



## International Journal of Advance Studies and Growth Evaluation

# Exploring Mangrove-Associated Fungal Diversity through a Taxonomic Expedition in Raigad District, Maharashtra

\*<sup>1</sup> Minal Anil Patil

\*<sup>1</sup> Assistant Professor, Department of Botany, J.S.M. College, Alibag, Raigad, Maharashtra, India.  
(Affiliated to the University of Mumbai)

### Article Info.

E-ISSN: 2583-6528

Impact Factor (SJIF): 6.876

Peer Reviewed Journal

Available online:

[www.alladvancejournal.com](http://www.alladvancejournal.com)

Received: 23/ June/2025

Accepted: 28/July/2025

### Abstract

Embarking on a taxonomic exploration within Maharashtra's Raigad District, this research paper illuminates the hidden realm of mangrove-associated fungi along the vibrant west coast of India. The mangrove ecosystem, a haven of coastal and tropical vegetation, is a focal point, particularly in the Goa and Maharashtra regions. While marine fungi have received considerable attention, the emphasis has predominantly veered towards wood-inhabiting species, sidelining the crucial role played by manglicolous marine fungi in the decomposition of litter and living woody species. This research paper endeavours to rectify this imbalance by delving into the mangrove fungi of the Raigad coast, addressing a significant dearth of data. Through meticulous sampling over two consecutive years across creeks, estuaries, and seashores, various plant components and drifted materials were scrutinised. The study, encompassing 1600 collections across six diverse sites, unraveled seventy-one higher marine fungi, showcasing a diverse array of taxonomic groups. Ascomycota claimed dominance with seventy percent, followed by Basidiomycota, Mucoromycotina, Hyphomycetes, and Coelomycetes. A detailed taxonomic classification of observed manglicolous fungi is meticulously presented. Further organisation into lower hierarchical orders revealed a total of fifty-one species, spanning twenty-six families and fifteen genera. Notably, *Aspergillus* and *Halosarpheia* emerged as key players in this intricate fungal diversity. This research not only contributes significantly to marine fungi knowledge on the west coast of India, specifically in the Raigad district, but also aligns observed species with those reported from different parts of the Indian subcontinent. The identification of potential new records calls for further taxonomic scrutiny, perpetuating the ongoing pursuit of precision in fungal taxonomy. A pivotal outcome of this taxonomic expedition is the proposal of a comprehensive identification key. This pioneering effort lays the foundation for future identification and nomenclature endeavors, filling a significant void in the understanding of manglicolous fungi along the Raigad coast. The challenges encountered in taxonomic assignments underscore the imperative for additional precision-enhancing taxonomic work.

**Keywords:** Mangrove-associated fungi, taxonomic exploration, biodiversity, identification key, mangrove ecosystem, raigad district.

### \*Corresponding Author

Minal Anil Patil

Assistant Professor, Department of Botany, J.S.M. College, Alibag, Raigad, Maharashtra, India.

### Introduction

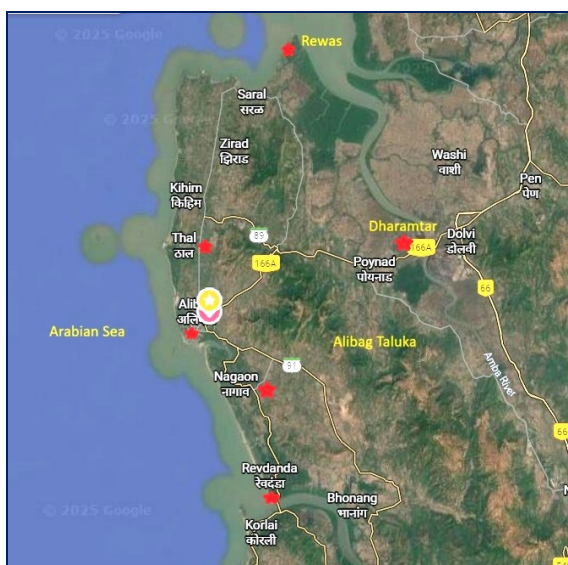
The mangrove ecosystem can be broadly defined as a typical tropical and coastal vegetation which occurs within the intertidal regions of estuaries, river deltas and backwater areas as well as creeks. These habitats are well known for high organic matter production, which supports nearby estuarine and offshore communities by detritus transport. Mangroves possess certain phenotypic and physiological adaptations like prop roots, pneumatophores, knee roots and viviparous germination which facilitate their growth in the tidally

influenced aquatic environment. Various mangrove parts such as dead and damaged stems, prop roots, seedlings as well as leaves which fall on ground are exposed during low tides and get submerged in water during high tides. Hence the dynamic mangrove environment facilitates creation of a unique habitat for a specific group of fungi which adapt to coastal and marine environment dominated by mangroves, called 'manglicolous fungi'. Manglicolous fungi usually grow on dead and decayed leaves, prop roots, stems, pneumatophores; drift wood and seedlings of mangroves. Due to diurnal

fluctuations in the tidal level substrates at low tide level get exposed for short periods and remain submerged for long period. Substrates at high tide level remain exposed for longer periods and submerged for shorter periods. Substrates at very higher level get the occasional splashes of tidal water and remain exposed for very long periods. This unique environment allows growing some specific fungi in varying conditions (Kohlmayer, 1979; Hyde and Jones, 1988). Ascomycetes are well adopted group in higher fungi to intertidal mangroves as compared to Basidiomycetes and Deuteromycetes (Kohlmayer, 1979; Hyde, 1990.) Adaptation of higher marine fungi shows unique morphological features in ascocarp, ascus and ascospores. An attempt was made to explore the diversity of fungal flora associated with mangrove in the coastal region of Raigad district. This was the first attempt to study the diversity of manglicolous fungi from this region. Taxonomical identification of the observed species leads to the preparation of key of such species.



Source: Google maps



★ Locations under study



Rewas creek with lush green mangrove vegetation

Revdanda-Salav creek with *Sonneratia* belt

### Study of Mangrove Plants Species in the Study area

Various types of mangrove plant species were recorded found at the six selected sites.

### Study of Diversity of Marine Fungi

Various fungal species associated with different mangrove plant species were studied with two techniques.

#### A. Direct Examination Method

The various plant parts and drifted substrates were collected

### Material and Methods

**Location of Study:** Raigad district in Maharashtra is along the Arabian sea on West coast of India at 17°51'N; 19°08' to 17°51'E; 73°04' E. District is spread North-East 150km and East-West 24-48 km. with an area of 7148 sq.km. at south of Mumbai and Thane districts. Raigad has a sea coast of 720 km with beaches, creeks and estuaries with low land areas. (Map No.01)

Following sites were selected for the study.

1. Rewas creek (Alibag Taluka; 18° 45'N, 72° 55'E)
2. Dharamtar creek (Alibag Taluka; 18° 40'N& 73° 00'E)
3. Revdanda- Salav creek: (Alibag Taluka; 18° 33'N& 73° 00'E)
4. Akshi-Nagaon creek (Alibag, 18° 35'N, 72° 50'E)
5. Amba river estuary (Tal Roha; 18° 30'N 73° 05'E)-
6. Thal – Nvgaon creek (Tal – Alibag; 18° 35'N 72° 55'E)

and packed in sterile polythene bags and brought in the laboratory. They are directly examined under dissection microscope for the presence of ascocarps, basidiocarps, pycnidia or conidia. Such fruit bodies are transferred with a needle to a microscopic slide, torn apart in a drop of water to expose the spores and carefully squeezed under a cover glass. Identification was made with the help of ascospores, basidiospores or conidia. In some cases, asci and sterile elements of the ascocarps, such as paraphyses and pseudo paraphyses were also observed.

## B. Culture Technique

To study the detail of some of the fungal species and for the identification and confirmation of the species at taxonomic level some of the fungal species are studied by culture techniques. Mangrove plant parts (bark, stem, pneumatophores, flowers, fruits,) were collected and washed thoroughly in sterile sea water and cut into small pieces.

Tissues were plated on antibiotic amended malt extract agar medium. The plates were incubated at  $23 \pm 2^\circ \text{C}$  up to four weeks at 12hr light and dark regime.

Periodically the tissues were screened for the sprouts of mycelia or discrete colonies on the mycelial portions were transferred to fresh antibiotic free malt extract medium and identified based on the colony characterizations, sporulation

and spore morphology using monographs and taxonomic keys. Diagrams are sketched through camera lucida. After several successive plating pure cultures were obtained. Pure culture slants in the test tubes were also prepared to send for the identification.

Samples of driftwood were collected from all six locations of study covering about 100 km. Moderately decomposed, entrapped wet mangroves twigs, branches, fallen leaves fruits flowers seedlings, wood logs of more or less uniform size were randomly collected throughout the year in all four seasons for successive two years. Around 1600 samples of decaying mangrove wood leaf blades, sea grasses, branches, pneumatophores leaves flowers and fruits of mangrove plants were randomly collected.

## Observations

**Table 1:** Occurrence of various mangrove plants species at various locations under study

S. No.	Name of the Mangrove Plant Species	Locations *					
		1	2	3	4	5	6
1.	<i>Acanthus illicifolius</i> L.	✓	✓	✓	✓	✓	✓
2.	<i>Aegiceras corniculatum</i> Blanco.	✓	✓	✓	✓	✓	✓
3.	<i>Aeluropus lagopoides</i>	✓	✓	✓	✓	✓	✓
4.	<i>Avicennia marina</i> (Forsk)Vierh	✓	✓	✓	✓	✓	✓
5.	<i>Avicennia officinalis</i> L.	✓	✓	✓	✓	✓	✓
6.	<i>Bruguiera cylindrica</i> (L)Bl.	✓	✓	✓	✓	✓	--
7.	<i>Ceriops tagal</i> (perr) Rob.	✓	✓	--	--	✓	--
8.	<i>Clerodendron innermii</i>	✓	✓	✓	✓	✓	✓
9.	<i>Derris trifolia</i>	✓	✓	✓	✓	✓	✓
10.	<i>Excoecaria agallocha</i> L.	✓	✓	✓	✓	✓	✓
11.	<i>Ipomoea pes-carpae</i>	✓	✓	✓	--	--	✓
12.	<i>Kandelia candel</i> (L)Druce.	✓	✓	✓	--	--	--
13.	<i>Portulaca olercea</i>	✓	✓	✓	✓	✓	✓
14.	<i>Salvadora persica</i>	✓	✓	✓	✓	✓	✓
15.	<i>Rhizophora apiculata</i> Blum,	--	✓	✓	--	--	--
16.	<i>Sonneratia alba</i> J.Smith in Ress	--	--	✓	✓	--	--
17.	<i>Sonneratia apetala</i> Buch-Ham	✓	--	✓	✓	✓	✓
18.	<i>Cyperus</i> sp.	--	✓	✓	✓	✓	--
Total		15	15	17	14	14	12

\*1. Rewas creek 2. Akshi – Nagaon estuary 3. Revadanda – Salav creek

4. Dharamtar creek 5. Amba river estuary 6. Thal –Nagaon creek.

Total 18 mangrove and associated mangrove species were recorded from the various sites. The dominant plant species in these mangroves includes *Acanthus illicifolius* *Avicennia alba*. *Avicennia marina*, *Avicennia officinalis*, *Bruguiera*

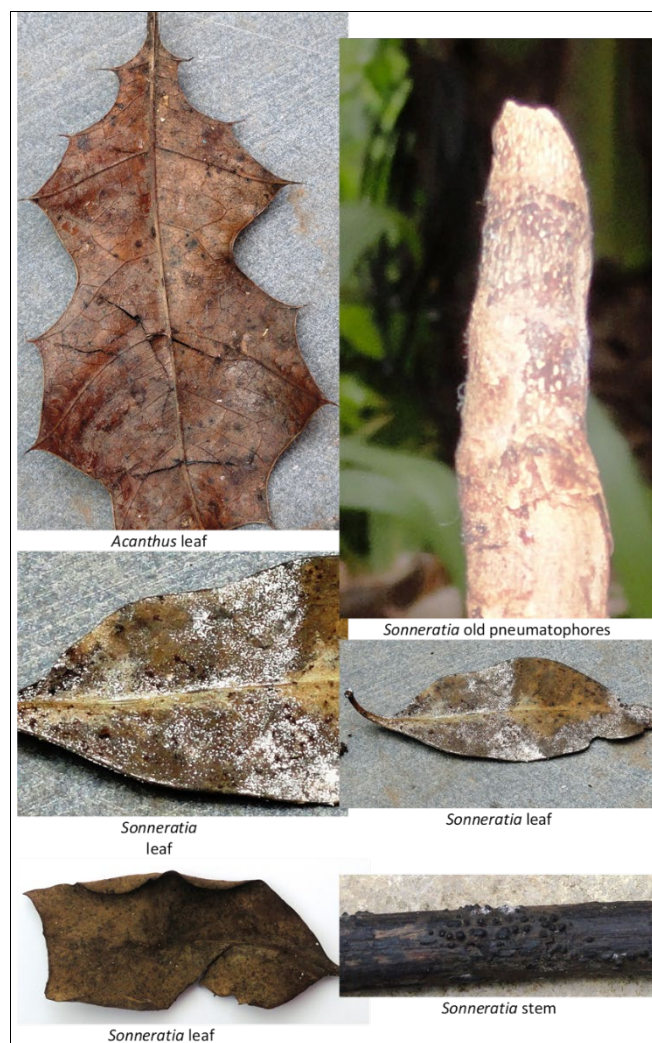
*gymnorhiza*, *Clerodendron* sp, *Cyperus* sp. *Derris trifolium*, *Rhizophora aapiculata*, *Sonneratia alba*, *Sonneritia apetala* etc.

**Table 2:** List of manglicolous fungi observed under the study with taxonomic groups

S. No.	Name of the Fungal Species	Taxonomic Classification
1.	<i>Aigialus grandis</i>	Ascomycota
2.	<i>Aigialus mangrovei</i>	Ascomycota
3.	<i>Aigialus parvus</i>	Ascomycota
4.	<i>Aniptodera chesapeakeensis</i>	Ascomycota
5.	<i>Aniptodera haispora</i>	Ascomycota
6.	<i>Aniptodera mangrovei</i>	Ascomycota
7.	<i>Aniptodera</i> sp.	Ascomycota
8.	<i>Antenospora quadricornuta</i>	Ascomycota
9.	<i>Anthostomella nypensis</i>	Ascomycota
10.	<i>Ascocratera manglicola</i>	Ascomycota
11.	<i>Aspergillus flavus</i>	Ascomycota
12.	<i>Aspergillus niger</i>	Ascomycota
13.	<i>Aspergillus ustus</i>	Ascomycota
14.	<i>Aspergillus versicolor</i>	Ascomycota
15.	<i>Aspergillus wentii</i>	Ascomycota
16.	<i>Caryospora rhizophorae</i>	Ascomycota
17.	<i>Ceriosporopsis cambrensis</i>	Ascomycota
18.	<i>Clavatospora bulbosa</i>	Ascomycota



19.	<i>Corollospora maritima</i>	Ascomycota
20.	<i>Cryptosphaeria mangrovei</i>	Ascomycota
21.	<i>Dactylospora haliotrepha</i>	Ascomycota
22.	<i>Dactylospora</i> sp.	Ascomycota
23.	<i>Eutypa bathurstensis</i>	Ascomycota
24.	<i>Gonytrichum</i> sp.	Ascomycota
25.	<i>Halorosellina oceanica</i>	Ascomycota
26.	<i>Halosarpheia abonis</i>	Ascomycota
27.	<i>Halosarpheia fibrosa</i>	Ascomycota
28.	<i>Halosarpheia marina</i>	Ascomycota
29.	<i>Halosarpheia minuta</i>	Ascomycota
30.	<i>Halosarpheia ratnagiriensis</i>	Ascomycota
31.	<i>Hysterium</i> Sp	Ascomycota
32.	<i>Kallichroma tethys</i>	Ascomycota
33.	<i>Lautospora gigantea</i>	Ascomycota
34.	<i>Leptosphaeria australiensis</i>	Ascomycota
35.	<i>Leptosphaeria</i> sp.	Ascomycota
36.	<i>Lignicola</i> sp.	Ascomycota
37.	<i>Lophiostoma mangrovei</i>	Ascomycota
38.	<i>Lulworthia grandispora</i>	Ascomycota
39.	<i>Lulworthia</i> sp.	Ascomycota
40.	<i>Marinosphaera mangrovei</i>	Ascomycota
41.	<i>Massarina velatospora</i>	Ascomycota
42.	<i>Penicillium chermessinum</i>	Ascomycota
43.	<i>Rhizophilla marina</i>	Ascomycota
44.	<i>Saccardoella mangrovei</i>	Ascomycota
45.	<i>Saccardoella marinospora</i>	Ascomycota
46.	<i>Savoryella lignicola</i>	Ascomycota
47.	<i>Savoryella paucispora</i>	Ascomycota
48.	<i>Tirisporea</i> sp.	Ascomycota
49.	<i>Verruculina enalia</i>	Ascomycota
50.	<i>Zopfiella</i> sp.	Ascomycota
51.	<i>Halocyphina villosa</i>	Basidiomycota
52.	<i>Cunninghamella elegans</i>	Mucoromycotina
53.	<i>Rhizopus stolonifer</i>	Mucoromycotina
54.	<i>Alternaria</i> sp.	Hyphomycetes
55.	<i>Chladosporium chladosporious</i>	Hyphomycetes
56.	<i>Cirrenalia basiminuta</i>	Hyphomycetes
57.	<i>Cirrenalia macrocephala</i>	Hyphomycetes
58.	<i>Cirrenalia tropialis</i>	Hyphomycetes
59.	<i>Curvularia lunata</i>	Hyphomycetes
60.	<i>Fusarium oxysporum</i>	Hyphomycetes
61.	<i>Monodictys pelagica</i>	Hyphomycetes
62.	<i>Periconia prolifica</i>	Hyphomycetes
63.	<i>Trichocladium achrasporum</i>	Hyphomycetes
64.	<i>Trichocladium alopallonellum</i>	Hyphomycetes
65.	<i>Trichoderma harzianum</i>	Hyphomycetes
66.	<i>Trichoderma</i> sp.	Hyphomycetes
67.	<i>Trimmatostroma</i> sp.	Hyphomycetes
68.	<i>Zalerion maritimum</i>	Hyphomycetes
69.	<i>Zalerion varium</i>	Hyphomycetes
70.	<i>Phoma</i> sp.	Coelomycetes
71.	<i>Phomopsis</i> sp	Coelomycetes



Drifted Plant parts showing the fungal growth

## Results

Taxonomic consideration of mangrove fungi in mangrove ecosystems of Raigad district: Fungi are divided into two main divisions-Myxomycota and Eumycota according to the scheme of Ainsworth's classification (1973). Eumycota has been divided into five subdivisions containing both lower and higher marine fungi. They are: Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. These have further been classified into classes' genera and species.

Seventy one species of higher marine fungi were collected and identified during the present studies on fungi associated with mangrove ecosystems of different habitats of Raigad district in Maharashtra. These species includes fifty species from the group ascomycota, one from the group basidiomycota, two from the group mucoromycotina, sixteen from the group hyphomycetes and two from the group

coelomycetes. Some of the species of the genus *Aniptodera*, *Dactylospora*, *Hysterium*, *Leptosphaeria*, *Lignicola*, *Lulworthia*, *Tirisporea*, *Zopfiella*, *Alternaria*, *Trichoderma*, *Trimmatostroma*, *Phoma* and *Phomopsis* did not match with the described species and therefore described as taxonomic species. Some of these taxonomic species were new records from this area.

An attempt has been made to prepare an artificial key of all the species identified in the study. On the basis of various classifications basic groups of fungi are further grouped into respective lower hierarchical orders. All the identified fungi are placed into five basic groups to the level of phylum, they are-Ascomycota, Basidiomycota, Mucoromycotina, Hyphomycetes and Coelomycetes (Deuteromycota). All the identified fungal species are representing fifty one genera from twenty six families and fifteen genera.

**Table 3:** Taxonomic distribution of fungal species associated with mangrove plants identified during the research with reference to the artificial key.

S. No.	Genus of the Fungal Species	Family	Order
Ascomycota			
1.	Aigialaus	Massariaceae	Pleosporales
2.	Massarina	Massarinaceae	
3.	Lophiostroma	Lophiostromaceae	
4.	Ascocretara		
5.	Verruculina	Didymosphaeriaceae	
6.	Lautospora	Lautosporaceae	
7.	Carvosporella	Melianommataceae	

8.	Leptosphaeria	Leptosphaeriaceae	
9.	Hysterium	Hysteriaceae	Hysteriales
10.	Gonytrichum	Chaetosphaeriaceae	Chaetosphaeriales
11.	Lignicola	Trypetheliaceae	Trypetheliales
12.	Kallichroma	Bionectriaceae	Hypocreales
13.	Aniptodera	Halosphaeriaceae	Microascales
14.	Halosarpheia		
15.	Clavatospora		
16.	Corollospora		
17.	Cerosporopsis		
18.	Antenospora		
19.	Tirispora		
20.	Savoryella		
21.	Antenospora		
22.	Eutypa	Diatrypaceae	Xylariales
23.	Cryptosphaeria		
24.	Anthostomella	Xyllariaceae	
25.	Halorosellina		
26.	Zopfiella	Lasiophaeriaceae	Sordariales
27.	Marinosphaera	Phyllachoraceae	Phyllachorales
28.	Rhizophila		
29.	Saccardoella		
30.	Aspergillus	Trichomataceae	Eurotiales
31.	Penicillium		
32.	Dactylospora	Dactylosporaceae	Lecanorales
33.	Lulworthia	Lulwortiaceae	Lulworthiales
Basidiomycota			
34.	Halocyphina	Niaceae	Agaricales
Zygomycota			
35.	Cunninghamella	Cunninghamellaceae	Mucorales
36.	Rhizopus	Mucoraceae	
37.	Periconia	Phycomycetaceae	
Deutromycota			
38.	Cladosporium	Torulaceae	Hyphomycetales
39.	Cirrenalia		
40.	Alternaria	Helminthosporaceae	
41.	Curvularia		
42.	Zalerion		
43.	Trichoderma		
44.	Fusarium		
45.	Phoma		Coelomycetes
46.	Phomopsis		
47.	Monodictys		
48.	Trichocladium		
49.	Trimmatostroma		

So, taxonomically 49 genera of manglicolous fungi were placed in 25 groups of family level under 16 groups of order level. 05 genera are grouped within a separate group of fungal species without distinct features. Ascomycota has 12 orders with maximum genera and fungal species from Microascales (09) followed by Pleosporales (08). Basidiomycota has only one genus from one family under one order Agaricales. Zygomycota has only one order Mucorales with 03 genera. Deutromycota has also one order with seven genera included in it. Five genera were included under Coelomycetes where Spores were produced in fruiting bodies and conidia were borne in fruit bodies.

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