CHAPTER

03

# SEAWEED BIODIVERSITY: AN IMPORTANT RESOURCE BASE TO DEVELOP BIOACTIVE COMPOUNDS FOR HEALTH AND DISEASES

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## ABSTRACT

This chapter is a brief insight into classification and diversity of marine macroalgae with an outline of its distribution in India. An overview of the importance of seaweeds, seaweed taxonomy, classification of main types, global distribution patterns, important seaweed-based ecosystems, seaweed diversity and distribution within India and important genera of seaweeds have been outlined.

***Keywords:*** Seaweed diversity, Taxonomy

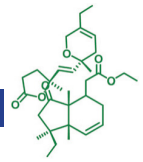
## INTRODUCTION

Seaweed or marine macroalgae are multicellular and macroscopic algae which thrive in diverse marine environments, ranging from sunlit intertidal and shallow regions to depths of 150 meters. They adapt to various surfaces, clinging to rocks, coral, and even sand and sometimes growing on other plants as epiphytes.

Highly valued in numerous countries, seaweed play an increasing role as food providing essential dietary elements, minerals, and trace elements. Beyond some beingedible species and providing food supplement products such as phycocolloids, agar and carrageenans and additives in animal feed, seaweed are also used to make a plethora of commercial products including industrial chemicals, fertilizers, pharmaceuticals, nutraceuticals and are even a potential source of biofuel. They contribute significantly to the environment and environmental health. Planktonic algae capture vast amounts of carbon, playing a crucial role in carbon sink and sequestration. They produce substantial quantities of the Earths oxygen through photosynthesis. Seaweed also impact fisheries, notably species such as kelp serve as essential nursery habitats for fish and other marine life, protecting future food sources. The global production of seaweed stands at 35.08 wet weight in 2020 (FAO, 2022) and in India the same for 2021 is 33345 tonnes (CMFRI, 2023). Seaweed farming empowers tens of thousands of households, boosting the local economy and providing sustainable livelihoods. The multifaceted benefits of seaweeds reach coastal communities, human health, and ecosystems.

## SEAWEED TAXONOMY

Seaweeds are taxonomically diverse marine macroflora from which land plants diverged



some 500 million years ago.They are a paraphyletic group as they lack a single common ancestor. Seaweed species are classified under five main classes under the domain Eukaryota and clade Diaphoretickes (photosynthesising organisms), namely classes Chlorophyceae and Ulvophyceae under the Division Chlorophyta (green algae) and the clade Eurhodophytina; classes Bangiophyceae and Florideophyceae under the Division Rhodophyta (red algae) and the class Phaeophyceae (brown algae) under the Phylum Gyrista and the Subphylum, Ochrophytina. The three main types of marine macroalgae are based on their major accessory pigments.

## CHLOROPHYTE SEAWEEDS OR GREEN ALGAE:

Green algae contain chloroplasts with the pigments chlorophyll a and chlorophyll b and store starch in plastids. The chlorophyll gives them the distinguishing green colour. According to Lelieart et al. (2012) the main classes of chlorophytes which comprise the marine green macroalgae are Ulvophyceae which consist of six orders namely Cladophorales, Dasycladales, Bryopsidales, Trentepohliaqles, Ulvales-Ulotrichales and Oltmasiellopsidales. Constant reclassifications and taxonomic complexity make naming the exact number of species belonging to green macroalgae a complex issue however it is believed that there are close to 800 species of the same.

## RHODOPHYTE SEAWEEDS OR RED ALGAE:

Red algae have chloroplasts lacking endoplasmic reticulum and have unstacked thylakoids with the phycobilliproteins pigments. About 95% of red algae are found in the marine habitat. The two latest classification systems available for Rhodophytes are based on Saunders and Hommersand (2004) and Hwan Su Yoon et al. (2006). In both systems red seaweed are placed under two classes Bangiophyceae and Florideophyceae following advances in molecular taxonomy. Earlier the species under both these classes were placed under Class Rhodophyceae. Bangiophyceae are not morphologically discernable from Florideophycea but are differentiated from them in genetic makeup. Bangiophyceae consist of a single order Bangiales and have genera such as Bangia and Porphyra. The majority of red algae are grouped into about 20 orders in Florideophyceae. The main orders include Hildenbrandiales (crustose coralline algae), Nemaliales (286 species), Colaconema, Acrochetiales, Palmariales, Rhodogorgonales and Coranillaes (coralline algae), Bonnimaisoniales, Gigartinales, Gelidiales (160 species, agar yielding), Gracilariales (some agar yielding), Halimeniales and Ceramiales.

## PHAEOPHYCETES OR BROWN ALGAE

Brown algae are characterised by chloroplasts that have four surrounding membranes, thylakoids present in triple stacks and a carotenoid pigment fucoxanthin that is more pronounced than chlorophyll-a and -c, giving these macroalgae their characteristic greenish-



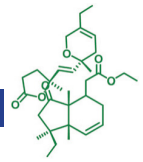
brown colour. They also store carbohydrate food in the form of a storage glucan laminarin and their cell wall matrix contains alginates and fucoidan. 99% of the brown algae are marine. Brown algae also have the fastest growth among seaweeds eg. the kelp Macrocystis can grow at the rate of 50 cms per day. As per the classification of Silberfeld, Rousseau & de Reviers (2014), the class Phaeophyceae comprises of 18 orders, 54 families and about 1800 species. The most important orders to humans are the Fucales, Laminariales, Ectocarpales and Dictyotales.

## SEAWEED DIVERSITY

The diversity and abundance of seaweed depend heavily on environmental, chemical, and biological factors. Various species are adapted to thriving in tropical, temperate and polar regions. Red seaweed are dominant in tropical and subtropical waters whereas brown seaweed are more abundant in temperate regions and cold waters. Seaweed found in the polar regions is mostly brown macroalgae. The most spectacular of seaweed-based ecosystems are very extensively floating *Sargassum* mats of the Saragossa Sea and the kelp forests. These are found in the eastern Pacific which hosts the world's most extensive kelp forests, stretching from Alaska to Baja California, Mexico. Giant kelp (*Macrocystispyrifera*) and bull kelp (*Nereocystisluetkeana*) are the dominant species in this area. Kelp forests are also found along the southern coasts of Tasmania and New Zealand, providing habitat for diverse marine life. *M. pyrifera* and *Eckloniaradiata* are common kelp species here. Kelp forests also flourish in the cold, nutrient-rich waters around these Nordic countries of Norway and Iceland. *Laminaria digitata* and *Saccharinalatissima* are some of the prominent species. The southern reaches of South America on the Argentina and Chile coastlines also feature kelp forests rich in biodiversity, with *M. pyrifera* and *Durvillaea antarctica* being key species. Colder coasts of South Africa also boast of Kelp forests providing habitat for abalone and other marine life. *Laminaria pallida* and *E. maxima* are prevalent species. Hokkaido and other northern islands of Japan also support kelp forests dominated by *Laminaria hyperborea* and *Saccharina japonica*. Kelp forests are biodiversity havens and champions of productivity with providing nurseries to fishes and other marine life, contribute significantly to nutrient cycling and provide raw material to food, agro- and pharmaceutical industries.

## SEAWEED DIVERSITY IN INDIA

The approximately 8000 km long coastline of India provides ample environs for seaweed growth and the same is found abundantly distributed along the coast from Rameswaram to Kanyakumari and the 21 islands of the Gulf of Mannar, Okha, Dwaraka, Porbandar, Veraval, and Gopnath along the Gujarat coast, Goa, Daman & Diu Islands, and near Mumbai, Ratnagiri, Karwar, Varkala, and Vizhinjam, Visakhapatnam, Srikakulam and the islands of



Lakshadweep and Andaman Nicobar. Early pioneers like Iyengar (1927) laid the groundwork for understanding India's seaweed diversity, focusing on the Krusadai Island on the southeast coast. Borgesen contributed substantially to documenting the seaweed flora of India with publications from 1933-38 while exploring the coasts of the Presidency of Bombay (present day Gujarat and Maharashtra) and southern India. 62 genera and 114 species of seaweed were identified Lakshadweep by Kaliaperumal et al. (1989). The maximum diversity and biomass of seaweed is found on the Tamil Nadu and Gujarat coasts. Seaweed diversity has been well documented from the Tamil Nadu coast for several decades. Publications by CMFRI researchers as Chennubotla et al. (1989), Chennubotla et al. (1990), Kaliapermalet al. (1992), Subba Rao et al. (1992), Rama Rao et al. (1993), Kalimuthu et al. (1995), Kaliaperumal et al, (1995) and Kaliaperumal et al. (1998) laid out detailed investigations into to the distribution of seaweed resources along various sectors of the Tamil Nadu coastline with observations from Dhanishkodi to Kanyakumari, Vallinokam to Kilakarai, Kattapadu to Tiruchendur, Tuticorin to Tiruchendur, Ramesaram island, Alantalai-Manapad and Vembar-Nallatanni Tivu and the estuaries of Tamil Nadu and Puducherry. The most recent estimates state 282 species of which 146 were from Rhodophyta, 80 from Chlorophyta, and 56 from Ochrophyta in Tamil Nadu.Jha et al. (2009) documented 366 species collectively from Gujarat and Tamil Nadu. This represents nearly half of India's total seaweed diversity.The same study also described the diversity along the Gujarat coast revealing 198 species representing Rhodophyta 109 species from 62 genera; Chlorophyta 54 species from 23 genera; Phaeophyceae 35 species from 16 genera. Seaweed diversity is rich in the Gulf of Kachchh islands totalling 130 species from Dani, Dhabdhaba, Kalubhar, Manmarodi, and Narara Islands with a maximum seen in Kaubharisland (93 spp.) (Ganesan et al. 2019). A total of 78 species of seaweeds was observed along the Karnataka coast belonging to 52 genera and 28 families by Kaladharan et al. (2011). Another recent publication by the Botanical Survey of India identified 108 taxa of seaweeds, belonging to 54 genera, 20 orders and 31 families including 42 taxa of Rhodophyceae, 36 taxa of Chlorophyceae and 30 taxa of Phaeophyceae (Palanisamy and Yadav, 2022). Kaliaperuma et al (2015) identified 16 species to be common along the Andhra coast where maximum diversity and biomass were observed along the Srikakulam, Visakhapatnam and east Godavari coasts. According to Untawale et al. (1983), there were 624 species of marine algae belonging to 215 genera and 64 families in India of which nearly 60 species were identified as commercially important. Oza and Zaidi (2001) compiled a checklist of 844 seaweed species (434 red, 194 brown, and 216 green) based on secondary data. The most recent estimate placed the seaweed diversity of India at 283 genera and 1019 species. Rhodophyceae dominates with 442 species followed by Chlorophyceae (212 spp.), Phaeophyceae (211 spp.) and blue-green algae (148 spp.) (Rao and Gupta, 2015).



The most specious green algae in the Indian diversity belong to the genera *Caulerpa, Codium, Halimeda* and *Ulva* and the genera *Acrosiphonia, Anastomonas, Boergesenia, Dictyosphaeria, Neomreis, Microdictyon, Struvea, Valonia* and *Valoniopsis* are monospecific. In brown algae, the genus *Sargassum*, *Dictyota* and *Padina* are the most speciose. *Turbinaria, Dictyopteris* and *Chnoosporahave* three species each and the genera *Ectocarpus, Hormophysa, Hydroclathrus, Iyengaria, Rosenvingea* and *Zonariaare* monospecific. The genera *Gracilaria, Laurencia, Grateloupia* and *Hypnea* are the most speciose while *Asparagopsis, Bostrichia, Botryocladia, Chondrococcus, Chondrocanthus, Dasya, Dictyurus, Digenea, Enantiocladia, Griffithesia, Halichrysis, Helminthocladia, Neurymenia, Nitophyllum, Peyssonnelia, Tenaciphyllum* and *Wrangelia* are represented by a single species each.

*Saragassum* spp. are the most dominant when biomass is considered and the maximum abundance is found along the Gujarat coast. *Gracilaria* species such as *G. edulis, G. crassa,* and *G. verrucose* are common along Tamil Nadu and Gujarat as is *Gelidiella acerosa*. The brown alga *Cystoseiratrinodisis* common along the Gujarat and Maharashtra coast. Various species of *Ulva* such as *U. fasciata* and *U. lactuca* thrive in sheltered bays thrive is sheltered bays and rocky substratum in intertidal regions. Genera such as *Halimeda, Dictyopteris, Lobophora, Codium, Galaxaura, Asparagopsis, Hildenbrandlia,* and *Anadyomene* are more prominent at greater depths (20-75 m). *Gracilaria crassa* and *Geliodiopsis variabilis* are found growing abundantly on coral in Lakshadweep. *Halimeda* and crustose coralline algae species are dominant in the lagoon and reef areas of the Lakshadweep and Andaman Nicobars.

## CONCLUSION

This chapter has summarised the scientific underpinnings of the diversity and distribution of seaweeds in India. Knowledge of taxonomy, diversity and distribution of seaweed is imperative to resource monitoring, potential prediction, biochemical explorations, designing technological interventions, novel products and culture techniques. India has a potential of 3.4% of the global estimate i.e. approximate 65000 tonnes of seaweed of which about half is realised at present. The basics of seaweed classification into its three major types and a brief account of the diversity and distribution of species within India have been provided. With impetus being given to large scale seaweed culture and development of new products, grounding in basic knowledge in seaweed is essential to developing further skills in laboratory and field culture techniques to drafting policy from mariculture to intellectual property rights which has been provided in the above chapter.

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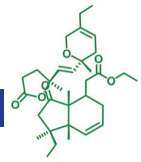

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