

## Seaweed in Marine Ecosystem: A Review

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### ABSTRACT

A total of 221 different species of seaweed from the 32 Chlorophyta, 64 Phaeophyta, and 125 Rhodophyta are employed for a wide range of applications worldwide. Roughly 145 species are consumed as food (L. W. Zemke-White and M. Ohno). India is home to 216 different species of green seaweed, 194 different species of brown seaweed, and 434 different species of red seaweed. A supply of seaweed In addition to its 2 million km<sup>2</sup> Exclusive Economic Zone (EEZ) and nine marine states, the tropical South Asian nation of India is located at latitudes 08.04-37.06 N and 68.07-97.25 E. It has a coastline that is around 7500 km long. The seaweed zone served as a permanent and temporary home for fish and other aquatic creatures. Most recently according to Karthik et al., 2013 Indian seaweed diversity includes 1153 species from 271 genera. Gujarat coast consist total 198 seaweed species diversity ((Jha et al., 2009).

**KEYWORDS:** Seaweed diversity, Indian coast, Gujarat coast, Marine Ecosystem

### INTRODUCTION

As a derivative of “biological diversity” (Wilson, 1985,1988) the term “biodiversity”, first used almost three decades ago that was in today one of the most cited terms in field of ecology and environmental management and conservation. Marine ecology is essentially made up of three processes (Gray and Elliott, 2009). First, environmental conditions such as physico-chemical components create a set of fundamental niches, and these niches are colonized according to their environmental tolerance capacity. Second the survival and relationship between the marine creatures is directly based on direct interaction between predators and pray competition, requirement, space, feeding and mutualism. Thirdly, the ecology has the power to break the cycle and change the phyco-chemical system through bioturbation, such as the removal or modification of some components.

Seaweeds can be thought of as marine plant but in real sense it marine macroalgae that complete their nourishment necessity for growth and maintenance through photosynthesis in maritime environment. The kingdom of Protista includes the macroalgae. This autotrophic organism primarily found in estuaries, lagoons and oceans. One of the most significant features that differed from plant to algae is the

absence of a circulatory system. Necessary nutrient absorption and internal movement are carried out through transfusion between cells and between the environmental and the epidermal cells. In general seaweed adhering on solid substratum such as rock, pebbles, shells, marine plants, dead corals. Base on the color pigmentation seaweed divided into three groups namely Chlorophyta (Green seaweed), Rhodophyta (Red seaweed) and Pheophyta (Brown seaweed).

In marine ecosystem the environmental conditions such as water temperature, water chemistry, nutrient availability, characteristic of coast directly affect the presence and absences of diversity, abundance, density, growth of diversity of marine flora and fauna. Due to the protective and nutrient rich environment provided by seaweed play important role for development of diversified diversity of marine organism within the ecosystem.

### MATERIAL AND METHOD

This study is mainly a review study. All of the information used in this review article has been collected from numerous secondary sources by reviewing articles, thesis, reports, and standard websites.

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## REVIEW ON INDAIN COAST

India has 7516.6 kilometers of coastline, consisting of nine maritime states and two union territories. It harbors 171 million population in 70 coastal districts of which about 4 million consists of fishermen residing in 3288 fishing villages (Database on Coastal States of India, institute of ocean management-<http://iomenvis.nic.in/index2.aspx?langid=1&mid=1&slid=758&sublinkid=119>). Indian contains nine maritime states and islands (Gujarat-1700, Maharashtra-572, Goa-104, Karnataka-280, Kerala560, Tamil Nadu-980, Andhra Pradesh-960, Orissa-432, West Bengal-280, Andaman and Nicobar Islands-1500 (approx.), Lakshadweep Islands-120 (approx.) in km (Subba Rao & Vaibhav Mantri, 2006).

The Bay of Bengal, the Arabian Sea and the Indian Ocean all encircle the country to its east, west and south respectively. The East coast lies between Eastern Ghats and the Bay of Bengal. It extends from the Ganga delta to Kanniyakumari. Eastern coast comprised of the Orrisa coast, Andhra Pradesh coast and Tamil nadu coast. The West coast strip stretches from Cape Comorin (Kanniyakumari) in the south to the Gulf of Cambay (Gulf of Khambhat) in the north. Some coast line formed due to uplift of the land or by the lowering of the sea level that referred as an Emergence coast line while Submergence is an exact opposite to emergence. Eastern coastline especially south-eastern part appears to be a coast of emergence. Western coast is both emergent and submergent. India's tide cycle is typically semidiurnal, with two unequally amplituded high tides and two low tides every day (Jha et al., 2009).

Nearly 43% of the Indian coastline is made up of sandy beaches, 11% is rocky with headlands, cliffs and 46% is made up of flats and marshy wetlands (ICMAM 2009).



**Fig: 1 Coastal state of India**

The eastern sea belt often consist of extensive expanses of sandy beaches flanked by (active or stable) coastal dunes and broken up by significant prograding deltas, whereas the western sea belt is more indented with rocky headlands, beaches and numerous estuaries. There are two archipelagos also present, one in the Arabian Sea and another in the Bay of Bengal.

**Table: 1 Nature of coast along the Indian coastline**

State / Union Territory	Marshy (%)	Muddy (%)	Rocky (%)	Sandy (%)
Arabian Sea Coast				
Gujarat	22	29	21	28
Daman & Diu	-	-	-	-
Maharashtra	-	46	37	17
Goa	-	35	21	44
Karnataka	-	14	11	75
Kerala	-	15	05	80
Lakshadweep	-	-	-	-
Bay of Bengal				
Tamil Nadu	-	38	05	57
Pondicherry	-	-	-	-
Andhra Pradesh	07	52	03	38
Odisha	10	33	-	57
West Bengal	49	51	-	-
Andaman & Nicobar	-	-	-	-
Mainlands	10	36	11	43
Islands	-	-	-	-

Data presented here was modified after Kumar et al. (2006) and ICMAM (2009)

## REVIEW ON GUJARAT COAST

One of the India's largest Maritimes state, Gujarat boasts a 1650 km long coastline. Gujarat state located between 20° 1' to 24° 7' N and 68° 4' to 74° 4' E (Trivedi and Vachhrajani, 2013; Jha, et al., 2009). 14 districts with 2 Union territories in Gujarat state share this longest coastline. On the east and west coasts, particularly in the gulf of Kutch, coral beaches are also prevalent in India (Krishnamurthi et al., 1967). Coral beaches are entirely absent from Gujarat's southwest coast, which is replaced by a sandy shoreline with rocky outcrops. In contrast, steep beaches are primarily a feature of India's west coast. The rocky shorelines are like a fantastic universe where you may observe numerous organisms and well defined banding patterns. Rockier shorelines are distinguished by their pools and crevices. In a rocky setting, there are additional habitat kinds including cobbles and boulders. The nicest thing about rocky intertidal areas is their unclear vertical division into supratidal zone to lower intertidal zone zones, all of which contain a variety of creatures (Ellis, 2003; Bandel and Wedler, 1987; Stephenson and Stephenson, 1949).

Gujarat's entire coastline can be divided into three distinct sections: a Saurashtra coastline, two gulfs (the Gulf of Kachchh and Gulf of Khambhat), and the entire coastline (Pandey and Pandey, 2009). The gulf of Kachchh is one of two gulf on India's west coast, and it has the greatest diversity of coastal habitat and organism (Jha et al., 2009).

Both Gulfs' coastlines are covered in intertidal mudflats and sandy beaches, salt marshes, and mangrove forests, mostly along the Gulf of Khambhat's river deltas. Gulf of Khambhat extends 151 kilometers north to south from Gujarat and pierces the Arabian Sea on India's western coast from south to north. It is roughly located between latitudes 71° 45' and 72° 53' E and 20° 30' and 22° 20' N. Gulf's coastline spans about 3,120 km<sup>2</sup> and has an intertidal volume of about 62,400 million m<sup>3</sup>, mostly made up of muddy shorelines and some rocky outcrops (Dev solanki et al., 2019).

Gujarat's shoreline is made up of pleistocene aged milliolite fossils formation and tertiary rocks from the Deccan traps. In some locations, there is also recent alluvium with lime stones. Gulf of Khambhat has seen more recent alluvium deposition (Jha et al., 2009). There is a great deal of information about the spatial and temporal variability of the organisms that live there, including macroalgae and invertebrates making intertidal rocky shores one of the most studied marine habitat as in ecological studies (e.g. Underwood & Chapman 1996, Menconi et al. 1999, Benedetti-Cecchi 2001, Blanchette et al. 2006, Martins et al. 2008, Burrows et al. 2009, Dal Bello et al. 2017a).

There are 44 ports along the Gujarat coastline. The portion between Diu and Bhavnagar demonstrates the change from an open ocean to a gulf environment. Gujarat is one of the 8 eco regions and the coastal zone takes up 14% of the total land area. The Kutch district accounts for 38% of the coastline area, with Jamnagar (17%), Junagadh (9%), and Bhavnagar (9%). Out of 16 coastal districts 10 districts has been face 45.8% of the erosion.

**SEAWEED DIVERSITY SCENARIO OF WITHIN IN INDIA AND GUJARAT**

India is home to 216 species of green seaweed, 434 species of red seaweed and 194 species of brown seaweed. Several of these are economically crucial. Seaweeds play a vital role in coastal ecosystem like kelp forest and coral reefs as important primary producers and ecosystem engineers. Seaweeds are important economically because they serve as the foundation of a successful food web (Graham MH, 2004 & Norderhaug KN et al., 2005).

Around 11,000 different species of seaweed have been identified worldwide, including about 7,200 Rhodophyceae species, 2,000 Phaeophyceae species, and 1,800 Chlorophyceae species (<http://www.seaweed.ie>).

According to Rao and Gupta (2015), the Indian coastlines are home to 865 taxa of seaweed, including 442 taxa of Rhodophyceae under 151 genera, 212 taxa of Chlorophyceae under 46 genera, and 211 taxa of Phaeophyceae under 50 genera.

Indian seaweeds show that among the various maritime states, the Tamil Nadu coast exhibits the highest diversity of seaweeds with 282 species (Anon.2012; Ganesan & al., 2019), followed by the Maharashtra coast with 240 species (Piwalatkar, 2010), Gujarat coast with 198 species (Jha & al., 2009), Kerala with 147 taxa (Palanisamy & Yadav, 2015), Karnataka with 105 tax (Sahoo & al., 2003). An additional 125 kinds of seaweeds that are endemic to india are found along the Indian coastline which is fascination (Oza & Zaidi, 2001).

**Table: 2 seaweed diversity at different Indian maritime zone**

Sr. No.	Coastal state / Union territories	Species diversity	
1.	Gujarat coast	198	(Jha et al., 2009)
2.	Maharashtra coast	240	Piwalatkar, 2010)
3.	Goa	90	(Palanisamy & Yadav, 2019)
4.	Diu island	70	(Mantri &Rao, 2005)
5.	Karnataka	105	(Yadav & Palanisamy, 2020)
6.	Kerala	147	(Palanisamy & Yadav, 2015)
7.	Tamil Nadu coast	282	(Anon.2012; Ganesan et al., 2019)
8.	Andhra Pradesh	65	(Anon., 1984)
9.	Odisha	14	(Sahoo et al., 2003)
10.	West Bengal	14	(Mukhopadhyay et al., 2002)
11.	Andaman & Nicobar islands	80	(Muthuvlan et al., 2001)

Iyengar (1927) was the to publish the marine algal flora of the Indian coast. He was the first phycologist then Subsequently, Børgesen (1935, 1937a, b) had stared series of publications on Indian marine algae.

According to checklists published to date, which range from 167 species in 1970 (Krishnamurthy & Joshi, 1970) to 865 species in 2015 (Rao & Gupta, 2015), and the number of new seaweed taxa reported from 1800 to 2019, Mantri & al. (2019) recently noted the gradual increase in diversity of seaweeds from Indian waters and suggested that there were two major peaks, the first from 1930-1940 and the second, from 1980-1990 appear. The east coast of India is roughly 2652 km long, the west coast is 3216 km long and the island make up about 1620 km of the country's total coastline (Rao & Mantri, 2006).

Its Exclusive Economic Zone (EEZ) is over 2.5 million square kilometres in size. The nation features 97 significant estuaries, 34 significant lagoons, 31 regions of mangroves, 5 coral reefs, and 31 Marine Protected Areas (MPAs) (Singh, 2003).

Gujarat, on India's southwest coast, is located between 22° 18' 33.9300" N and 72° 8' 10.4280" E on the north-western tip of the peninsula. Ishakani et al. (2016) identified a total of 67 species from the Veraval shore, including 32 species of Rhodophyta, 14 species of Phaeophyta, and 21 species of Chlorophyta. In the current study, 50 species of seaweed were identified, of which 17 species are Chlorophyceae, 14 species are Phaeophyceae, and 19 species are Rhodophyceae from the Gujarati coasts of Veraval and Sikka (Shivani Pathak et al.,2020). At the head of the "Gulf of Kachchh," on the territory of Saurashtra in Gujarat state, is the coast of Beyt Dwarka, which is located at 22°28'N and 69°05'E. There are 39 different species of marine algae, although only five species of green algae were found, 26 species of red algae, and eight species of brown algae (Haresh Kalasariya et al., 2019). Indian seaweed's most recent diversity included 1153 species from 271 genera (Karthik et al., 2013).



## DISTRIBUTION OF SEAWEED IN MARINE ECOSYSTEM

In marine ecosystem seaweed should be highlighted that there are no input needed for growing seaweed, including land, water for irrigation, fertilizer or pesticides. Understanding the zonation patterns of the flora and animals for a rocky shore ecosystem can help us better understand its state of equilibrium. The harshness of the intertidal zone's circumstances worsens with height above sea level, making it harder for fewer species to survive there (Kaliaperumal et al. 1995). As a result, species diversity in intertidal zones decreases as height rises. Seaweed zonation patterns along different Indian beaches have been described by Srinivasan (1959), Misra (1959), Subbaramaiah (1970 & 1971), Agadi & Untawale (1978), and Agadi (1983 & 1985).

According to Kaliaperumal et al. (1995), the majority of seaweed species were found in depths between 5.5 and 17 meters, indicating that some species are widely dispersed over the vertical gradient of beaches. Agadi & Untawale (1978) and Agadi (1983) noted vertical gradients of *Chaetomorpha*, *Ulva*, and *Enteromorpha* species throughout the Goa coast, with the higher concentrations on rocks exposed to light where just humidity is necessary for algae growth.

Along the coast of Visakhapatnam, similar observations were made. Nevertheless, Misra (1959) had noted *Ulva* and *Enteromorpha* bands in the upper mid-littoral zone. The species' capacity to withstand the constantly changing intertidal circumstances, including the endless cycles of submergence and emergence and the attendant wash, splash, and spray, is what accounts for their spread across the various intertidal levels (Balakrishnan et al. 1990; Russell 1991; Chapman 1995).

Sun exposure (Hameed & Ahmed 1999), salinity (Thom 1980), submergence (Arun 1972; Druehl & Green 1982; Luning 1990), tidal factors (Lawson 1957; Reddy et al. 2006), nutrient concentrations (Jhansi & Rarmadas 2009), and water temperatures are some of the variables that affect the seasonal and vertical seaweed community variations in intertidal systems (McQuaid & Branch 1984). The ability of a species to cope with abiotic factors related to emersion stress, such as desiccation, which determines their upper limits, while biotic interactions, such as competition with other species, set their lower limits, makes vertical zonation an excellent ecological concept to study for a variety of reasons. The intertidal zone is the region of a shore defined by the upper and lower boundaries of the tide; it is exposed at low tide and submerged at high tide,

and both plant and animal species display zonation patterns there.

In the shallow, intertidal, and sub tidal zones of the marine ecosystems, seaweed typically grows on rocks, pebbles, dead corals, mollusk shells, coastal wastes like ropes and nets, as well as on mangroves and other plants as epiphytes. As seaweeds are primarily lithophilic in nature, the lack of sufficient rocky substrata, proper feeding, among other factors, may be to blame for this (Sudhir Kumar Yadav et al., 2020).

A variety of marine vegetation and wildlife can thrive on the firm ground provided by mangrove roots. The distribution of macroalgae in the mangrove area is influenced by the height of pneumatophores, surface texture, distance between pneumatophores, and canopy of mangroves. Environmental factors that determine the presence or absence of macro marine algae in mangrove ecosystem include temperature, salinity, dissolved oxygen, pH, and others (Fernandes & Aives 2011).

In in Sundarban Biosphere Reserve, West Bengal, India (Sudhir Kumar Yadav et al., 2020) reported total eight species of seaweeds associated with mangrove, comprising of six species of Chlorophyceae and two species of Rhodophyceae. Talaat Et Al, Mohamed, 2022 reported ten macroalgae species in the mangrove site, including three Chlorophyta species), five Phaeophyta species and Rhodophyta with two species (*Digenea simplex* and *Actinotrichia fragilis*).

Coralline algae and shells are two examples of macroalgae bearing associated carbonate material. Up to 85% of holdfasts on a beach may have up to 116 g CaCO<sub>3</sub> per holdfast (Garden and Smith, 2015). Green algae can grow on empty molluscan shells, which could lead to a rise in their population in shallow waters (Lutaenko et al., 2020).

In various place of Peter the Great Bay (north-western East Sea/Sea of Japan), the distribution of shells with seaweed on beaches and in the intertidal zone provide the data on the species composition of seaweed and associated mollusks and give the information about seaweeds frequently employ mollusc shells as a substrate (Lutaenko et al., 2015).

Gravel transportation due to wave amplitudes, currents also contributes the transportation of seaweed as it prefers gravel as a substratum. The presence of an algal "sail" (Kudrass, 1974) on sediments in the upper shore face and intertidal zone undoubtedly increases coarse sediment transport landward (Emery and Tschudy, 1941; Smith and Bayliss-Smith, 1998).

## RESULT AND DISCUSSION

seaweed resources India involving a tropical South Asian nation, is situated at latitudes 08.04–37.06 N and 68.07–97.25 E. Excluding its island territories, which total 2 million km<sup>2</sup>, it has a coastline of around 7500 km, along with nine marine states.

The maintenance and balance of the marine food chain is significantly aided by seaweeds. It gives marine life nutrition and energy, either directly when the fronds are consumed or indirectly when the small particles it decomposes into are ingested by creatures that filter-feed. For all or part of their lives, coastal animals can find shelter and a home in seaweed beds. Numerous commercial species, like the rock lobster, abalone, and green-lipped mussel, depend on them as vital breeding grounds.

By employing marine microorganisms, invertebrates, and algae, researchers discovered bioactive chemicals at the end of the 1990s (Mayer AMS et al., 2000). According to seaweed, other marine invertebrates are in second place to algae as a cheap source for the creation of new compounds (Ireland CM et al., 1993).

The crucial role of seaweed in formation of marine ecosystem and efforts in maintain whole food chain within ecosystem, it is very important to conserve and protect the status of seaweed diversity. Fish and various other aquatic creatures made the seaweed zone their temporary and permanent home (Emma LJ et al., 2001). In maritime environments, certain seaweed performs the role of a civil engineer, helping macroalgae or microalgae to create intricate communities on their hosts. This relationship occasionally fruitful by preserving the food chain, increasing the rate of ecosystem productivity. At Gopnath coast located in Bhavnagar district, Gujarat, India three host macroalgae (*Gelidium crinale*, *Chaetomorpha crassa*, and *Cladophora glomerata*), 7 species of epiphytic microalgae were identified (Mehta Nirali et al., 2021).

## CONCLUSION

Seaweeds are an essential component of biodiversity and potential marine biological resources. Along with their ecological and biological significance, seaweeds have enormous economic potential as food, fodder, and raw materials for a variety of industries. Because of this, its proper use requires proper identification and documentation.

If stocks are managed sensibly, it has been estimated that India's seaweed resources may support more than 20,000 fishers during the harvesting process and an equal number of jobs during the post-harvesting phase (Krishnan & Kumar, 2010). Seaweed communities can change in distribution, productivity,

and community composition as a result of changes in sea level, salinity, temperature, atmospheric CO<sub>2</sub>, and UV radiation. So, as it play crucial role in formation of marine ecosystem and give efforts in maintain whole food chain within ecosystem, it is very important to conserve and protect the status of seaweed diversity.

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