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Tandel Bhavika
College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India

Bhatt Ashish
College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India

Tandel Lata
College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India

Tandel Mayur
College of Fisheries, Ratnagiri, Dr. Balasaheb, Sawant, Konkan, Krishi, Vidyapeeth, Dapoli, Maharashtra, India

Parmar Jeet
College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India

Katara Satyendra
College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India

Corresponding Author
Tandel Bhavika
College of Fisheries Science, Kamdhenu University, Veraval, Gujarat, India

Diversity of Phaeophyceae group of seaweed along the Sikka coast, Gujarat

Tandel Bhavika, Bhatt Ashish, Tandel Lata, Tandel Mayur, Parmar Jeet and Katara Satyendra

Abstract
Sikka coast (22˚25' 55.85" N and 69˚50' 29.69" E) is situated in the center of southern coast of Gulf of Kachchh and is one of the most important places of interest for algal growth in India. The present study highlights the diversity of Phaeophyceae along two locations of Sikka coast *viz*., GSFC jetty and Vador site. In present study (from October-2020 to March-2021), a total of 18 and 16 species of Phaeophyceae were recorded from GSFC Jetty and Vador site respectively. Highest number of phaeophyceae was recorded during March while least was observed in October and December. *Padina gymnospora, Dictyota dichotoma, Ectocarpus sp.* and *Sargassum sp.* were the most dominant species found during investigation. Temperature is an important factor that was observed to play an important role in controlling seaweed diversity in the present study because with increased temperature, diversity of Phaeophyceae was also increased. Among the two sites, GSFC Jetty have more species diversity as compared to the Vador site.

Keywords: Phaeophyceae, diversity, gulf of Kachchh, physico-chemical parameters

1. Introduction
Seaweeds are macroscopic marine algae or macroalgae found along the seashore (Patel *et al.*, 2020; Ganesh *et al.*, 2019) [15, 7]. Among all the coastal regions of India, Tamil Nadu and Gujarat coasts are rich in seaweed resources. There are 841 species of seaweeds belonging to 216 genera of 68 families present in Indian waters. Gujarat has the highest coastline of about 1600 km, which harbours about 198 species of seaweeds, representing rhodophyta: 109 species from 62 genera; chlorophyta: 54 species from 23 genera; phaeophyta: 35 species from 16 genera. The coastline of Tamil Nadu is about 1076 km, which harbours 282 species (Ganesan *et al.*, 2019) [6].

Seaweeds are known for reducing eutrophication because they have the characteristic of remove or consume the nutrients like nitrogen and phosphorus from domestic sewage and other effluents. They contain bioactive substances and are important sources of fertilizers and many other commercially important substances (Saxena, 2012) [19]. Seaweed beds offer ultimate habitation, food and shelter to numerous marine faunas and also provides feeding, breeding and nursery grounds to various epiphytic fauna. 5 Marine algae bind the sediments together by their holdfast or hapteron, through which it prevents coastal erosion (Kolanjinathan *et al.*, 2014) [9]. The Seaweed resources of the Indian coast are significantly characterized as good food and also they are a rich source of minerals, particularly macro and micronutrients essential for human nutrition. Seaweeds yield about 60 trace elements in a concentration 4 much higher as compared to terrestrial plants (Ponnanikajamideen *et al.*, 2014) [16].

Phaeophyceae, a group of seaweed is also known as brown algae (derived from the Greek word Phaeos, meaning “brown”) are more or less exclusively marine. Around 1500 species of brown algae are solely found in marine habitats. A brown pigment called fucoxanthin present in seaweed is the reason behind its brown colour (Sahoo, 2010) [18]. *Sargassum* and *Cystoseira* are the most commonly occurring brown algae of the Indian coast. Alginic acid and the alginates are produced from these species. Their ecology, life cycle and methods of cultivation have been studied on the Gujarat coast and southeast coast of India. Many experiments for the culture of brown seaweeds were carried out on both the West coast (Okha, Gujarat) and East coast (Mandapam, Tamil Nadu) of India (Reddy *et al.*, 2014) [17].

Brown seaweeds such as Sargassum, Turbinaria, Cystoseira, Spatoglossum, Hydroclathrus, Padina and Dictyota have mostly occurred in the Gulf of Kachchh, Okha, Dwarka, Bombay,

Goa, Karwar, Vizhinjam, Muttam, Kovalam, Tuticorin, 6 Mandapam, Mahabalipuram, Madras, Pulicat, Visakhapatnam and Andaman-Nicobar coasts of India as per their preferred geographical area (Chennubhotla *et al.*, 1991) [3].

2. Materials and Methods

2.1 Study location

The Sikka coast is situated in the center of the southern coast of Gulf of Kachchh and is one of the most important places of interest for algal growth in India. This coast is found at the mouth of the Gulf of Kachchh experiences strong water currents round the year as compared to other parts of the country in Gujarat, India.

An initial survey was conducted along two different sites of the Sikka coast to identify the major areas of seaweed-prone sites.

Site 1: GSFC Jetty (Gujarat State Fertilizers and Chemicals Ltd)

Site 2: Vador site

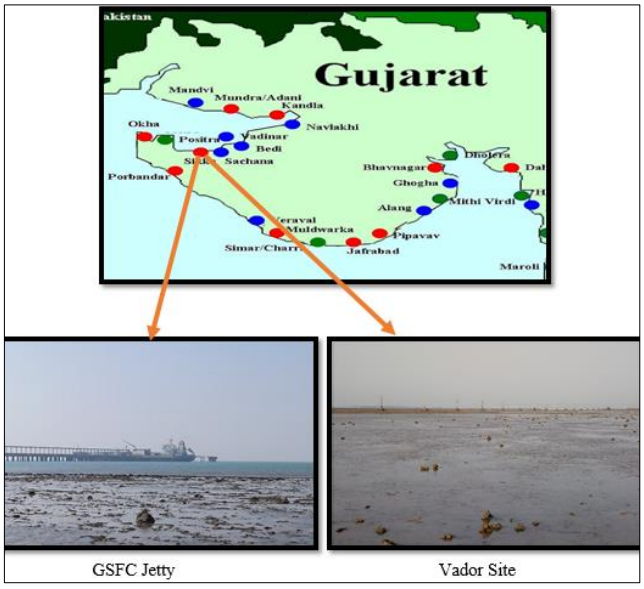


Fig 1: Map showing the study area of GSFC Jetty and Vador site, Sikka coast, Gujarat

2.2 Study period

The study was conducted for six months and the samples were collected monthly during the year October-2020 to March-2021 from the GSFC Jetty and Vador site of the Sikka coast, Gujarat, during the lowest low tide of the chart datum.

2.3 Sampling procedure

For the study of species diversity of Phaeophyceae, the belt transect method was used. For this quadrate of 1 m^2 was used. Total 30 quadrates (3 transects) were studies and analysed. The species diversity collected was identified up to the species level in the laboratory using the guides given by Jha *et al.* 2009 [8]; Dodia and Joshi, 2012 [5]. Few species were preserved in the form of herbaria. The physico-chemical parameters such as temperature, pH, salinity and dissolved oxygen of water were also recorded. Dissolved oxygen was analysed by using Winkler's method at laboratory.

2.4 Biodiversity assessments

Biodiversity indices such as Shannon Wiener diversity index (*H'*) and Margalef diversity index (*D*) were also calculated for GSFC Jetty and Vador site of Sikka coast.

3. Results

3.1 Species diversity

Table 1 indicates the different seaweed species recorded during the period of investigation. A total of 18 and 16 Phaeophyceae species belonging to 4 orders (Dictyotales, Fucales, Scytosiphonales and Ectocarpales), 5 families (Dictyotaceae, Sargassaceae, Scytosiphonaceae, Chnoosporaceae and Ectocarpaceae) and 10 genera were recorded from GSFC Jetty and Vador site of Sikka coast. The highest number of species were recorded from the family Sargassaceae followed by Dictyotaceae and Ectocarpaceae.

From 18 species of Phaeophyceae recorded in the study, 5 species belonging to Dictyotaceae *viz.*, *Padina gymnospora*, *Dictyota dichotoma*, *Dictyota pinnatifida*, *Dictyota ciliolata* and *Spatoglossum asperum* were identified. From Sargassaceae family, 8 species – *Sargassum tenerrimum*, *Sargassum cinctum*, *Sargassum cinereum*, *Sargassum prismaticum*, *Sargassum swartzii*, *Sargassum johnstonii*, *Sargassum vulgare* and *Cystoseira trinodis* were recorded. Scytosiphonaceae family was represented by 3 species *viz.*, *Iyengaria stellate*, *Hydroclathrus clathratus* and *Rosenvingea intricata*. From the family Chnoosporaceae and Ectocarpaceae, only one species from each family *Rosenvingea orientalis* and *Ectocarpus sp.* were investigated during the study.

Table 1: Taxonomic classification of collected Phaeophyceae from Sikka coast

Order	Family	Genus	Species	GSFC Jetty	Vador
Dictyotales	Dictyotaceae	Padina	gymnospora	+	+
		Dictyota	dichotoma	+	+
			pinnatifida	+	+
			ciliolata	+	+
		Spatoglossum	asperum	+	+
Fucales	Sargassaceae	Sargassum	tenerrimum	+	+
			cinctum	+	+
			cinereum	+	+
			prismaticum	+	+
			swartzii	+	-
			johnstonii	+	-
			Vulgare	+	+
		Cystoseira	Trinodis	+	+
Scytosiphonales	Scytosiphonaceae	Iyengaria	Stellate	+	+
		Hydroclathrus	clathratus	+	+
		Rosenvingea	intricata	+	+

Ectocarpales	Chnoosporaceae	Rosenvingea	orientalis	+	+
	Ectocarpaceae	Ectocarpus	sp.	+	+

+: Available
-: Not available

At GSFC Jetty, maximum species diversity of Phaeophyceae was recorded from January to March and minimum diversity was observed during October to December. The most dominant species was *Ectocarpus sp.* with maximum numbers recorded in January. While at Vador site, the highest number of species were recorded during March. There were no species recorded in December. The most dominant species was *Padina gymnospora* with maximum numbers recorded in March (Figure 2 and Figure 3).

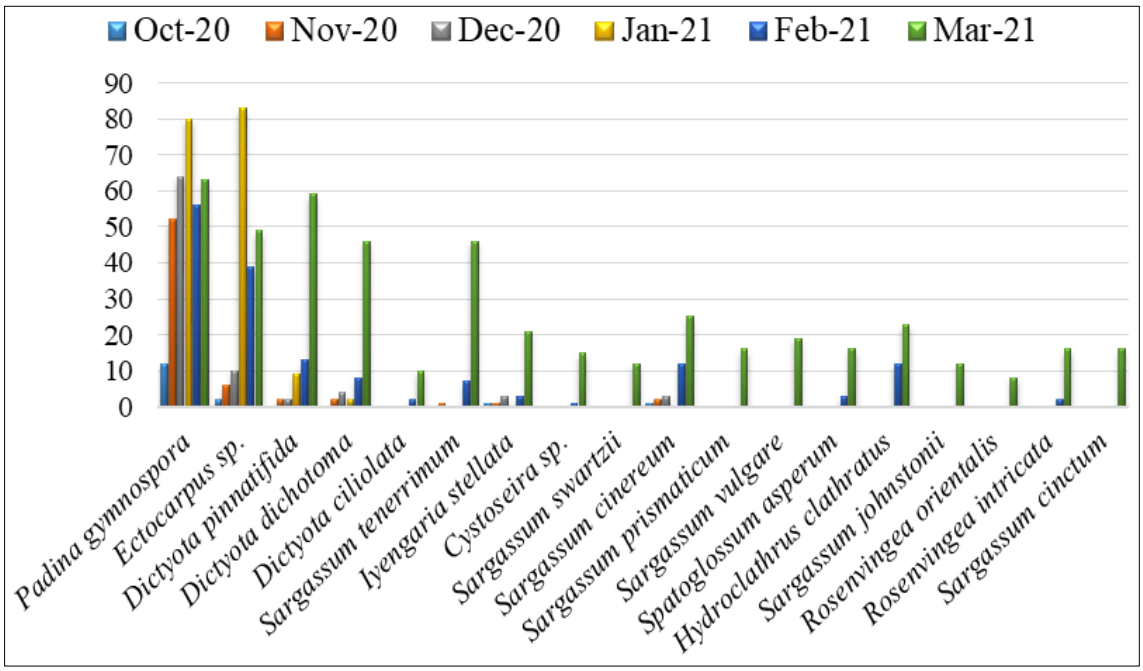


Fig 2: Diversity of Phaeophyceae along GSFC Jetty, Sikka

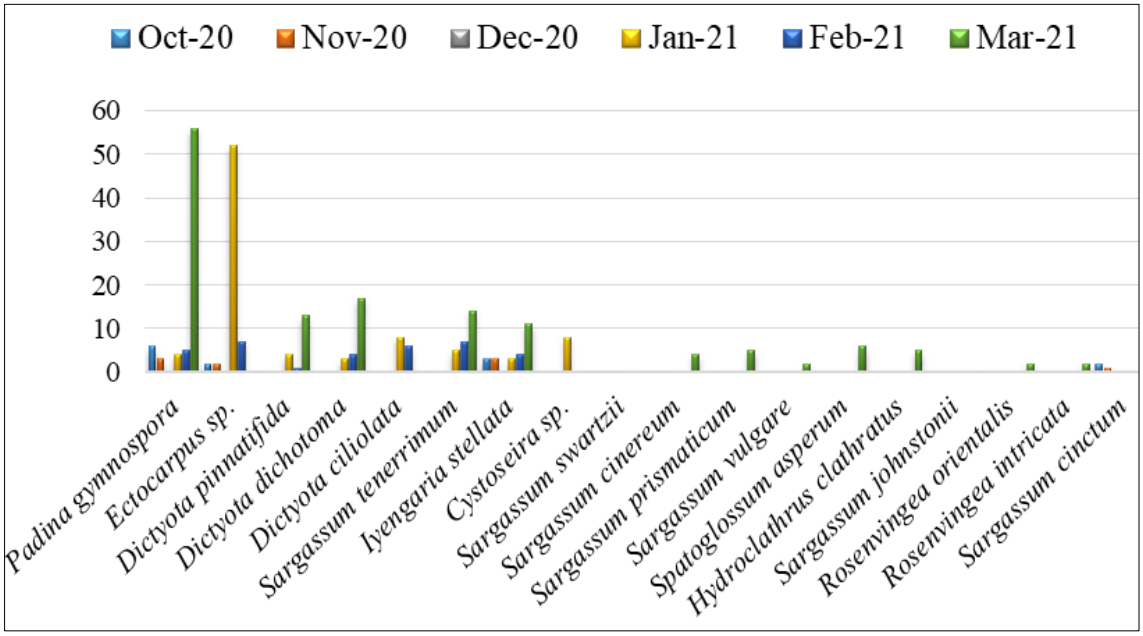
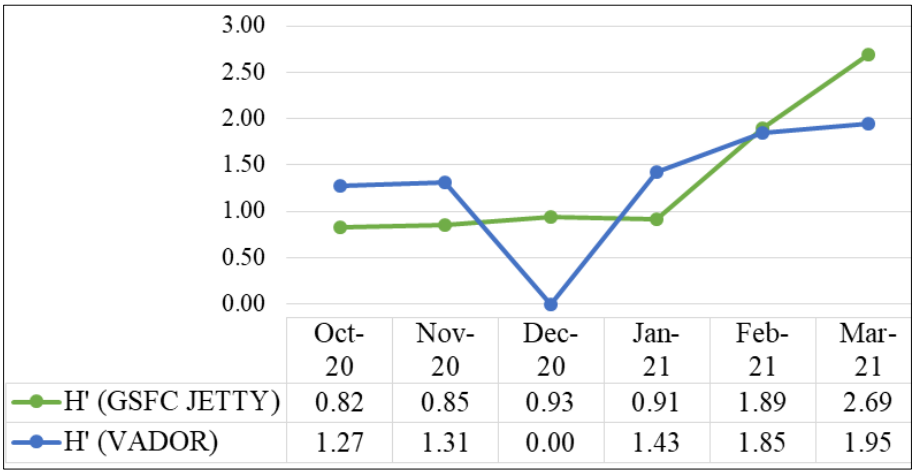


Fig 3: Diversity of Phaeophyceae along the Vador site, Sikka

3.2 Biodiversity assessments

3.2.1 Shannon Wiener diversity index (*H'*)

The Shannon Wiener diversity index (*H'*) of Phaeophyceae along GSFC Jetty and Vador site of Sikka coast during different months are represented in Figure 4. The Shannon Wiener diversity index (*H'*) in GSFC Jetty and Vador site of Sikka coast were in the range of 0.82-2.69 and 0.00-1.95 respectively. From GSFC Jetty, the highest and lowest values of *H'* were observed in March and October respectively while from the Vador site, highest and lowest values of *H'* were observed in March and December respectively.

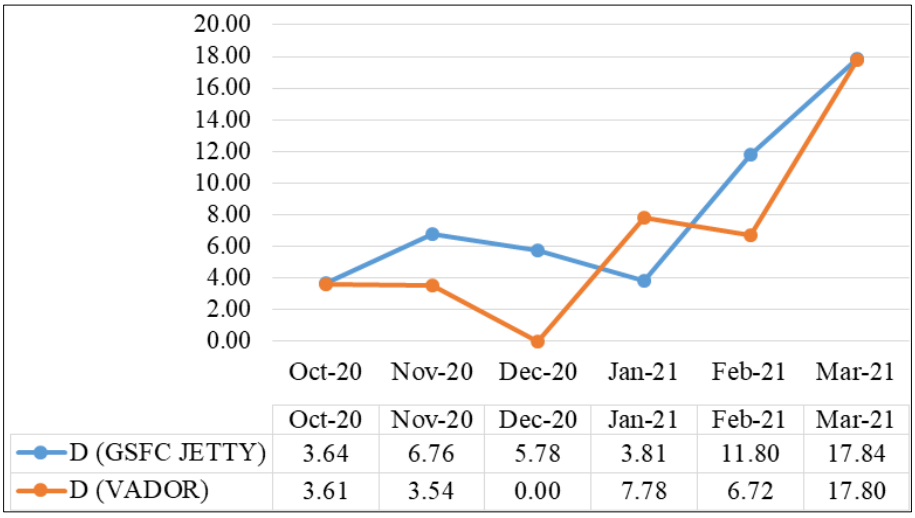


	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21
H' (GSFC JETTY)	0.82	0.85	0.93	0.91	1.89	2.69
H' (VADOR)	1.27	1.31	0.00	1.43	1.85	1.95

Fig 4: Variation in Shannon Wiener diversity index (*H'*) of Phaeophyceae along GSFC Jetty and Vador site, Sikka

3.2.2 Margalef diversity index (D)

Margalef diversity index (*D*) of Phaeophyceae along GSFC Jetty and Vador site of Sikka coast during different months are represented in Figure 5. The Margalef diversity index (D) in GSFC Jetty and Vador site of Sikka coast were in the range of 3.64-17.84 and 0.00-17.80 respectively. From the GSFC Jetty, the highest and lowest values of *D* were observed in March and October respectively while from the Vador site, the highest and lowest values of *D* were observed in March and December respectively.



	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21
D (GSFC JETTY)	3.64	6.76	5.78	3.81	11.80	17.84
D (VADOR)	3.61	3.54	0.00	7.78	6.72	17.80

Fig 5: Variation in Margalef diversity index (*D*) of Phaeophyceae along GSFC Jetty and Vador site, Sikka

3.3 Analysis of hydrological parameters studied at Sikka coast

The seawater temperature at GSFC Jetty and Vador site was ranging from 21.3 – 29.4^0 C (Figure 6) and 21 – 28.8^0 C (Figure 7) respectively. The value of pH at GSFC Jetty and Vador site was ranging from 7.9 – 8.3 (Figure 6) and 8.0 – 8.4 (Figure 7) respectively. The value of salinity at GSFC Jetty and Vador site was ranging from 39 - 41ppt (Figure 6) and 38 - 41ppt (Figure 7) respectively. The value of dissolved oxygen (DO) at GSFC Jetty and Vador site was ranging from 7.62 – 8.90ppm (Figure 6) and 7.71 – 8.84ppm (Figure 7) respectively.

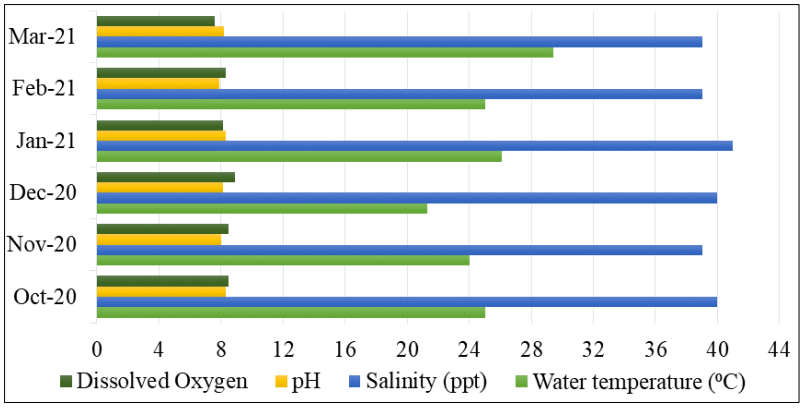


Fig 6: Monthly variation in physico-chemical parameters along GSFC Jetty, Sikka (October 2020 – March 2021)

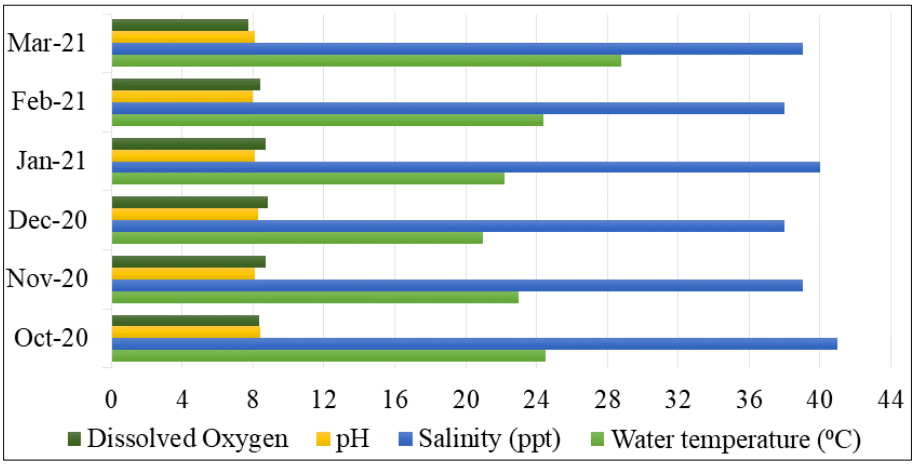
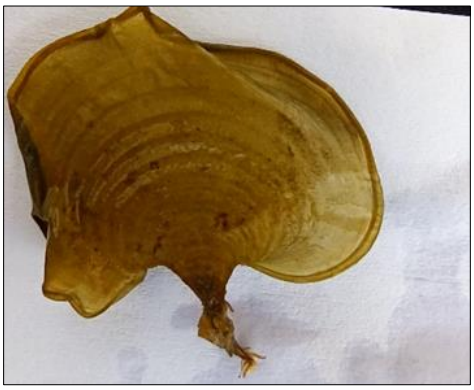
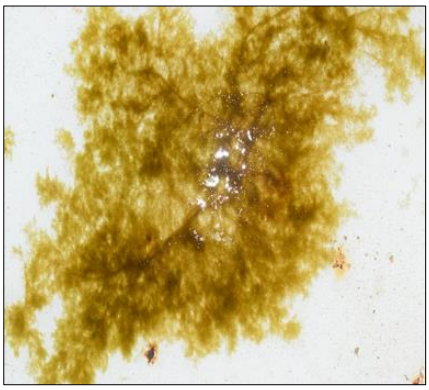


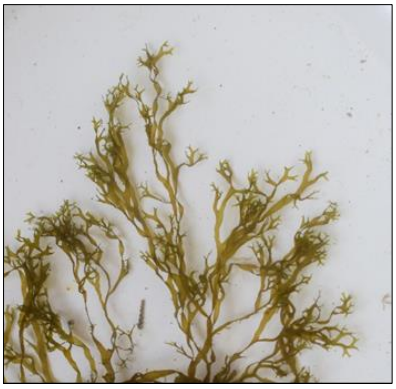
Fig 7: Monthly variation in physico-chemical parameters along Vador site, Sikka (October 2020 – March 2021)



Padina gymnospora



Ectocarpus sp.



Dictyota pinnatifida

Dictyota dichotoma

Dictyota ciliolate

Sargassum tenerrimum

Iyengaria stellate

Cystoseira sp.

Sargassum swartzii

Sargassum cinereum

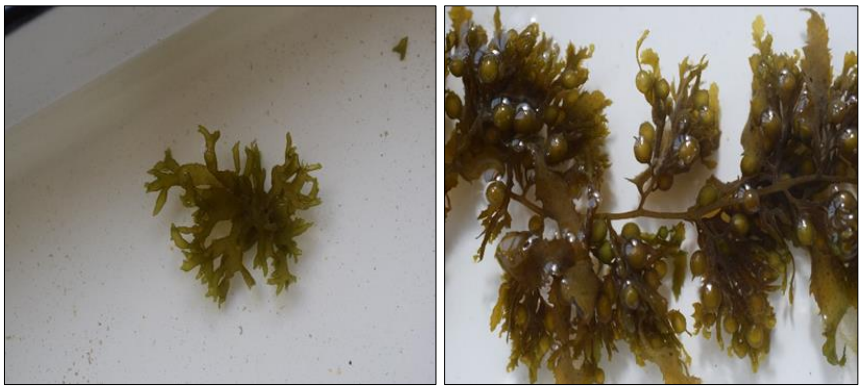
Sargassum prismaticum

Sargassum vulgare

Spatoglossum asperum

Hydroclathrus clathratus

Sargassum johnstonii *Rosenvingea orientalis*



Rosenvingea intricata *Sargassum cinctum*

Fig 8: Different types of Phaeophyceae species collected from GSFC Jetty and Vador site, Sikka

4. Discussion

Dave *et al.* (2019) [4] recorded 10 species of Phaeophyceae from the intertidal coast of Okha, Gulf of Kachchh, Gujarat. Kumar *et al.* (2017) [10] reported 18 species of Phaeophyceae from Okha coast, Gujarat. From Okha port, 14 species of Phaeophyceae were recorded from that *Sargassum* was most dominant Thakur *et al.* (2008) [21]. Kurve *et al.* (2015) [11] recorded 12 species of Phaeophyceae from the coastline of Borli, Maharashtra. Mayakun and Prathep (2005) [14] recorded 10 species of Phaeophyceae. Malsatar and Mehta (2017) [12] reported 10 species of Phaeophyceae from Panchotiya village of Mandvi coast Kachchh, Gujarat. Out of tot

al 5 families of Phaeophyceae, Dictyotaceae family dominated with 4 species followed by Sargassaceae family with 3 species. Both *Sargassum* and *Dictyota* were denoted by 2 species.

The values of the Shannon-Wiener index (H') (at log 10) ranged between 0.60 - 1.74 and the highest was found in February (Ajaj *et al.*, 2016) [1]. Canciyal (2014) [2] reported Margalef diversity index (*D*) in the range of 11.32 to 15.18.

5. Conclusion

The study of Phaeophyceae along Sikka coast region will help us in the farming of economically important seaweeds and also gives an idea about the availability of seaweed resources diversity and hydrological parameters for future necessities. The seasonal variations in the physico-chemical parameters are one of the factors responsible for the monthly seasonal variations in the diversity and density of Phaeophyceae at the Sikka coast. This study could also provide a baseline for future more complex ecological studies, conservation management and sustainable use of inshore marine resources, as well as applied aspects of the uses of seaweed.

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