RESEARCH | Egyptian Journal of Agricultural Research | Ecosystem

Biological distribution of the rich source of marine algae from the rocky shoreline of the coast of Shivrajpur, Gujarat, India

Masuma M. Hakim Anita D. Solanki and Illa C. Patel*

Address:

Department of life Sciences, Hemchandracharya North Gujarat University, Patan-Gujarat, India

*Corresponding author: ***Masuma M. Hakim***, hakim.masuma1@gmail.com

Received: 14-05-2022, **Accepted**: 25-06-2022, **Published:** 14-07-2022 DOI, 10.21608/ejar.2022.138429.1233

ABSTRACT

In the marine environment, seaweeds are a rich natural resource. Marine algae deliver several external and internal ecological resources. The distribution of marine algal abundances was among the most studied natural occurrences, and reliable variations are regularly seen in aquatic ecosystems. This study aimed to explore a diverse group of seaweeds observed from the Shivrajpur coast, Gujarat, from December 2021. The study identified 70 species across 36 genera and 24 families. Among these, eighteen species belong to Chlorophyta, twenty-two from Phaeophyta and thirty from Rhodophyta were recorded. Compared to brown and green algae, red algae are the most prominent. But based on abundance, brown algae are dominant. Throughout the study, some economically important seaweeds are also found. Three significant orders, Fucales, Dictyotaleas, and Ceramiales, are recorded at this coastal site. In addition, many species were recorded from the Dictyotaceae and Sargassaceae families. This research outline provides the diverse seaweed resources available in the chosen location, which will be utilized in future ecological studies.

Keywords: Seaweeds, Distribution, Shivrajpur coast

INTRODUCTION

Seaweeds are the primary producer of the marine environment. They have been developing the base of the aquatic food chain; thus, they are significant to the ecosystem and almost all aquatic animals depend on them (marine algae) (Huynh and serediak, 2006). Algae remain existing around all across the earth: under the oceans, streams, above land also, on roofs, in a symbiotic relationship between plants and animals, and almost everywhere else, there is enough light to perform photosynthesis. They range in size from unicellular 3–10 microns to 70 microns and long giant kelps grow approximately 50 cm daily (El Gamal, 2010; and Hillison, 1977).

With over 7000 kilometres of coastline, India supports a rich diversity of algae (Oza and Zaidi, 2001). There are many forms of diversity, but compositional diversity, structural diversity, the separation between entities, and functional diversity are significant conceptual elements (Sala and Knowlton, 2006). Gujarat's coast possesses two gulfs, the Gulf of Kachchh (GOK) also the Gulf of Khambhat (GOKh), which are incredibly diverse due to their various coastal features, such as physiography, geomorphology, and coastal habitats. The Gujarat shoreline consists of Deccan traps, tertiary rocks, and recent alluvium and limestones with Pleistocene fossil types. Newer alluvium deposits can be found in the Gulf of Khambhat. The tidal cycle on the Indian coast is semidiurnal, with two high and two low tides each day with different tidal amplitudes (Jha *et al*., 2009). The marine algal flora of the Indian coast was first published by Iyengar (1927). In the first diversity assessment of seaweeds in India, (Krishnamurthy and Joshi, 1970) reported only 153 species belonging to 95 genera from the entire beach of Gujarat. Gujarat is rich in coastal bio-resources but is also experiencing rapid industrial and infrastructure growth (Jha *et al*., 2009). These development activities affect marine resources. There is limited data on the diversity of marine algae on the coast of Shivrajpur, so this study aimed to determine the distribution of marine algae from the coast of Shivrajpur, Gujarat.

MATERIAL AND METHODS

In the present study, algae were collected from Shivrajpur beach in Gujarat, a coastal town in the Devbhoomi Dwarka district of Gujarat, India (Figure 1). The rough bottom in this area promotes algae variety. There are few tiny, rounded rocks. To get further visibility at the collection site, samples were taken at a low tidal height (0.05 meter) and grabbed some photographs of their natural habitat (Figure 2).

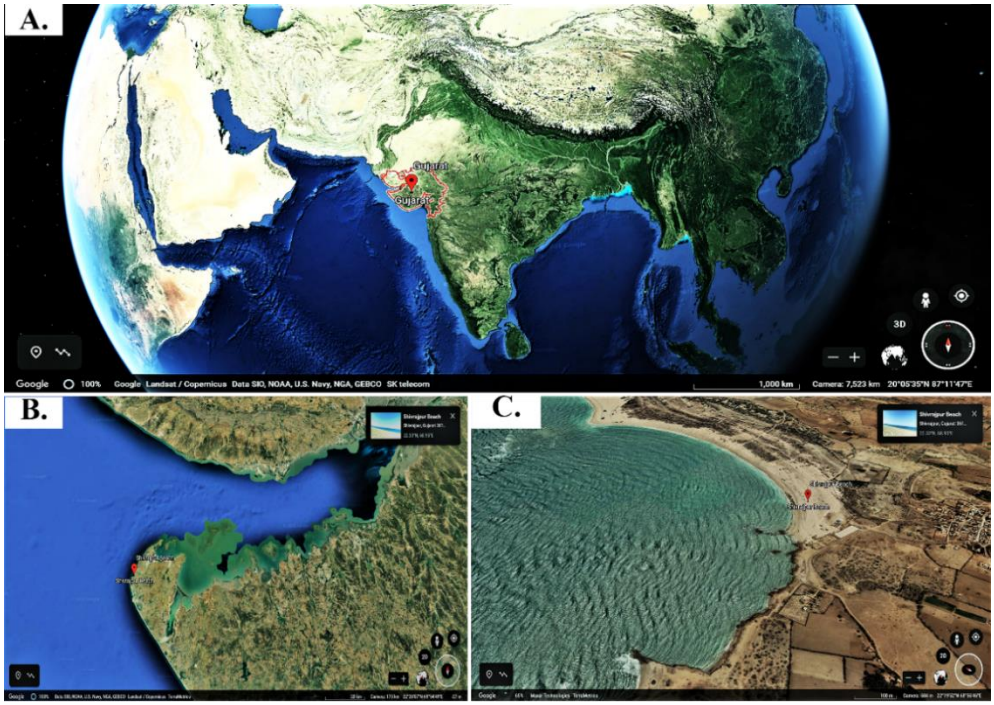


Fig. 1. Map showing A. Gujarat state. B. Map was showing Shivrajpur beach in the Gulf of Kutch. C. Map was showing the collection site.

A zip-locked polyethylene bag was used to collect the marine algae. The large quantities of marine alga samples were continuously washed with seawater followed by distilled water to remove unnecessary particles, including sand and salt. The algae were identified using morphological criteria such as scale, shape, and leaf (frond) colour using standard reference (Jha *et al*., 2009; and Sahoo, 2001) and with the extra help of the Fisheries Research Station in Okha, Gujarat.

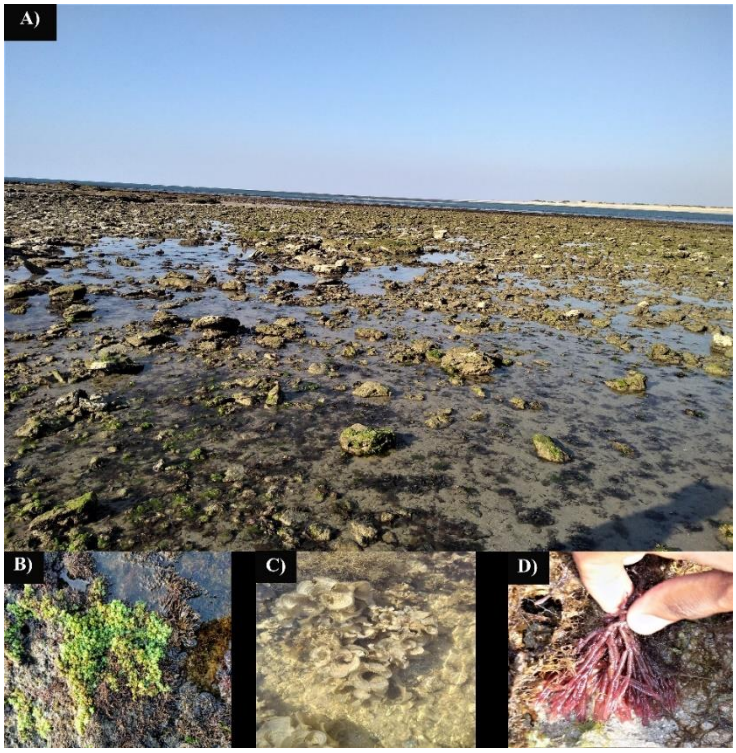


Fig. 2. The original photograph was taken during collection A. Coastal site view during low tide. B, C and D. Marine algae photograph in their natural habitat.

RESULTS

The seaweed distribution along the coast was measured using a random sampling process. The location for the sample was chosen based on the abundance of seaweed and the accessibility area. It is necessary to cover the maximum possible area during low tide. In the intertidal zone, the survey was done in a zigzag pattern. During low tide, the maximum area of the coast was assessed. A list of seaweed distribution in the Shivrajpur coast of Gujarat from December-2021 reveals the presence of 70 species under 36 genera belonging to three different classes. The Chlorophyta had 18 species belonging to 8 genera, the Phaeophyta had 22 species about 10 genera, and the Rhodophyta had 30 species referring to 18 genera. Table 1 shows a list of various marine algae species observed during the collection period, recorded species arranged in the table based on their respective order and family. It was clear from the Table 1 that the ratio of Chlorophyceae: Phaeophyceae: Rhodophyceae is 18:22:30.

Among 70 species of seaweeds, 18 species belong to green algae (Figure 3), viz., *Bryopsis hypnoides*, *Bryopsis pennata*, *Bryopsis plumose*, *Caulerpa racemosa* (Forsskal) J. Agardh, *Caulerpa racemosa* v.occidentalis (J.Agardh), *Caulerpa sertularioides*, *Caulerpa taxifolia*, *Halimeda discoida*, *Halimeda macroloba*, *Halimeda tuna*, *Udotea indica*, *Chaetomorpha* crassa, *Cladophoropsis javanica*, *Enteromorpha compressa*, *Enteromorpha linza*, *Ulva conglobate*, *Ulva lactuca* and *Ulva rigida.* In addition, 22 species were recorded from brown algae (Figure 4), viz., *Hincksia mitchelliae*, *Dictyopteris acrostichoides*, *Dictyota bartayresiana*, *Dictyota cervicornis*, *Dictyopteris australis*, *Dictyota dichotoma*, *Padina boergesenii*, *Padina boryana*, *Padina tetrastromatica*, *Spatoglossum asperum*, *Colpomenia sinuosa*, *Hydroclathrus clathratus*, *Iyengaria stellate*, *Sargassum cinctum*, *Sargassum cinereum*, *Sargassum johnstonii*, *Sargassum plagiophyllum*, *Sargassum prismaticum*, *Sargassum swartzii*, *Sargassum tenerrimum*, *Sargassum vulgare* and *Cystoseira indica*. In addition, 30 species were recorded from red algae (Figure 5), viz., *Asparagopsis taxiformis*, *Acanthophora dendroides*, *Acanthophora nayadiformis*, *Chondria dasyphylla*, *Polysiphonia ferulacea*, *Anotrichium tenue*, *Griffithsia opuntioides*, *Centroceras clavulatum*, *Spyridia filamentosa*, *Platysiphonia delicate*, *Halymenia porphyraeformis*, *Halymenia venusta*, *Grateloupiaindica*, *Grateloupia filicina*, *Champia compressa*, *Champia globulifera*, *Champia indica*, *Champia parvula*, *Champia somalensis*, *Gracilaria dura*, *Gracilaria salicornia*, *Gracilaria textorii*, *Hypnea flagelliformis*, *Hypnea musciformis*, *Hypnea valentiae*, *Sarconema filiforme*, *Sarconema scinaioides*, *Solieria robusta*, *Liagora ceranoides* and *Scinaia hatei*.

That may clarify why Rhodophyceae (red algae) grow so well in contrast to Phaeophyceae and Chlorophyceae. During the diversity study, economically valuable seaweed was identified like *Gracilaria dura*, *Hypnea musciformis*, *Asparagopsis taxiformis*, *Sargassum tenerrimum*, *S. plagiophyllum*, *S. swartzii*, *Enteromorpha compressa* and *Caulerapa* species are also present. Table 2 shows the colour scale illustration of the number of seaweeds per their respective family. Among the maximum number of species found in the Dictyotaceae (9 species) and Sargassaceae (9 species) family, the least number of species (1 species) found in Udoteaceae, Cladophoraceae, Boodleaceae, Acinetosporaceae, Bonnemaisoniaceae, Ceramiaceae, Spyridiaceae, Sarcomeniaceae, Ligoraceae and Scinaiaceae family. The brown algae (*Sargassum*, *Padina* and *Dictyota* species) and green algae (*Coulerpa* and *Ulva* species) are common algae species observed along the coast.

Table 1. Taxonomic classification of seaweed recorded at Shivrajpur coast, Gujarat.

Sr. No.	Scientific name of Algae	Order	Family
CHLOROPHYTA			
1.	*Bryopsis hypnoides* Lamouroux	Bryopsidales	Bryopsidaceae
2.	*Bryopsis pennata* Lamouroux		
3.	*Bryopsis plumose* (Hudson) C.Agarth		
4.	*Caulerpa racemosa* (Forsskal) J. Agardh		Caulerpaceae
5.	*Caulerpa racemosa* v.occidentalis (J.Agardh)		
6.	*Caulerpa sertularioides* (S.Gmelin)		
7.	*Caulerpa taxifolia* (Vahl) C.Agardh		
8.	*Halimeda discoida*		Halimedaceae
9.	*Halimeda macroloba* Decaisne		
10.	*Halimeda tuna* (Ellis&Solandes)		
11.	*Udotea indica* A. & E. Gepp.		Udoteaceae
12.	*Chaetomorpha crassa* (C.Agardh) Kutzing	Cladophorales	Cladophoraceae
13.	*Cladophoropsis javanica* P.Siva		Boodleaceae
14.	*Enteromorpha compressa* (Linnaeus) Nees	Ulvales	Ulvaceae
15.	*Enteromorpha linza* (Linnaeus) J.Agardh		Ulvaceae
16.	*Ulva conglobata* Kjellman		Ulvaceae
17.	*Ulva lactuca* Linnaeus		Ulvaceae
18.	*Ulva rigida* C. Agardh		Ulvaceae
PHAEOPHYTA			
19.	*Hincksia mitchelliae* J.agardh	Ectocarpales	Acinetosporaceae
20.	*Dictyopteris acrostichoides* (J. Agardh) Bornet	Dictyotales	Dictyotaceae
21.	*Dictyota bartayresiana* Lamouroux		

22.	*Dictyota cervicornis* Kutzing		
23.	*Dictyopteris australis* (Sonder)		
24.	*Dictyota dichotoma* (Hudson) Lamouroux		
25.	*Padina boergesenii* Allender& Kraft		
26.	*Padina boryana* Thivy		
27.	*Padina tetrastromatica* Hauck		
28.	*Spatoglossum asperum* J. Agardh		
29.	*Colpomenia sinuosa* (Martens ex Roth) Derbes & Solier	Ectocarpales	Scytosiphonaceae
30.	*Hydroclathrus clathratus* (C.Agardh) Howe	Scytosiphonales	
31.	*Iyengaria stellata* (Borgesen)		
32.	*Sargassum cinctum* J. Agardh	Fucales	Sargassaceae
33.	*Sargassum cinereum* J. Agardh		
34.	*Sargassum johnstonii* Setchell& Gardner		
35.	*Sargassum plagiophyllum* (Martens) J. Agardh		
36.	*Sargassum prismaticum* Chauhan		
37.	*Sargassum swartzii* C. Agardh		
38.	*Sargassum tenerrimum* J. G.		
39.	*Sargassum vulgare* C. Agardh		
40.	*Cystoseira indica* (Thivy&Doshi) Mairh		
RHODOPHYTA			
41.	*Asparagopsis taxiformis* (Delile) Trevisan	Bonnemaisonial es	Bonnemaisoniaceae
42.	*Acanthophora dendroides* Harvey	Ceramiales	Rhodomelaceae
43.	*Acanthophora nayadiformis* (Delile) Papenfuss		
44.	*Chondria dasyphylla* (Woodward) C.Agardh		
45.	*Polysiphonia ferulacea* Suhr ex J.Agardh		
46.	*Anotrichium tenue* (C.Agardh) Nageli		Wrangeliaceae
47.	*Griffithsia opuntioides* J.Agardh		
48.	*Centroceras clavulatum* (C.Agardh) Montagne		Ceramiaceae
49.	*Spyridia filamentosa* (Wulfen) Harvey		Spyridiaceae
50.	*Platysiphonia delicate* (Clemente) cremades		Sarcomeniaceae
51.	*Halymenia porphyraeformis* Parkinson	Halymeniales	Halymeniaceae
52.	*Halymenia venusta* Borgesen		
53.	*Grateloupia indica* Borgesen		
54.	*Grateloupia filicina* (Lamouroux) C.Agardh		
55.	*Champia compressa* Harvey	Rhodymeniales	Champiaceae
56.	*Champia globulifera* Bogesen		
57.	*Champia indica* Bogesen		
58.	*Champia parvula* (C.Agardh)Harvey		
59.	*Champia somalensis* Hauk		
60.	*Gracilaria dura* (C.Agardh)	Gracilariales	Gracilariaceae
61.	*Gracilaria salicornia* (C.Agardh)Dawson		
62.	*Gracilaria textorii* (Suringar)De Toni		
63.	*Hypnea flagelliformis* Greville ex. J.Agardh	Gigartinales	Cystocloniaceae
64.	*Hypnea musciformis* (Wulfen) Lamouroux		
65.	*Hypnea valentiae* (Turner) montagne		
66.	*Sarconema filiforme* (Sonder) Kylin		Solieriaceae
67.	*Sarconema scinaioides* Borgesen		
68.	*Solieria robusta* (Greville) Kylin		
69.	*Liagora ceranoides* Lamouroux	Nemaliales	Ligoraceae
70.	*Scinaia hatei* Borgesen		Scinaiaceae

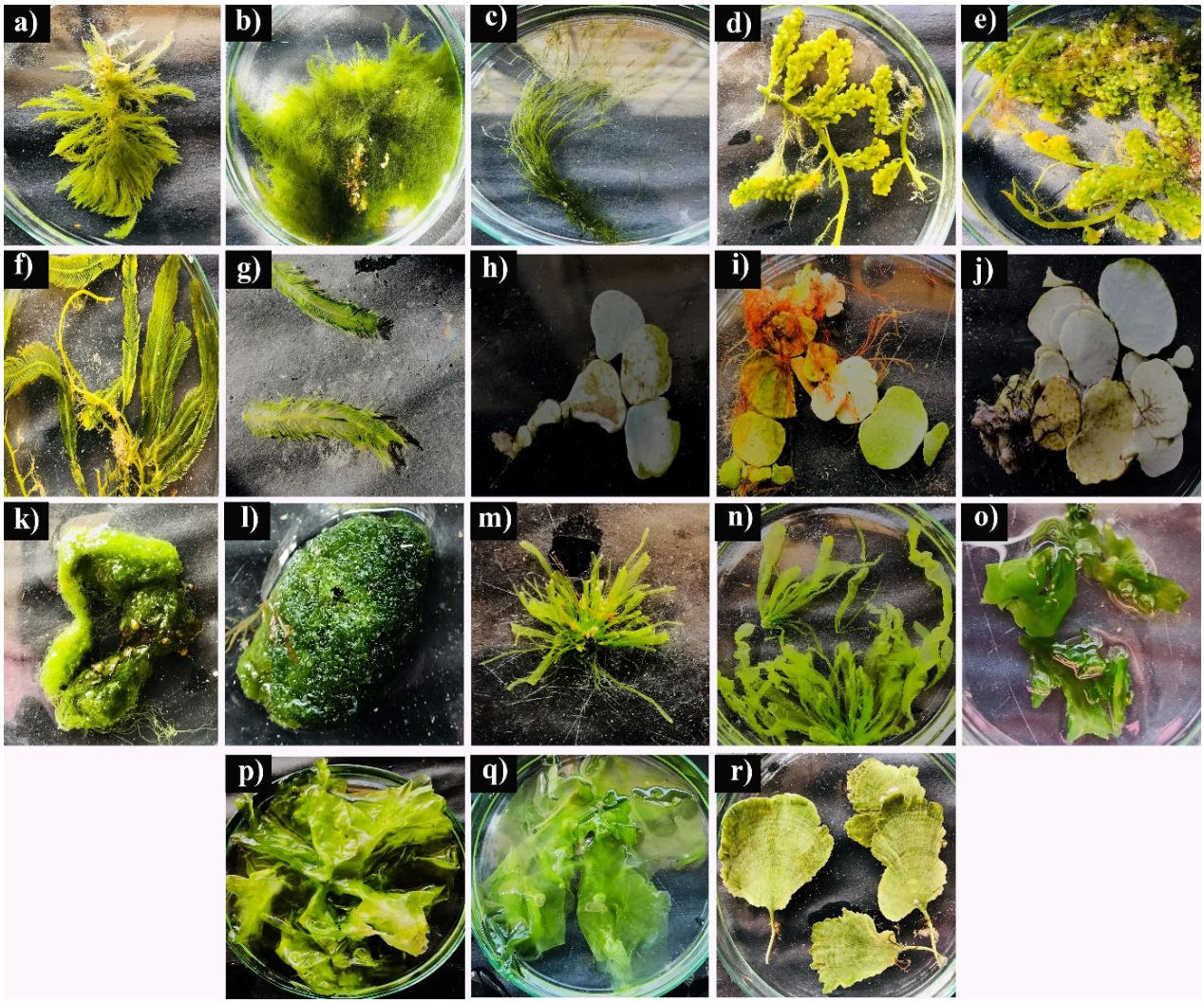


Fig. 3. Photograph of green algae collected from the coastal site. a) *Bryopsis hypnoides* b) *Bryopsis pennata* c) *Bryopsis plumose* d) *Caulerpa racemosa*(Forsskal) J. Agardh e) *Caulerpa racemosa* v.occidentalis (J.Agardh) f) *Caulerpa sertularioides* g) *Caulerpa taxifolia* h) *Halimeda discoida* i) *Halimeda macroloba* j) *Halimeda tuna* k) *Chaetomorpha crassa* l) *Cladophoropsis javanica* m) *Enteromorpha compressa* n) *Enteromorpha linza* o) *Ulva conglobate* p) *Ulva lactuca* q) *Ulva rigida* r) *Udotea indica.*

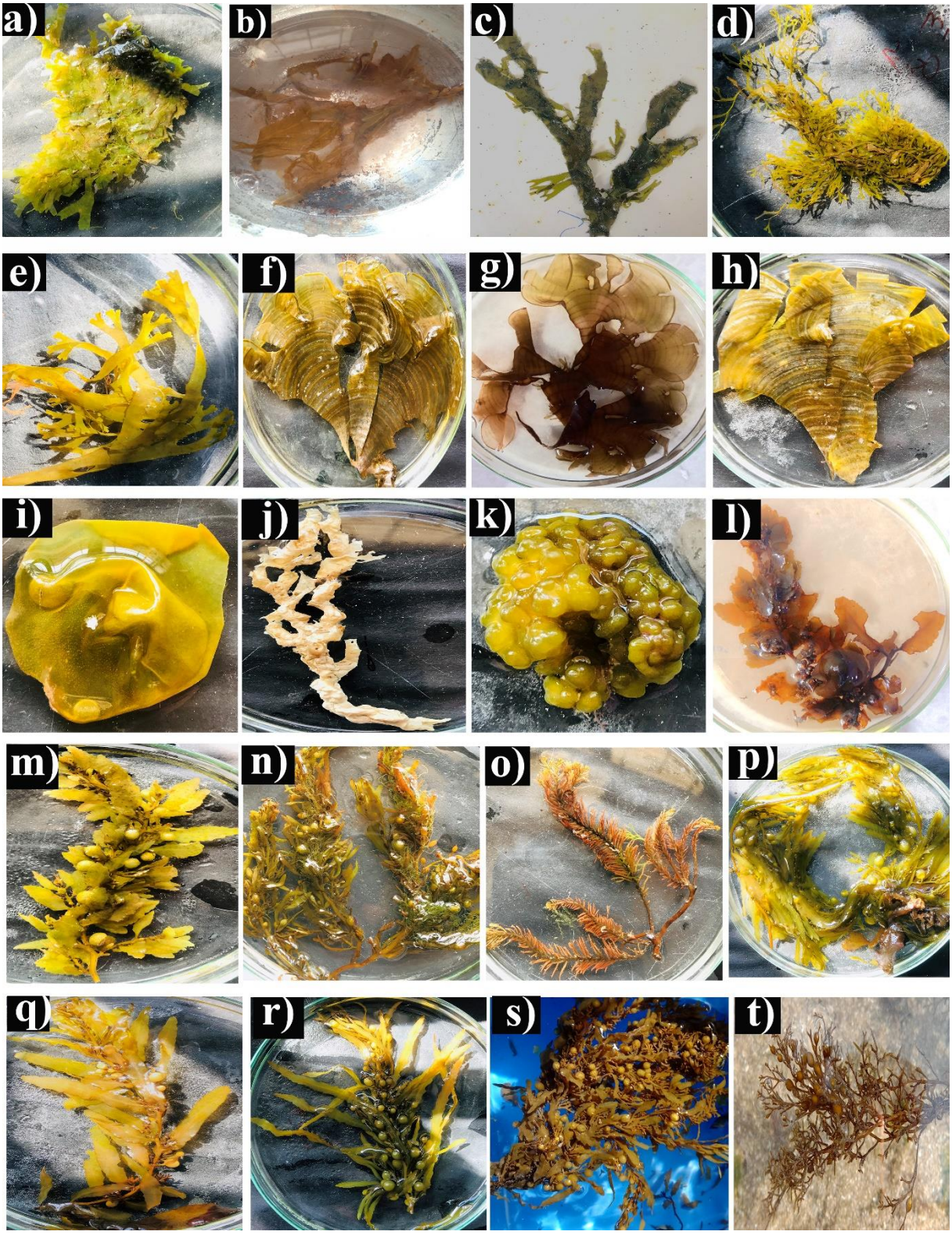


Fig. 4. Photograph of brown algae collected from the coastal site. a) *Dictyopteris acrostichoides* b) *Dictyopteris australis* c) *Dictyota bartayresiana* d) *Dictyota cervicornis* e) *Dictyota dichotoma* f) *Padina boergesenii* g) *Padina tetrastromatica* h) *Padina boryana* i) *Colpomenia sinuosa* j) *Hydroclathrus clathratus* k) *Iyengaria stellata* l) *Sargassum cinctum* m) *Sargassum cinereum* n) *Sargassum johnstonii* o) *Sargassum plagiophyllum* p) *Sargassum prismaticum* q) *Sargassum swartzii* r) *Sargassum tenerrimum* s) *Sargassum vulgare* t) *Cystoseira indica*

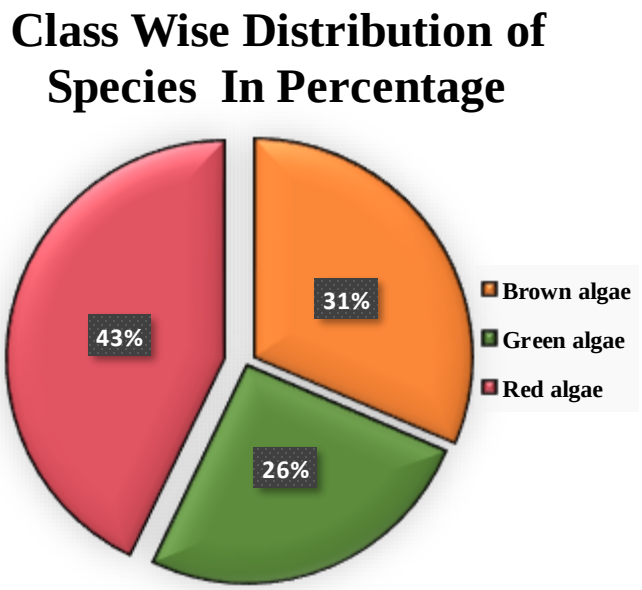
DISCUSSION

The occurrence and diversity of seaweed in a marine environment are primarily determined by insignificant exposure depth, temperature, tides, and seashore characteristics (Darghalkar and kavlekar, 2004). Their diversity benefits a variety of other species while also providing conservation benefits in the coastal zone (Wernberg *et al*., 2011). Seaweeds occupy a significant amount of rocky shore space and associate with other species, making them important contributors to overall coastal biodiversity (Sathe esh and Wesley, 2012). Algae occur along the coasts of India's various

Fig. 5. Photograph of red algae collected from the coastal site. a) *Asparagopsis taxiformis* b) *Acanthophora dendroides* c) *Acanthophora nayadiformis* d) *Chondria dasyphylla* e) *Polysiphonia ferulacea* f) *Anotrichium tenue* g) *Halymenia porphyraeformis* h) *Griffithsia opuntioides* i) *Centroceras clavulatum* j) *Spyridia filamentosa* k) *Platysiphonia delicate* l) *Halymenia venusta* m) *Grateloupia indica* n) *Grateloupia filicina* o) *Champia compressa* p) *Champia parvula* q) *Champia globulifera* r) *Champia indica* s)

Champia somalensis t) *Gracilaria dura* u) *Gracilaria salicornia* v) *Gracilaria textorii* w) *Hypnea flagelliformis* x) *Hypnea valentiae* y) *Sarconema filiforme* z) *Solieria robusta* aa) *Liagora ceranoides* bb) *Scinaia hatei* cc) *Sarconema filiforme* dd) *Hypnea musciformis.*

states, where they are diverse and primarily comprise tropical varieties. However, multiple rocky shores, mudflats, shorelines and coral rocks in the coastal areas of India offered suitable environments for developing marine algae due to boreal, temperature, and sub-tropical elements (Sirajunnisa *et al*., 2016). There is a wide diversity of marine algae from Tamil Nadu (Mandapam) to Kanyakumari, the coastal area of Gujarat, Lakshadweep and Andaman-Nicobar Islands (Parthiban and Anantharaman, 2018). Thivy, in 1958, was the first to survey the occurrence of commercial algal sources on the Indian shoreline. Floating marine algae



from the Indian Ocean, Atlantic and Pacific seas have been recorded by Hirata *et al*., (2003). The findings of this study correlated with earlier studies by Rao *et al*., (2011), who investigated the seasonal changes in occurrences of marine algae from three distinct areas of the Bhimili coast. Similarly, a biodiversity analysis was performed along the Okha coast, which revealed a total of 39 species of marine algae, including 16 Chlorophyta species, 10 Phaeophyta species, and 13 Rhodophyta species (Dave *et al*., 2019), Whereas studies, were done by Kumar *et al.,* (2017) revealed a total 70 species of marine algae, including 36 Rhodophyta species, 18 Phaeophyta species, and 16 Chlorophyta species among all seaweeds S*argassum* species are a large portion of Okha beach throughout the research.

Fig. 6. Class-wise distribution of seaweed species at Shivrajpur coast.

Table 2. The Colour scale illustrates species as per class and families (Generated using Microsoft Excel 2019).

Class	Family	Number of species
Chlorophyta	Bryopsidaceae	3
	Caulerpaceae	4
	Halimedaceae	3
	Udoteaceae	1
	Cladophoraceae	1
	Boodleaceae	1
	Ulvaceae	5
Phaeophyta	Acinetosporaceae	1
	Dictyotaceae	9
	Scytosiphonaceae	3
	Sargassaceae	9
Rhodophyta	Bonnemaisoniaceae	1
	Rhodomelaceae	4
	Wrangeliaceae	2
	Ceramiaceae	1
	Spyridiaceae	1

	Sarcomeniaceae	**1**
	Halymeniaceae	**4**
	Champiaceae	**5**
	Gracilariaceae	**3**
	Cystocloniaceae	**3**
	Solieriaceae	**3**
	Ligoraceae	**1**
	Scinaiaceae	**1**
Total class: 3	**Total Family: 24**	**Total species: 30**

CONCLUSION

Expanding worldwide human influences and climate change have contributed to changing the ecology and distribution of marine algae. This study provides evidence that brown and green seaweeds are this area's most widely distributed seaweed species. However, brown seaweed, namely, *Sargassum* species found to be the most abundant in areas most exposed to sea waves. The increasing abundance of specific species was directly correlated with environmental variables. The greater diversity of red marine algae indicated that the environment is conducive to the growth of red algae. Seaweed diversity data may also serve as a starting point for more specific ecological studies in the future, such as preparing the protection and sustainable use of coastal natural resources, as well as serving as a climatic change and coastal management predictor and a practical aspect of seaweed use. Furthermore, systematizing investigations into marine algae resources contributes to protecting marine algae resources in this coastal environment.

Funding: Not applicable.
Conflict of Interest: The authors declare no conflict of interest

REFERENCES

Dave, T. H., Vaghela, D. T., & Chudasama, B. G. (2019). Status, distribution, and diversity of some macroalgae along the intertidal coast of Okha, Gulf of Kachchh, Gujarat in India. *Journal of Entomology and Zoology Studies*, 7(3), 327-331.

Dhargalkar, V. K., & Kavlekar, D. P. (2004). Seaweeds-a field manual.

Domettila, C., Brintha, T. S. S., Sukumaran, S., & Jeeva, S. (2013). Diversity and distribution of seaweeds in the Muttom coastal waters, south-west coast of India. *Biodiversity Journal*, 4(1), 105-110.

El Gamal, A. A. (2010). Biological importance of marine algae. *Saudi pharmaceutical journal*, 18(1), 1-25.

Hillison, C.I., (1977). Seaweeds, a color-coded, illustrated guide to common marine 1977. Plants of east coast of the United States, Keystone Books. *The Pennsylvania State University Press*, pp. 1–5.

Hirata, T., Tanaka, J., Iwami, T., Ohmi, T., Dazai, A., Aoki, M., ... & Yokohama, Y. (2003). Ecological studies on the community of drifting seaweeds in the south-eastern coastal waters of Izu Peninsula, central Japan. II: Seasonal changes in plants showing maximum stipe length in drifting seaweed communities. *Phycological research*, 51(3), 186-191.

Huynh, M., & Serediak, N. (2006). Algae Identification Field Guide Agriculture and Agric-Food Canada. *Agri-Environment Services Branch, Majesty the Queen in Right of Canada: Ottawa, ON, Canada.*

Iyengar, M. O. P. (1927). Krusadai island flora. *Bulletin of the Madras Government Museum, New Series, Natural History Section*, 1, 185-188.

Jha, B., Reddy, C. R. K., Thakur, M. C., & Rao, M. U. (2009). *Seaweeds of India: the diversity and distribution of seaweeds of Gujarat coast* (Vol. 3). Springer Science & Business Media.

Krishnamurthy, V., & Joshi, H. V. (1970). *A check-list of Indian marine algae*. Central Salt & Marine Chemicals Research Institute.

Kumar, N. J., Barot, M., & Kumar, R. N. (2017). Distribution and biochemical constituents of different seaweeds collected from Okha coast, Gujarat, India.

Oza, R. M., & Zaidi, S. H. (2001). A revised checklist of Indian marine algae. *CSMCRI, Bhavnagar*, *296*.

Parthiban, C., & Anantharaman, P. (2018). Diversity and Biomass of Drift Seaweeds from the Tuticorin Coast, India. *License This work is licensed under a Creative Commons Attribution 4.0 International License.*, *19*, 72-86.

Rao, K. S., Murty, K. P., & Rao, G. N. (2011). Seasonal studies on marine algae of the Bhimili coast, East coast of India. *Journal of Algal Biomass Utilization*, 2(2), 69â.

Sahoo D, Sahoo N, Debasish (2001*) Seaweeds of India coast*. A.P.H Publication, New Delhi, p 283

Sala, E., & Knowlton, N. (2006). Global marine biodiversity trends. *Annual review of environment and resources*, *31*(1), 93-122.

Satheesh, S., & Wesley, S. G. (2012). Diversity and distribution of seaweeds in the Kudankulam coastal waters, south-eastern coast of India. *Biodiversity Journal*, *3*(1), 79-84.

Sirajunnisa, A. R., & Surendhiran, D. (2016). Algae–A quintessential and positive resource of bioethanol production: A comprehensive review. *Renewable and sustainable energy reviews*, *66*, 248-267.

Thivy, F., 1958. Economic seaweeds. In: Jones, S. (Ed.), Fisheries of west coast of India. *CMFRI,* Cochin. 1-8.

Umamaheswararao, M., & Sreeramulu, T. (1964). An ecological study of some intertidal algae of the Visakhapatnam coast. *The Journal of Ecology*, 595-616.

Wernberg, T., Russell, B. D., Moore, P. J., Ling, S. D., Smale, D. A., Campbell, A., ... & Connell, S. D. (2011). Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming. *Journal of experimental marine biology and ecology*, *400*(1-2), 7-16.