

Algal Biodiversity Along Southern Coasts of India: A Review

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Abstract

Recent studies of phycological researches have shown that marine algae should be given with the equal consideration like any other groups of plant kingdom, primarily because these groups of plants also play or can also play a great role in human life when used in a sustainable manner. Thereby, finding of algal resources has evolved to be a chief necessity for phycological research. Along with the biodiversity assessment, comparing those survey works that has already undertaken can provide more information regarding with the establishment of new species, vanishing off of existed species, migration or invasion of species etc. Current paper reviews marine algal wealth along southern coasts of India and the comparative analysis of distribution, occurrence and richness of species along the different coastal areas of the southern coast.

Keywords: Phycological; Marine alga; Invasion.

Introduction

India has a coastline of about 7500 km including those of islands of Andaman & Nicobar and Lakshadweep. It harbors unique marine habitats which display a wide variety of marine biological diversity. The variety of coastal ecosystems along the Indian coastline includes estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches and coral

reefs. These marine habitats play very significant role in ecological and economical stability of the country. It has an Exclusive Economic Zone (EEZ) of around 2.5 million sq km and accounts for about 8% of the global biodiversity (Oza, 2005).

Among the various marine organisms, seaweed plays ecologically and economically important role as they exhibit various properties which make them suitable to be used in many economic purposes like

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medicine, food, industry etc. Thereby Phycology or study of algae has become an interested field in botanical researches. It is important to primarily assess the biodiversity and richness of these groups as a preliminary step of phycological researches. Current paper reviews the algal survey works undertaken by various authors along the southern coasts of India, i.e. along the selected coastal areas of Kerala, Tamil Nadu, and Karnataka (Fig. 1).

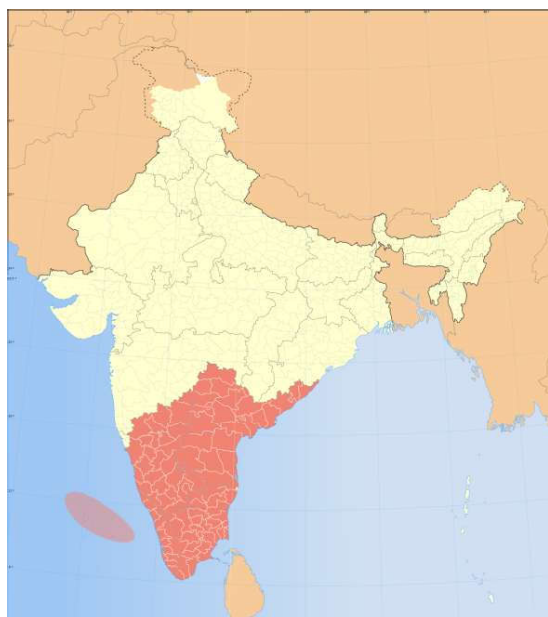


Fig. 1: India map showing southern coasts.

Economically Important Seaweeds of Kerala coast, India: A Review

SK Yadav and Mookkan Palanisamy, 2015 have conducted extensive field surveys along Kerala coast During September 2011 to March 2013 to study the algal wealth of Kerala. Kerala has a coastline of about 580 km, which is extended in 9 districts of the state from Poovar, Thiruvananthapuram district in south to Thalapady, Kasaragod district in north. It is the third largest coast of India after Gujarat with 1600 km (Jha et al., 2009) and Maharashtra with 720 km (Sakhalkar & Mishra, 2014). The coast of Kerala supports a large number of marine flora and fauna, owing to its variety of habitats such as beaches,

back waters, estuaries, cliffs, lagoons, mangroves and coral reefs. Thus it forms an integral part of the marine biodiversity of India.

During the current study entire coast of Kerala was studied. A total of seven field tours were conducted to collect seaweeds in various seasons during the low tides as per Meteorological data. More than 1200 field numbers of seaweeds were collected from a total of 125 localities in Kerala coast. The seaweed samples were collected randomly from the intertidal regions. Collected samples were thoroughly washed in sea water and subsequently in fresh water without damaging the specimens. A set of herbarium specimens were prepared for each field number and the live samples were preserved in 4% formalin. All the collected specimens are deposited at Botanical Survey of India, Madras Herbarium (MH), Coimbatore. The results of present study reveal that a total of 42 economically important seaweeds species found in Kerala coast (Table 1 and Fig. 2). Among these, 29 species are edible for humans, 24 species are suitable for industries to extract the phycocolloids (agar-agar, agaroids, algin, carageenans etc.), 14 species as fodder for domestic animals, 11 species for the production of manures and 7 species are medicinal. The number of species cited above for each usage explicitly indicates that many of them have multipurpose significance. Total of 14 species are used as both food and fodder while 3 species of green seaweeds such as *Enteromorpha compressa*, *Ulva fasciata* and *U. quilonensis* are used as food, fodder and medicine. The class wise representation of enumerated seaweed species indicates the dominance of red algae (Rhodophyceae) with 19 species (45%), followed by green algae (Chlorophyceae) with 14 species (33%) and brown algae (Phaeophyceae) with 9 species (22%).

Table 1: List of the economically important seaweeds of Kerala coast, India

Sl. No.	Name of the taxa	Uses
1.	Class: Chlorophyceae, Family: Ulvaceae <i>Enteromorpha compressa</i> (L.) Nees	Edible, Fodder, Medicinal
2.	<i>Ulva fasciata</i> Delile	Edible, Fodder, Medicinal
3.	<i>Ulva lactuca</i> L.	Edible, Fodder, Medicinal, Manure
4.	<i>Ulva reticulata</i> Forssk.	Edible
5.	<i>Ulva rigida</i> C. Agardh	Edible
6.	<i>Ulva quilonensis</i> Sindhu & Panikkar	Edible, Fodder, Medicinal
7.	Family: Acrosiphoniaceae <i>Acrosiphonia orientalis</i> (J. Agardh) P.C. Silva	Medicinal
8.	Family: Cladophoraceae <i>Cladophora prolifera</i> (Roth) Kutz.	Edible, Fodder

Sl. No.	Name of the taxa	Uses
9.	<i>Cladophora fascicularis</i> (G. Mertens ex C. Agardh) Kutz.	Edible, Fodder
10.	Family: Bryopsidaceae <i>Bryopsis plumosa</i> (Huds.) C. Agardh	Edible, Fodder, Manure
11.	Family: Caulerpaceae <i>Caulerpa peltata</i> J.V. Lamour.	Edible, Fodder, Manure
12.	<i>Caulerpa racemosa</i> (Forssk.) J. Agardh	Edible
13.	<i>Caulerpa sertularioides</i> (S.G. Gmel.) M. Howe	Edible, Fodder, Manure
14.	<i>Caulerpa taxifolia</i> (Vahl) C. Agardh	Edible, Fodder, Manure
15.	Class: Phaeophyceae Family: Dictyotaceae <i>Dictyopteris bartayresiana</i> J.V. Lamour.	Edible, Fodder, Medicinal, Manure
16.	<i>Lobophora variegata</i> (J.V. Lamour.) Womersley ex E.C. Oliveira	Industrial
17.	<i>Padina gymnospora</i> (Kutz.) Sond.	Edible, Fodder, Industrial, Manure
18.	<i>Padina tetrastromatica</i> Hauck	Edible, Fodder, Industrial, Manure
19.	Family: Sargassaceae <i>Sargassum myriocystum</i> J. Agardh	Edible, Manure, Industrial (Algin)
20.	<i>Sargassum tenerrimum</i> J. Agardh	Edible, Manure, Industrial (Agaroid)
21.	<i>Sargassum wightii</i> Grev.	Edible, Fodder, Industrial (Algin)
22.	<i>Turbinaria conoides</i> (J. Agardh) Kutz.	Industrial (Algin)
23.	<i>Turbinaria ornate</i> (Turner) J. Agardh	Edible, Industrial (Agaroid)
24.	Class: Rhodophyceae Family: Bangiaceae <i>Porphyra indica</i> V. Krishnam. & Baluswami	Edible
25.	<i>Porphyra kanyakumariensis</i> V. Krishnam. & Baluswami	Edible
26.	Gelidiaceae <i>Gelidium micropterum</i> Kutz.	Edible, Industrial (Agar)
27.	<i>Gelidium pusillum</i> (Stackhouse) Le Jolis	Industrial (Agar)
28.	<i>Gelidiella acerosa</i> (Forssk.) J. Feldmann & G. Hamel	Industrial (Agar)
29.	Family: Gracilariaceae <i>Gracilaria corticata</i> (J. Agardh) J. Agardh	Industrial (Agar)
30.	<i>Gracilaria corticata</i> (J. Agardh) J. Agardh var.	Industrial (Agar)
31.	<i>Gracilaria edulis</i> (S.G. Gmel.) P.C. Silva	Edible, Industrial (Agar)
32.	<i>Gracilaria foliifera</i> (Forssk.) Borgesen	Industrial
33.	<i>Gracilaria verrucosa</i> (Hudson) Papenf.	Manure, Industrial (Agar)
34.	Family: Bonnemaisoniaceae <i>Asparagopsis taxiformis</i> (Delile) Trevis.	Edible, Industrial (Antifouling agent)
35.	Family: Halymeniaceae <i>Grateloupia filicina</i> (J.V. Lamour.) C. Agardh	Edible, Industrial (Carageenan)
36.	Family: Corallinaceae <i>Corallina elongate</i> J. Ellis & Sol.	Medicinal
37.	<i>Jania adherens</i> J.V. Lamour.	Industrial
38.	Family: Hypneaceae <i>Hypnea musciformis</i> (Wulfen) J.V. Lamour.	Edible, Medicinal, Industrial (Carageenan)
39.	<i>Hypnea valentiae</i> (Turner) Mont.	Edible, Medicinal, Industrial (Carageenan)
40.	Family: Lomantariaceae <i>Gelidiopsis intricata</i> (C. Agardh) Vickers	Industrial
41.	Family: Ceramiaceae <i>Spyridia hypnoides</i> (Bory) Papenf.	Industrial (Agaroid)
42.	Family: Rhodomelaceae <i>Acanthophora spicifera</i> (Vahl) Borgesen	Edible, Industrial (Agaroid)

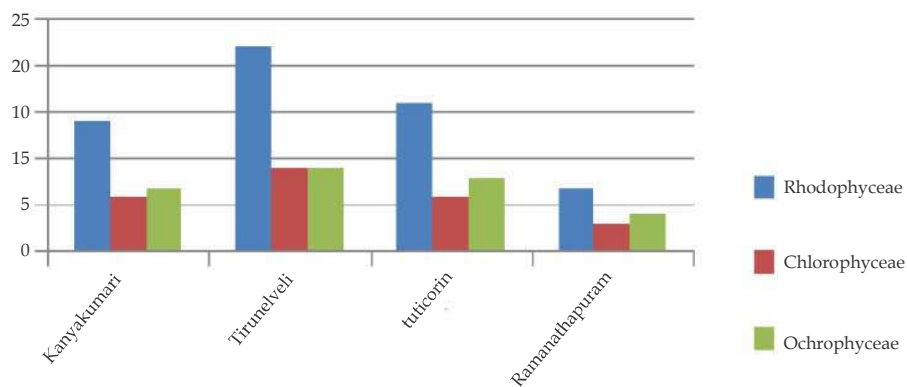


Fig. 2: Various algae reported from Kerala coast.

Distribution and Diversity Assessment of Marine Macroalgae at Four Southern Districts of Tamil Nadu, India

K Sahayaraj et al., have examined occurrence and seasonal distribution of marine macroalgae from four southern districts (Kanyakumari, Tirunelveli,

Tuticorin and Ramanathapuram) of Tamil Nadu. A total of 19 coastal areas have been selected further from these districts for the current study. For each of the specimen collected, different biological indices like Specific species score of localities (SSpL), Specific score of a locality (SSL), Berger-Parker index, Shannon index etc. were



Graph 1: Total number of algal taxa of different classes at various districts.

calculated. Their examination results into a record of species, which belonged to 56 taxa of algae among which 24 species were of Rhodophyceae, 18 were of Chlorophyceae and 14 species belong to the class Ochrophyceae (Phaeophyceae) (Fig. 3 and Table 2). On analyzing the data district wise (Graph 1), it was observed that Tirunelveli district harbored a maximum of 48 taxa (SSpL=84%) with a highest Berger-Parker index value of 0.615. Tirunelveli was followed by Tuticorin (SSpL=47%) and Ramanathapuram (SSpL=26%).

In all the four selected districts red algae were dominated over green and brown algae. For

instance the red algae *Gracilaria corticata* (Fig. 3) was recorded in all the four districts dominating all other species followed by the green algae *Caulerpa scalpelliformis*, which was recorded during all four seasons. All other species were specifically present at certain seasons only. Intense seasonal variations of macroalgae populations were observed among the four sampling periods. During the study period, 57, 21 and 7 species were recorded from Bay of Bengal, Indian Ocean and Arabian Sea respectively. Higher Shannon index, Simpson index and Evenness index were recorded for Tuticorin district, whereas Berger-Parker index was in favor of Ramanathapuram.



Fig. 3: Dominant Species of Tamil nadu coast-*gracilaria corticata*.

Table 2: List of algae collected from Tamil Nadu coasts

Chlorophyceae	Phaeophyceae	Rhodophyceae
Bryopsis plumose	Chnoospora fastigiata	Acanthophora spicifera
Caulerpa cupressoides	Hormophysa triquetra	Amphiroa anceps
Caulerpa racemosa	Lobophora variegata	Amphiroa fragilissima
Caulerpa scalpelliformis	Padina gymnospora	Ceramium trunkatum
Caulerpa veravalensis	Padina pavonica	Ceramium sp.
Chaetomorpha antennina	Padina tetrastromatica	Chondrococcus hornemanni
Chaetomorpha crassa	Sargassum wightii	Galaxaura marginata
Cladophora fascicularis	Sargassum sp.1	Geledium pusillum
Enteromorpha compressa	Sargassum sp.2	Gracilaria corticata
Enteromorpha intestinalis	Sargassum sp.3	Gracilaria edulis
Enteromorpha prolifera	Sargassum sp.4	Gracilaria fergusonii
Halimeda macroloba	Spathoglossum asperum	Gracilaria foliifera
Halimeda tuna	Stoechospermum marginatum	Gracilaria verucosa
Udotea flabellum	Turbinaria ornata	Grateloupia sp.
Ulva fasciata		Hypnea musciformis
Ulva lactuca		Hypnea sp.
Ulva reticularis		Hypnea valentiae
Valoniopsis pachynema		Jania adhaerens
		Laurencia ceylanica
		Liagora ceranoides
		Polysiphonia sp.
		Sarconema filiforme
		Sarconema sp.
		Spyridia sp.



Fig. 4: Some of the marine algae collected from Tamil Nadu coasts

Coastal and marine floral biodiversity along the Karnataka coast

P. Kaladharan, P. U. Zacharia and K. Vijayakumaran, 2016, Assessment of floral biodiversity along the Karnataka coast carried out by P. Kaladharan, P. U. Zacharia and K. Vijayakumaran during 2005–2006. Karnataka has a coastline of about 300 km starting from Talapadi in the south to Karwar in the north. Distribution of marine algae in the littoral zone of the entire Karnataka coast was first studied in detail by Agadi (1985) and is found to be of 43 species. For sample collection, the Karnataka coastline is divided into nine sampling grids.

Seaweeds were collected from 48 intertidal as well as estuarine stations and 12 stations from the island ecosystems along the Karnataka coast during low tide period. From the island ecosystems, seaweeds from the reef slope and subsurface were collected.

A total of 78 species (Table 4) of seaweeds were observed along the Karnataka coast belonging to 52 genera and 28 families. Generally, seaweed vegetation was found sparsely populated along the coast. Intertidal rocks in the Islands registered fairly good flora of brown seaweeds dominated by *Sargassum ilicifolium*, having economic importance in extracting alginate. Table 3 represents the class-wise distribution of collected marine algae.

Table 3: Distribution of green, brown, red and blue green algae along the Karnataka coast

	Chlorophyceae	Phaeophyceae	Rhodophyceae	Cyanophyceae	Total
Order	3	7	7	1	18
Family	9	6	12	1	28
Genus	14	14	22	2	52
Species	26	21	29	2	78

Table 4: List of species collected from Karnataka coast

Chlorophyceae	Phaeophyceae	Rhodophyceae	Cyanophyceae
Enteromorpha intestinalis	Giffordia mitchellae	Porphyra vietnamensis	Lyngbya majuscula
Enteromorpha clathrata	Ectocarpus sp.	Grateloupia filicina	Schizothrix sp.
Enteromorpha flexuosa	Sphacelaria frucigera	Grateloupia lithophila	
Ulva reticulata	Sargassum ilicifolium	Cheliosporum spectabile	
Ulva fasciata	Sargassum tenerrimum	Gelidium pusillum	
Ulva lactuca	Sargassum myriocystem	Gelidiella acerosa	
Ulva rigida	Sargassum wightii	Gracilaria corticata	
Monostroma sp.	Sargassum cinereum	Gracilaria foliifera	
Chaetomorpha antennina	Turbinaria ornate	Gracilaria edulis	
Chaetomorpha linum	Stoechospermum marginatum	Gracilariopsis lemneiformis	
Chaetomorpha media	Spathoglossum asperum	Gelidiopsis variabilis	
Cladophora fascicularis	Dictyota bartayresiana	Rhodymenia australis	
Spongomorpha sp.	Dictyota dichotoma	Champia parvula	
Codium decartatum	Dictyota dumosa	Amphiroa fragilissima	
Microdictyon sp.	Padina gymnospora	Amphiroa sp.	
Ernodesmis verticillata	Padina tetrastratica	Jania adherence	
Caulerpa peltata	Dictyopterus australis	Melobasia sp.	
Caulerpa racemosa	Dilophus fasciola	Hypnea musciformis	
Caulerpa sertularioides	Lobophora variegata	Hypnea pannosa	
Caulerpa scalpelliformis	Ralfsia sp.	Hypnea cervicomis	
Caulerpa prolifera	Colpomenia sinuosa	Centroceros clavulatum	
Caulerpa taxifolia,		Ceramium fastigatum	
Bryopsis plumose		Antithamnion sp.	
Struvea sp.		Chondria armata	
Chlorodesmis hildebrandtii		Caloglossa leprieuri	
Avrainvillea amadelpha		Acanthophora spicifera	
		Laurencia papillosa	
		Polysiphonia sp.	
		Polysiphonia macrocarpa	



Cladophora fascicularis



Ulva fasciata



Turbinaria ornate



Sargassum ilicifolium



Grateloupia filicina



Gracilaria foliifera

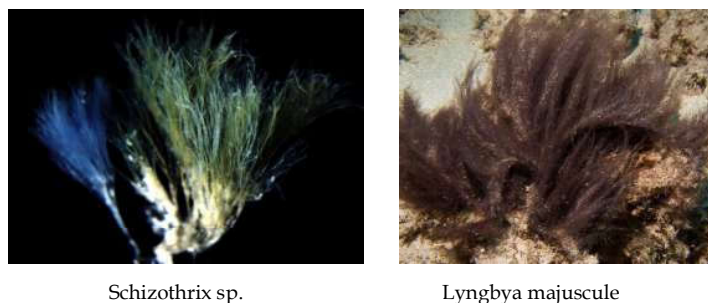


Fig. 5: Some of the marine algae collected from Karnataka coast.

Comparative Analysis of Algal Distribution along the Selected Coasts

Current study has reviewed algal diversity of three coasts of southern India along Kerala, Tamil Nadu and Karnataka. When comparing floristic wealth of three coasts, Karnataka coast showed many number of species. A total of 78 species were recorded from Karnataka coast while, 56 and 42 species records were obtained from Tamil Nadu and Kerala respectively. From all three plots selected, algae from classes, Chlorophyceae, Rhodophyceae and Phaeophyceae were observed, but from Karnataka coast in addition to these three common algal classes, 2 Cyanophycean algae were also recorded, indicating certain variations or adaptive ecological features of this coast may be made the establishment of these new groups possible. In all the selected

coasts Rhodophyceae was the dominating group.

A species-wise cross checking of algal composition in the coasts suggested that the commonness of species occurrence is very much appreciable along all the three coasts selected. A total of 14 species were common in all the three western coasts selected, and they are *Acanthophora spicifera*, *Amphiroa fragilissima*, *Bryopsis plumose*, *Caulerpa racemosa*, *Cladophora fascicularis*, *Gracilaria corticata*, *Gracilaria edulis*, *Gracilaria foliifera*, *Hypnea musciformis*, *Padina tetrastomatica*, *Sargassum wightii*, *Ulva fasciata*, *Ulva lactuca*, *Ulva reticulata*. Neither the variations in climatic changes nor any other environmental factors may play a significant role in these areas. As expected, western marine coasts of India exhibit many common genera as well as species.

Table 5: Some common species along western state coasts of India

No	Species	Karnataka	Tamil Nadu	Kerala
1	<i>Acanthophora spicifera</i>	+	+	+
2	<i>Amphiroa fragilissima</i>	+	+	+
3	<i>Bryopsis plumose</i>	+	+	+
4	<i>Caulerpa peltata</i>	+	-	+
5	<i>Caulerpa racemosa</i>	+	+	+
6	<i>Caulerpa scalpelliformis</i>	+	+	-
7	<i>Caulerpa sertularioides</i>	+	-	+
8	<i>Caulerpa taxifolia</i>	+	-	+
9	<i>Chaetomorpha antennina</i>	+	+	-
10	<i>Cladophora fascicularis</i>	+	+	+
11	<i>Dictyota bartayresiana</i>	-	+	+
12	<i>Enteromorpha intestinalis</i>	+	+	-
13	<i>Gelidiella acerosa</i>	+	-	+
14	<i>Gelidium pusillum</i>	+	-	+
15	<i>Gracilaria corticata</i>	+	+	+
16	<i>Gracilaria edulis</i>	+	+	+
17	<i>Gracilaria foliifera</i>	+	+	+
18	<i>Grateloupia filicina</i>	+	-	+
19	<i>Hypnea musciformis</i>	+	+	+
20	<i>Hypnea valentiae</i>	-	+	+
21	<i>Padina tetrastomatica</i>	+	+	+

No	Species	Karnataka	Tamil Nadu	Kerala
22	<i>Sargassum tenerrimum</i>	+	-	+
23	<i>Sargassum wightii</i>	+	+	+
24	<i>Spathoglossum asperum</i>	+	+	-
25	<i>Stoechospermum marginatum</i>	+	+	-
26	<i>Turbinaria ornate</i>	+	-	+
27	<i>Ulva fasciata</i>	+	+	+
28	<i>Ulva lactuca</i>	+	+	+
29	<i>Ulva reticulata</i>	+	+	+
30	<i>Ulva rigida</i>	+	-	+

Conclusion

The scope of algal research has recently reached a crucial point that these natural resources have to be conserved as they act as a reservoir of various medicinal as well as nutritional Phytochemicals. The objective of current study was to highlight India as a rich country for the inhabitation of its coastal areas with a rich occurrence of marine algae. Current paper reviewed various algal diversity assays along the southern coasts of India conducted by different investigators. Apart from the independent algal diversity assessment of each coast, a comparative analysis between these selected coasts has also undertaken (Table 5). It has been found that all the three southern coasts of India along Kerala, Tamil Nadu, and Karnataka harbor a rich vegetation of marine algae along their marine coast with a promising diversity, distribution and abundance of algal species. Comparative Analysis on species commonness have shown to be negligible variations in environmental as well as climatic factors may only taken place in these areas and hence many species were identified as common along all the three coasts studied.

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