and wide range of substrata makes it a logical candidate to adapt to life in sea, also isolated from marine substrata including sponges (Holler *et al*., 2000). Diversity, frequency of occurrence, substrate preference, seasonal and vertical; distribution of fungi were made by (Sarma and Vittal,2001) and (Sarma et al., 2002) from Godavari and Krishna deltaic mangroves in Andhra Pradesh state along the east coast of India.

Biodiversity and ecological observations on manglicolous fungi from west coast of India have been reported by (Maria and Sridhar,2003).Vast diversity of novel environmental phylotypes was also found through molecular investigations of marine oxygen depleted environments and a few oxygen depleted fresh water environments (Sabet *et al*., 2009).

Coastal regions are charecterized by eutrophication from terrestrial run-off and high primary production (Danovano and Pusceddu, 2007). Majority of the fungi obtained from deep sea habitats belonged to Ascomycota, Basidiomycota with large representations from Yeasts belonging to both phyla (Bass *et al*., 2007: Lai et al., 2007). Species counts in the deep sea sediments are very low in comparison with coastal sediments and majority of the culturable fungi isolated are from the common terrestrial forms (Damare *et al*., 2008).

Certain species of fungi can thrive even in the harshest habitats (Sole *et al*.2008). Measures of species diversity and fungal biomass can be useful ecosystem indicators for reflecting the ecological health of a given habitat (Gonzalez and Hanbie, 2010). Aquatic fungal communities in bio-films can be excellent candidates as bio-indicators of ecosystem disturbance. Among the genera, *Aspergillus*, *Fusarium* and *Penicillium* were the dominant genera. All these fungal species were reported earlier from soils and a variety of substrates in the terrestrial environment. Phyllogenetic studies suggest that many obligatory marine lineages recently transitioned from terrestrial ancestors (Schoch *et al*., 2009) and such transitions to marine habitats have occurred multiple times. A great majority of them were also reported from oceans and estuaries as facultative forms to marine habitats. Similar findings were reported by Gomes *et al*., 2011, who analyzed filamentous fungi from the sediment collected from a mangrove swamp in Pernambuco, Brazil. Though the coastal soils are considered to be the transitional areas between the land and sea, they exhibit the occurrence of only terrestrial species, often describing as facultative fungi based on their ability to grow and reproduce, but not the obligate fungi. Introduction of terrestrial species into the coastal and marine environs is termed as invasion which is facilitated through various sources such as plant litter, other organic materials, erosion and run off from soil.

Higher incidence of fungi during dry season as compared to the rainy season was found and the species *Aspergillus* and *Trichoderma* were both common in both seasons (Gomes *et al*., 2011). Studies have explored the effects of environmental conditions or the physiological state of the non fungal host on fungal communities (Littman *et al*., 2011). The opportunistic strategy of fungal nutrition enables swift responses to changing conditions (Gutierrez *et al*., 2011).

The nature of these interactions remains unclear although in terrestrial systems; extracellular enzyme activities and secondary metabolite production might play significant roles in interaction of fungi with marine hosts (Raghukumar and Ravindran, 2012). Many fungi that are found in sea are also found in terrestrial environments indicating remarkably effective adaptive capabilities. Strong co-relations with gene expression data (Amend *et al*., 2012) suggest that at least some fungi display a truly amphibious ability. Turnover rates of marine fungal biomass are not yet known, however molecular analyses of zooplankton gut contents indicate that fungi can form a substantial proportion of their diet (Hu *et al*.,2015). At both stations *Aspergillus* was the genus constituted by more number of species followed by *Fusarium* and *Penicillium*. The genus *Aspergillus* was constituted with 8 species at station I and 10 at station II. As in the present study the trend of species composition with bulk number of *Aspergillus species* were reported from mangrove sediments along the south east coast of Tamil Nadu (Prince and Samuel, 2015).

The physical and chemical factors such as pH, temperature, DO, BOD and salinity of all water samples had not influenced any significant changes in the occurrence of fungi. The study revealed that all the physical and chemical parameters viz., temperature, pH, salinity and EC positively correlated with fungal population and nutrients such as nitrogen, potassium, zinc, copper, iron, manganese and phosphorous registered a negative correlation.

All the fungi isolated in the present study, were ubiquitous soil saprophytes and their diversity exhibited fluctuations during different seasons. But there was no regular seasonal pattern noticed in their diversity at both the stations.

In this aspect the present study by yielding 29 species indicates that the fungal diversity in the coastal environs vary greatly. This was in agreement to the fungi found common in Godavari, Krishna and Pichavaram mangroves (Vittal and Sarma., 2006). Further (Damare *et al*., 2006 reported the presence of Aspergillus, Penicillium, Cladosporium and Fusarium from the deep sea sediments. In the present investigation Aspergillus contributed maximum percentage. The dominance of Aspergillus in any kind of coastal or marine soils was reported along the coastal area of Tuticorin (Thennarasu *et al*., 2011: Ashok et al., 2015). 10 fungal species of *Aspergillus, Alternaria, Rhizopus* and *Penicillium* were isolated from the mangrove leaves of Pichavaram. In this present study, identification of fungal species supports the previous researchers who have identified the same fungal species from different mangrove habitats of India. Of the fungi isolated Aspergillus in water and Penicillium in sediments were the most commonly observed genera. This is in agreement with the findings of (Sonia *et al*., 2018) on the water and sediments of Araca Bay in Sao Sebastia, Sao Paulo, Brazil.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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