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Seasonal variation on the density of seaweed species from Veraval and Sikka coast, Gujarat

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Abstract
The aim of the present study was to analyze the different group of seaweeds observed from Veraval and Sikka coast, Gujarat from September 2019 to February 2020, to understand their seaweeds density with relation to seasons. Seaweed density at Veraval and Sikka coasts has been studied for six months the using belt transect random sampling method. This sampling survey was selected to get an idea of seaweed density at the difference between two different locations and seasons. There were variations in density of marine macroalgae between sites and seasons with a total of 28 taxa of marine algae found at both sites. Among the two seasons, the percentage of green algal density (64.12%) was highest during post-monsoon season followed by pre-monsoon at the Veraval site than the Sikka sites because of the selected sites are often greatly complicated by rocks pools, cracks, and crevices. During the diversity survey, economically important species like *Ulva lactuca, U. fasciata, Sargassum sp.,* and *Caulerpa sp.,* were reported. Hence, it is recommended that the population density of the intertidal area of seaweed was more during the winter season and was most favorable for the growth of seaweeds while the summer season was the least favorable condition.

Keywords: seaweed density, density percentage, dominance, post-monsoon, pre-monsoon

1. Introduction
As over 70% of Earth's surface is covered by water and in that 97% of water is Marine, marine ecosystems are the largest types of ecosystems on the planet (Temkar *et al*., 2018) [2]. But due to the increasing population-level, several human-induced activities were making a major impact on the remaining 30% water from land. Human activities like urbanization, industrial development, coastal development, aquaculture practices, etc. were tremendously increasing, which is going to causes harmful impacts (Temkar *et al*., 2018) [2]. Apart from the increased human population causes increased hunger, so to satisfy food requirement marine resources were one of the major attractions. But due to indiscriminate fishing activities, those marine fish food resources were depleting fastly in the last few decades. So to minimize that pressure seaweeds can play a major role as an alternative food resource, because they contain all essential food components *viz*. nutritional and mineral components that we're more than that of land plants (Temkar *et al*., 2018) [2].
Currently, there are 42 countries with intensive studies on seaweeds in the World. China holds the first rank in seaweed production followed by North Korea, South Korea, Japan, Philippines, Chile, Norway, Indonesia, USA, and India. These top ten countries contribute about 95% of the world's commercial seaweed volume (Khan and Satam, 2003) [11]. About 90% of seaweed production comes from culture-based practices. According to Food and Agricultural Organization of the United Nation (FAO, 2014), the average annual growth rate was 8.13% in quantity and 6.84% in monetary value in between 2003 and 2012. Global level about 20,000 marine algal species have been reported and about 221 species of seaweeds are commercially utilized (Khan and Satam, 2003) [11].
India (08˚04'-37˚06' N and 68˚07-97˚25'), a tropical South Asian country is rich in marine biodiversity resources, with a coastline of more than 8,120 km in length, and an Exclusive Economic Zone of 2.02 km^2 adjoining the continental regions and the offshore islands including those of the island of Andaman and Nicobar group and Lakshadweep harbors unique marine habitats which display a wide variety of marine biological diversity (Oza and Zaidi, 2001). India has the highest record of seaweed species from the Indian Ocean region. Marine diversity is mostly studied in water along the coast and around the islands (Saxena, 2012) [16].

India is one of the developing countries with rich biodiversity in the world. Indian seaweeds comprise mostly of tropical species, but temperate and subtropical elements have also been reported (Anonymous, 2005) [1]. Many of the rocky beaches, mudflats, estuaries, coral reefs, and lagoons along the Indian coast provide ideal habitats for the growth of seaweeds (Rao and Vaibhav, 2006) [18]. The coastal region of Tamil Nadu and Gujarat coasts has the richest diversity of seaweeds. A standing crop of 16,000 tons wet wt. of *Sargassum* and *Turbinaria* has been reported from Indian waters, (Khan and Satam, 2003) [11].

The southwest coast of India that is Gujarat is situated on the north-western part of peninsular India (20˚1' to 24˚7' N and 68˚4' to 74˚4' E) which is a unique marine habitat infested with diverse macroalgae species. Gujarat has 1,600 km of coastline –the longest coastline of the country, the total area of 196,024 km^2, a continental shelf of 1,64,200 km^2, and an Exclusive economic zone (EEZ) is 2,14,000 km^2 (GEC, 2012).

In the marine ecosystem, seaweed is one of the commercially important marine living and renewable resources in India. Seaweeds are found in the coastal region between high tide to low tide i.e. intertidal region and in the sub-tidal region up to a depth where photosynthetic light is available. They constitute one of the important living resources found mostly on a mudflat and rocky coastal wetlands, coral reefs and lagoons, estuaries, attached to the bottom on solid substrates such as rocks in the intertidal zones, washed up on beaches floating on the oceanic surface, and also in giant underwater forests, dead corals, pebbles, shells and plants (Sahayaraj *et al*., 2014) [17].

Seaweed is a primary producer and they are used as human food, cattle, poultry, and other farm animal feed, manure for land plants, fodder, bio-fertilizer, a medical source, and economically important phycocolloids source like iodine and bioactive substances (such as toxins and antibiotics) throughout the world (Levering *et al*., 1969; Chapman, 1970) [12, 2]. Seaweeds are usually harvested for food, fertilizer, and medicine for thousands of years, particularly in China and Japan. Seaweeds have been harvested for a very long time in the South East Asian Countries where they form staple human food. Some seaweeds species of *Sargassum, Hydroclathrus, Laminaria, Undaria, Macrocystis, Porphyra, Gracilaria laurencia,* and *Acanthophora* is consumed by the human in the form of vegetable, salad, soup, porridge, curry and pickle (Chennubhotla *et al.*, 1987) [4].

The seaweed *Porphyra vietnamensis* is reported to contain 16-30% protein on a dry weight basis, and this amount is higher than that of cereals, eggs, and fish (Visweswara Rao, 1964) [21]. Other seaweeds like *Ulva fasciata, U. lactuca, U. rigida, Centroceras clavulatum,* etc. are also rich in protein. In Japan, about 21 varieties of seaweeds are being used as sea-vegetables in everyday cookery. According to Fujiwara *et al.* (1983) [9], Japanese consume seaweeds as much as 1.6 kg (dry) per capita annually. The thin delicate red seaweed Porphyra is processed and used as a culinary dish known as 'Laver' in Britain and 'Nori' in Japan (Chapman and Chapman 1980) [3]. Apart from this, the Japanese use 'Kombu' a preparation out of Laminaria and 'Wakame' a preparation out of Undaria in their daily diet.

Therefore present study conducted to define the temporal variations of the seaweed species density, occurrence, and seasonal distribution of marine macroalgae at two different location areas of Saurashtra region of Veraval and Sikka coast of Gujarat.

2. Materials and Methods

2.1 Study area

The present study was conducted at two places of the Western coast of Gujarat, India i.e. Veraval and Sikka coasts. The Veraval coast is situated at 20°54'34"N latitude & 70°21'08"E longitudes. It has a flat rocky intertidal belt provided with many tidal pools and crevices. Here northwest side the temple of Jaleshwar founded. Where the northeast side of Dargah was situated. Behind the lighthouse studied area has been selected. The Sikka coast is situated at 22°27'31"N latitude 69°48'17"E longitudes which is situated at the coast of Marine National Park, Jamnagar, and the mouth of the Gulf of Kutchh on the north-westernmost part of Saurashtra in Gujarat. At Sikka coast, particularly Gujarat State Fertilizer Company's Jetty (GSFC Jetty) studied area has been selected.

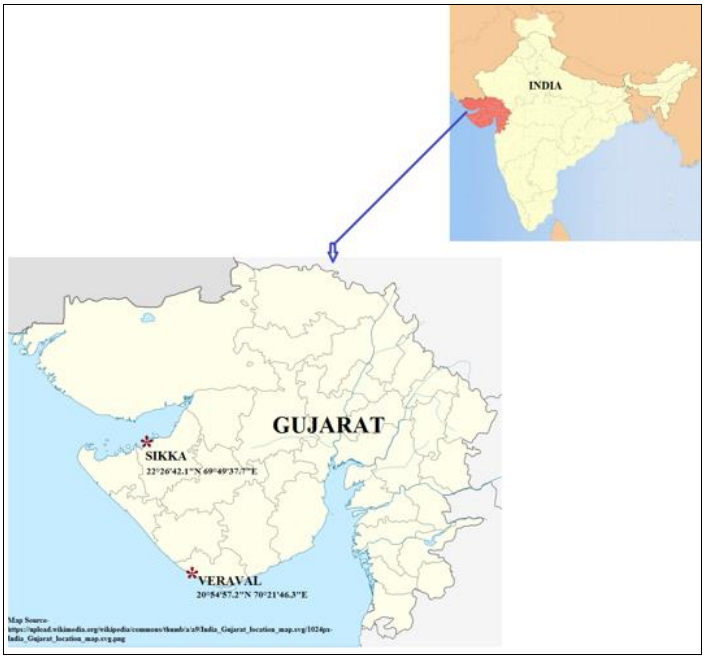

Fig 1: Map showing the study area of Veraval and Sikka coast, Gujarat

2.2 Sampling period
The seaweed density survey was conducted at Veraval and Sikka sites for eight months but due to COVID-19 (Corona Virus Disease-19), two months sample was not able to collect. The study was conducted for six months and it was initiated from September-2019 and it continued up to February-2020. This sampling survey was selected to get an idea of seaweed density at the difference between two different locations and seasons.

2.3 Sampling method
To find out the quantitative density of seaweed in a given area a belt transect was laid Perpendicular to the coast from high tide mark to the low tide mark covering all the tidal levels, with the help of graduated long rope. Sampling points along the rope were marked depending on the gradient and the expanse of the intertidal area. Whenever the intertidal area was small, sampling points were marked at 3 m intervals along the rope, and where the intertidal area was quite large the sampling point was marked at 8 or 10 m along the rope. A quadrant measuring 1 m^2 area was placed at the sampling points. All the species of seaweeds present within the quadrant were uprooted completely along with the holdfast, identified, and numbers of individuals were recorded for density. All the collected seaweeds were categorized and count species-wise and the numbers of individuals in each species were recorded for quantitative assessment of their abundance with information on density.

2.4 Data analysis
2.4.1 Statistical Analysis
The collected monthly data was presented as seasonally for the seasonally approach like post-monsoon and pre-monsoon season. Seasonal variations in the population density of seaweeds in both the stations were calculated (Misra, 1968). The collected data of density percentage was calculated by below formula.

2.4.2 Density (%)
It is the count of the number of individuals of a species in a unit area.

$$\mathbf{D(\%) = \frac{n}{A} \times 100}$$

Where,
D = Density
n = total number of individual of the species
A = total area sample

3. Results and Discussion
3.1 Seaweed density
There was a variation in the density of marine macroalgae between sites and seasons with a total of 28 taxa of marine algae found at both sites. Among the two seasons, the maximum density of seaweeds was recorded during the post-monsoon season at Veraval and Sikka coast. Veraval recorded the highest percentage density of Green algae (64.12%) and Sikka recorded 50.76 % of Green algae.

At Veraval coast, the maximum percentage density of seaweeds species recorded during post-monsoon was *Ulva lactuca* (28.24%), *U. fasciata* (10.31%), and *Caulerpa racemosa* (7.63%) whereas, at Sikka coast, the maximum percentage of density was recorded *U. lactuca* (25.19%), *U. fasciata* (10.69%), *Sargassum johnstonii* (8.40%), *Padina tetrastomatica* (8.02%) species contributed much to the total percentage density of this macroalgae community (Table-1). During the post-monsoon season, 30 & 22 species contributed to the total percentage density of seaweed at Veraval & Sikka coasts, respectively.

During pre-monsoon, dominant species were *P. tetrastromatica* (8.97%), *U.lactuca* (8.01%), *U. fasciata* (7.05%), *C. racemosa* (7.05%) followed by *Padina gymnospora* (4.58%) at the Veraval coast whereas, at the Sikka site, 22 species were recorded of which *U. lactuca* (8.78%), *U. fasciata* (6.11%), *C. racemosa* (4.96%), and *Gelidiella acerosa* (4.96%) and remaining species did not contribute much to the total percentage density of seaweed species (Table-2). During pre-monsoon, 37 & 40 species contributed to the total percentage density of seaweed at Veraval & Sikka coasts, respectively.

Table 1: Percentage density of seaweed species during the post-monsoon season (September to November) at Veraval & Sikka coasts, Gujarat

Sr.no.	Seaweed species	Veraval Percentage (%)	Sikka Percentage (%)
1	*Bryopsis plumose*	1.15	-
2	*Boodlea composite*	-	1.15
3	*Caulerpa racemosa*	7.63	-
4	*Caulerpa taxifolia*	0.76	1.15
5	*Caulerpa scalpelliformis*	2.29	-
6	*Chaetomorpha spiralis*	2.29	1.91
7	*Chaetomorpha antennina*	3.82	1.91
8	*Halimeda macroloba*	1.53	3.44
9	*Halimeda tuna*	3.82	2.29
10	*Ulva fasciata*	10.31	10.69
11	*Ulva lactuca*	28.24	25.19
12	*Ulva reticulate*	-	1.91
13	*Ectocarpus confervoides*	2.29	-
14	*Ectocarpus siliculosus*	-	1.91
15	*Cystoseira indica*	2.67	1.53
16	*Iyengaria stellata*	2.29	3.44
17	*Padina gymnospora*	4.58	2.67
18	*Padinatetrastromatica*	3.82	8.02
19	*Sargassum plagiophyllum*	1.53	-
20	*Sargassum polycystum*	3.44	-
21	*Sargassum tenerrimum*	1.91	-
22	*Sargassum cinclum*	-	2.67

23	*Sargassum johnstonii*	-	8.40
24	*Spatoglossum asperum*	1.53	-
25	*Acanthophora spicifera*	0.76	-
26	*Champia indica*	1.91	-
27	*Chondria armatass*	1.91	0.38
28	*Gelidiella acerosa*	2.29	5.73
29	*Gelidium pusillum*	1.91	3.44
30	*Gracilaria corticata*	1.53	6.87
31	*Gracilaria foliifera*	0.38	-
32	*Gracilaria salicornia*	0.76	4.20
33	*Polysiphonia platycarpa*	0.76	-
34	*Enteromorpha compressa*	1.53	1.15
35	*Valonia aegagrophila*	0.76	-
	Total	100%	100%

Table 2: Percentage density of seaweed species during the pre-monsoon season (December to February) at Veraval & Sikka coasts, Gujarat

Sr.no.	Seaweed species	Veraval Percentage (%)	Sikka Percentage (%)
1	*Bryopsis plumose*	3.21	-
2	*Boodlea composite*	-	1.53
3	*Caulerpa racemosa*	7.05	4.96
4	*Caulerpa taxifolia*	0.96	2.29
5	*Caulerpa scalpelliformis*	0.64	1.15
6	*Chaetomorpha spiralis*	1.60	1.91
7	*Chaetomorpha antennina*	0.96	3.05
8	*Halimeda macroloba*	3.21	2.29
9	*Halimeda tuna*	1.92	1.53
10	*Ulva fasciata*	7.05	6.11
11	*Ulva lactuca*	8.01	8.78
12	*Ulva reticulate*	-	1.53
13	*Cladophora socialis*	1.60	2.29
14	*Codium indicum*	0.64	-
15	*Valonia aegagrophila*	0.64	-
16	*Valonia spp*	-	1.91
17	*Ectocarpus confervoides*	1.92	-
18	*Cystoseira indica*	2.56	1.91
19	*Iyengaria stellata*	3.21	2.67
20	*Padina gymnospora*	4.81	2.67
21	*Padina tetrastromatica*	8.97	3.44
22	*Padina boergesenii*	-	1.15
23	*Sargassum plagiophyllum*	3.21	-
24	*Sargassum polycystum*	5.13	-
25	*Sargassum tenerrimum*	0.96	1.53
26	*Sargassum cinclum*	-	1.53
27	*Sargassum johnstonii*	-	3.44
28	*Spatoglossum asperum*	2.88	1.15
29	*Acanthophora spicifera*	1.92	2.67
30	*Champia indica*	1.92	1.91
31	*Chondria armata*	2.24	3.05
32	*Gelidiella acerosa*	2.88	4.96
33	*Gelidium pusillum*	1.28	3.82
34	*Gracilaria corticata*	4.49	4.20
35	*Gracilaria foliifera*	-	1.53
36	*Gracilaria salicornia*	1.60	2.29
37	*Ceramium cruciatum*	2.56	2.29
38	*Ceramium rubram*	0.96	1.53
39	*Ceramium tenerrimum*	-	1.53
40	*Polysiphonia platycarpa*	1.60	-
41	*Platysiphonia delicate*	-	1.15
42	*Halymenia venusta*	1.92	1.53
43	*Halymenia porphyraeformis*	1.28	-
44	*Hypnea musciformis*	2.24	2.67
45	*Scinaia moniliformis*	0.96	-
46	*Scinaia hatei*	0.96	1.15
47	*Scinaia carnosa*	-	1.15
	Total	100 %	100%

3.2 Seasonal Variations of Seaweed Species recorded at the Veraval and Sikka coasts

Seasonal studies on marine macroalgae from the southwest coast of Gujarat were studied by various authors. There were seasonal variations in seaweed density among sites and seasons.

Species like *Gracilaria corticata, G. salicornia, Gelidium pusillum, Gelidiella acerosa, Sargassum polycystum, S. johnstonii, and Padina tetrastromatica* were an appreciable number in both pre and post-monsoon seasons. During the initial month of the survey that is September to November months, *Scinaia hatei, Scinaia carnosa, Platysiphonia delicate, P. tetrastromatica. S. tenerrimum, S.cinereum, Ceramium rubram, C. cruciatum, Halymenia venusta, H. porphyraeformis* species did not contribute much to the total percentage density of seaweed species.

The months of September to December have shown a significant change in the cover of seaweed species, *Ulva lactuca* (green algae) has the most coverage of all three classes of seaweed species at both the Veraval and Sikka coasts. According to our data, there was a gradual decline in cover as the February month-end. This decline in seaweed numbers over six months could be a result of the seasonal changes hence as the months grew colder and significant weather changes consisting of regular cloud cover approaching, February the seaweed species started to decline.

Species of *C. taxifolia, C. racemosa, U. lactuca, U. fasciata, Ectocarpus siliculosus, P. tetrastromatica, S. johnstonii* were abundant in the post-monsoon season. Red seaweed species of *Acanthophora spicifera, Gracilaria foliifera, C. cruciatum, C. rubram, Champia indica, H. venusta, Platysiphonia delicate,* and *Chondria armata* was abundant in December to February months but reduced in September to November at both the sites.

Table 3: Seasonal density of different divisions of seaweeds at the Veraval coast

Algae	Seasonal density (%)	
	Post-monsoon	Pre-monsoon
Green algae	64.12%	37.50%
Brown algae	24.05%	33.65%
Red algae	12.21%	28.85%
Total	100	100

At Veraval, the percentage of green algal density (64.12%) was highest during post-monsoon that is September to November months and a comparatively low percentage of density (37.50%) was recorded during pre-monsoon that is December to February months (Table -3). Brown algal density (33.65%) was high during pre-monsoon and less percentage (24.05%) in post-monsoon. The Percentage of Red algal density (28.85%) was also high during pre-monsoon i.e. December to February months and comparatively low during post-monsoon months (12.21%). The Percentage of Algal density was highest during the post-monsoon season followed by pre-monsoon (Table-3).

Table 4: Seasonal density of different divisions of seaweeds at the Sikka coast

Algae	Seasonal density (%)	
	Post-monsoon	Pre-monsoon
Green algae	50.76 %	40.46%
Brown algae	28.63%	22.14%
Red algae	20.61%	37.40%
Total	100	100

At Sikka, green algal density percentage was highest (50.76 %) during post-monsoon that is September to November months and comparatively low density (40.46%) was recorded during pre-monsoon that is December to February months (Table-4). Brown algal density (28.63%) was high during post-monsoon followed by pre-monsoon (22.14%). Red algal density (37.40%) was high during pre-monsoon i.e. December to February months and comparatively low during post-monsoon months (20.61%). During all the season green algae showed the highest density. Algal density percentage was maximum during post-monsoon followed by the pre-monsoon season (Table-4).

Results of the present study were satisfied with earlier reports of Naik *et al*. (2015) [14] from Karwar way, Rao *et al.* (2011) [19] in the Bhimili coast, east coast of India, was reported that the maximum number of species and density of macroalgae during the winter months from November to February whereas the minimum number of species and density during the rainy season between July to October months. According to Naik *et al*. (2015) [14], richness and diversity were higher during post and pre-monsoon seasons when nutrients availability was more which supports the growth rate of these macrophytic algae, especially in the intertidal zone. Algal vegetation is usually luxuriant from September to February months along the Gujarat coast. In summer months it vanishes and almost negligible. A similar observation was made in the present investigation also.

4. Conclusion

From the above results, it's concluded that the station which showed the highest species composition did not thus show the highest density. The seaweed density in the present study was high during most of the time at Veraval than the Sikka coast. Among the two seasons, the maximum density of seaweeds was recorded during the post-monsoon season followed by pre-monsoon.Therefore it can be said that the monthly/ seasonal variations in the hydrological parameters are one of the factors responsible for the monthly/ seasonal variations in seaweed densities.

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6. Reference

1. Anonymous. Seaweeds: Wonder Plants of the Sea. 5thed. Aquaculture Foundation of India, Chennai 2005, 30.
2. Chapman VJ. Seaweeds and their uses. (2nd edn.), The Camelot Press Ltd., Methuen and Co Ltd., London and Southampton 1970, 63-85.
3. Chapman VJ, Chapman DJ. Seaweeds and their uses. 3rd ed. Chapman and Hall, London 1980, 62-97.
4. Chennubhotla VS, Kaliaperumal N, Kalimuthu S. Economically important seaweeds. CMFRI Bulletin 1987;41:3-18.
5. FAO. The state of world fisheries and aquaculture 2001-2000, Elec-tronic edition http://fao.org.
6. Food and Agricultural Organization of the United Nations, Fisheries and aquaculture Information and

Statistics Services. Food and Agricultural Organization of United Nations, Rome, Italy 2014.
7. FAO. The state of world fisheries and aquaculture 2001-2000, Elec-tronic edition http://fao.org
8. Zakari Abdurahman Ya'u, Emmanuel Aduojo Ekpa, Nancy Erika Michael, Oluwatosin Comfort Oluwatoyin. Studies on spread of algal species in some fish samples from three water bodies in Zaria-Kaduna state Nigeria. Int. J Adv. Biochem. Res 2020;4(1):47-52. DOI: 10.33545/26174693.2020.v4.i1a.101
9. Fujiwara-Arasaki T, Mino M, Kuroda M. The protein value in human nutrition of edible marine algae in Japan. Proc. XI Int. Seaweed. Symp. China 1983, 74. (Abstract).
10. Gujarat Ecological Commission. Study of seaweed diversity along the islands of the Gulf of Kachchh, Gujarat. The government of Gujarat, Gujarat Ecological Commission, Gandinaga 2012, 81.
11. Khan SI, Satam SB. Seaweed mariculture: scope and potential in India. Aquaculture Asia 2003;8(4):26-29.
12. Levering T, Hoppe HA, Schmid OJ. Marine Algae. A survey of research and Utilization. Granm be Gruyter & Co., Hamburg 1969, 1-421.
13. Misra R. Ecology Work Book. Oxford and IBH Publishing Co., Calcutta, India 1968.
14. Naik UG, Beligiriranga V, Haragi SB. Seaweeds of Karwar Bay, Arabian Sea, West Coast of India - A Diversity Profile. International Journal of Science and Nature 2015;6(4):728-732.
15. Oza RM, Zaidi SH. A revised checklist of Indian marine algae. Central Salt and Marine Chemicals Research Institute, Bhavnagar 2001, 296.
16. Saxena A. Marine biodiversity in India: Status and Issues. International day for biological diversity (Marine diversity) 2012.
17. Sahayaraj K, Rajesh S, Asha A, Rathi JM, Raja P. Distribution and diversity assessment of the marine microalgae at four southern districts of Tamil Nadu, India. Indian Journal of Geo-Marine Sciences. 2014;43(4):607-616.
18. Rao SPV, Vaibhav AM. Indian seaweed resources and sustainable utilization: Scenario at the dawn of a new century. Curr. Sci 2006;91:164-174.
19. Rao KS, Murty PM, Narasimha Rao GM. Seasonal Studies on Marine algae of the Bhimili Coast, East Coast of India. J Algal. Biomass. Utln 2011;2:69-82.
20. Temkar G, Bhatt AJ, Joshi A. The Indian Seaweed Resource: Their Nutritive Importance to Human Beings and Threats. International Journal of Bio-resource and Stress Management 2018;9(5):641-646.
21. Visweswara Rao A. Protein from Ulva. Salt Res. Ind 1964;1:37.