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DISTRIBUTION AND DIVERSITY OF MARINE ALGAE OF SINDH COASTAL AREA: ALPHA, BETA AND GAMMA DIVERSITY

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Abstract

Algae occupies a significant position in humans life due to its utilization in different aspects. However, their composition and dominance are being disturbed by many factors. An ecological study was directed to check the species conforrmation, vertical dissemination and monthly variation of marine macro algae along the Sindh coast, Pakistan between February 2020 and January 2021. A sum of 64 species was recorded having the species distribution % *i.e.,* 20% from Chlorophyta, 45% from Phaeophyta and 34% from Rhodophyta. Phaeophyta found to be most prevailing phylum trailed by Rhodophyta and Chlorophyta. Moreover, Monthly growth of Phaeophyta was on peak during November to March while Chlorophyta was on top in May to August and Rhodophyta was moderate throughout the year. However, alpha, beta and gamma diversification of marine algae was also observed that showed alpha diversity was relatively smaller than the beta diversity.

Key words: Variation, Algae, Species, Quadrat, Seasonal.

Introduction

Significance of seaweeds in the monetary existence of people and biological systems is generally notable. The utilization of seaweeds as food, creature feed, composts, unrefined components in creation of modern phycocolloids and regular feeds for monetarily significant hydroponics species has gotten a lot of consideration in Thailand and in numerous different nations all around the world, for example, Japan (Kazutosi *et al.,* 1987), China (Bangmei & Abbott, 1987) and other Asian countries *e.g*., Korea, Phillipines, India (Dennis, 2003). Essential exploration on irregularity of an environment gives data on seaweeds creation and use (Wang & Li, 2021). Occasional and vertical seaweeds local area varieties in intertidal frameworks had run by such substances with openness to sun illumination (Hameed & Ahmed, 1999; Burnett & Gaylord, 2021), saltiness (Thom, 1980; Druehl & Green, 1982; Luning, 1990), waves fluctuation (Lawson, 1957; Reddy *et al*., 2006), nutritional values (Jhansi & Rarmadas, 2009) and water temperatures (McQuaid & Branch, 1984) and Quantitative analysis (Saifullah, 1973; 1984; Fasakhodi *et al*., 2021).

Vertical zonation is an incredible environmental idea to read for some reasons, as these examinations talk about the species capacity to adapt abiotic factors related with emersion stress (Rogers, 2019). Intertidal region is a space of coast set apart by the top and bottom cutoff points of the drifts; it is uncovered that at low drifts and drenching at elevated tide, shows regionalization in plants and animals (Kaliaperumal *et al.,* 1995; Sumalani *et al.*, 2021), consequently species variety decreases in accordance to expanding stature in intertidal regions (Srinivasan, 1959; Misra, 1959; Subbaramaiah, 1970; Subbaramaiah, 1971; Agadi & Untawale, 1978; Agadi, 1983; Agadi, 1985; Cappelatti *et al*., 2020).

Accessible writings and exploration contemplates in most recent fifty years on environmental parts of marine algae along the Sindh coast are accessible from the examination commitments of Saifullah, (1973); Saifullah, (1984). The species-wise conveyance examples, creation and occasional varieties of seaweeds accounted by Rao *et al.,* (2011); Ramachandra & Hebbale, (2020). Mathematical information concerning thickness, predominance and recurrence of seaweeds was introduced by Lakshmi & Rao, (2009); Sangil *et al*., (2021).

The above investigations on species documentations with occasional progression of seaweeds growth from the Sindh shore were pitiful and need a lot of consideration. A limited attention has been paid to current state of seaweeds growth because of post-industrialization effect at the Sindh coast regarding changes in algal species creation and variety designs.

In this way the current study was led with an outline to tell the progressions on the algal growth conformation and to assess the month to month changes in the circulation designs from the rough and sandy shores of the Sindh coast. The data gathered were contrasted with before examines, which discover the species dissemination status, creation and progression designs in sharp regionalization.

Methodology

Study area: The current study was designed during February 2020 to January 2021. For this purpose ten inspecting locales were set up at various areas of Sindh coast including: Chach Jaan Khan, Shah Bandar, K.T. Bandar, Manora, Sandspit, Hawksbay, Buleji, Paradise point, Sonehra point and Mubarak Village (Fig. 1). However, their geo-morphological and topographical features are provided in Table (1).

Fig. 1. Map Shows the area of Sindh coast from where sampling takes place.

Table 1. The sampling sites with Geo morphological/ Topographical features of Sindh coast.

Site No.	Sampling sites	Geo morphology/Topography	α Diversity
S1	Chach Jaan Khan (Sujawal)	Creek Area (Mangrove, muddy beach)	3
S2	Shah Bandar (Sujawal)	Creek Area (Mangrove, muddy beach)	1
S3	K.T. Bandar (Thatta)	Creek Area (Mangrove, muddy beach)	3
S4	Manora (Karachi)	Rocky area with pools and sandy beaches	44
S5	Sandspit (Karachi)	Sandy area with pools	24
S6	Hawksbay (Karachi)	Sandy coast	26
S7	Buleji (Karachi)	Rocky platforms with pools (Rocky & sandy)	56
S8	Paradise Point (Karachi)	Rocky area with pools and sandy beaches	34
S9	Sonehra Point (Karachi)	Rocky areas with sandy beaches	16
S10	Mubarak Village (Karachi)	Sandy beaches and rocky platforms	15

Collection of material: Seaweeds collection were done by random sampling with the help of 50X50 cm iron frame Quadrat (Bray & Curtis 1957). For this purpose 25 quadrats were made at each sampling sites.

Preservation of material: The seaweeds were saved in zip lock plastic bags in the wake of eliminating sand particles and other fauna joined to the seaweeds substratum. The gathered species were preserved in 4% formaldehyde solution.

Identification of material: All gathered samples were Identified through standard ordered keys and accessible literature.

Biomass assessment of material: In laboratory fresh weight of each specie was noted on a top loading electric balance, than kept for a week in order to air dry and re-weighted for dry mass determination.

Alpha, beta and gamma diversity: Alpha, beta and gamma diversity was deliberated by following Hussain *et al*., (2015). Alpha diversity represents the richness of the species (Shaukat *et al*., 1981). Beta diversity is expressed as spatial differentiation (Legendre, 2014). Gamma diversity refers to diversity in total species within a region. However, beta diversity is calculated by the following formula:

$$\beta = (S1 - C) + (S2 - C)$$

Table 2. Showing monthly presence of seaweeds from the coast of Sindh.

Groups	F	M	A	M	J	J	A	S	O	N	D	J
Chlorophyta												
Caulerpa faridii	-	-	-	-	-	-	-	-	-	-	+	+
Caulerpa racemosa	-	-	-	-	-	-	-	-	-	+	+	-
Caulerpa scalpelliformis	-	-	-	-	-	-	-	-	-	-	+	+
Caulerpa taxiffolia	+	+	+	-	-	-	-	-	-	-	+	+
Caulerpa veravalensis	-	-	-	-	-	-	-	-	-	-	-	+
Chaetomorpha antennina	-	-	-	-	-	-	+	+	+	-	-	-
Codium iyengarii	+	+	+	-	-	-	-	-	+	+	+	+
Codium latum	-	-	-	+	-	-	-	-	-	-	-	-
Enteromorpha intestinalis	+	-	-	-	-	-	-	-	-	-	-	+
Halmedia tuna	-	+	+	-	-	-	-	-	+	+	-	-
Udotea indica	+	+	-	-	-	-	-	-	-	-	-	+
Ulva fasciata	-	-	-	-	+	+	+	+	+	+	-	-
Ulva rigida	+	-	-	-	-	-	-	-	-	-	-	+
Valoniopsis pachynema	+	-	-	-	-	-	-	-	+	+	+	+
Rhodophyta												
Ahnfeltia spicifera	+	-	-	-	-	-	-	-	+	+	+	+
Botryocladia leptopoda	+	+	-	-	-	-	-	-	-	-	-	-
Ceramium manorense	-	-	-	-	-	-	+	-	-	+	+	+
Champia globulifera	-	-	-	-	-	-	-	-	-	-	-	+
Champia plumose	+	-	-	-	-	-	-	-	-	-	-	+
Coelarthrum muelleri	-	+	+	-	-	-	-	-	-	-	-	-
Galaxaura oblongata	-	-	-	-	-	-	-	-	-	+	+	+
Gelidium folifera	-	-	-	-	-	-	-	+	-	+	+	+
Gelidium usmanghanii	-	-	-	-	-	-	-	-	+	+	-	-
Gracilaria verrucosa	-	-	-	-	-	-	-	-	-	+	-	-
Halymenia Porphyroides	+	-	-	-	-	-	-	-	-	-	+	+
Hypnea musciformis	+	-	-	-	-	-	-	-	-	-	+	+
Jania adherens	-	-	+	-	-	-	-	-	-	-	+	-
Jania caillacea	+	+	+	-	+	+	+	+	+	+	+	+
Laurencia obtuse	+	-	-	-	-	-	-	-	-	-	-	-
Laurencia pinnatifida	-	-	-	-	-	-	+	+	-	+	+	-
Laurencia platyclada	-	-	-	-	-	-	-	-	-	+	-	-
Melanothamnus somaliensis	-	-	-	-	-	-	-	+	-	-	-	-
Sarcodia dichotoma	+	-	+	-	-	-	-	-	-	-	-	-
Sarconema furcellatum	-	-	-	+	-	-	-	-	-	-	-	-
Scinaia indica	+	-	-	-	-	-	-	-	-	-	-	-
Solieria robusta	+	+	+	+	-	-	-	-	-	-	-	-
Phaeophyta												
Colpomenia sinuosa	+	+	-	-	-	-	-	-	+	+	+	+
Colpomenia ecuticulata Parsons	+	+	-	-	-	-	-	-	-	-	-	+
Cystoseira indica	+	-	-	-	-	-	-	-	-	-	+	+
Dictyota dichotoma	+	+	+	-	-	-	-	-	+	+	-	+
Dictyota indica	-	-	-	-	-	-	-	-	+	+	-	-
Dictyota flabellata	+	+	-	-	-	-	-	-	-	-	+	+
Dictyota hauckiana	+	+	-	-	-	-	-	-	-	-	+	+
Dilophus alternans	+	+	-	-	-	-	-	-	-	-	+	+
Iyengaria stellate	+	+	+	-	-	-	-	-	+	+	+	+
Iyengaria nizamudinii	+	+	-	-	-	-	-	-	+	+	+	+
Jolyna laminarioides	-	-	-	-			+	+	-	-	-	-
Lobophora variegate	+	+	-	-	-	-	-	-	-	-	-	-
Padina pavonica	+	+	+	-	-	-	-	-	+	+	+	+
Padina tetrastromatica	+	+	+	-	-	-	-	-	+	+	+	+
Padina afaqhusainii	+	+	+	-	-	-	-	-	+		+	+
Padina antillarum	+	+	+	-	-	-	-	-	-	+	+	+
Padina nizamuddinii	+	+	+	-	-	-	-	-	-	-	+	+
Sargassum boveanum	+	+	-	-	-	-	-	-	-	+	+	+
Sargassum crassifolium	-	-	-	-	-	-	-	-	-	+	+	+
Sargassum filifolium	+	+	-	-	-	-	-	-	-		+	+
Sargassum tenerrimum	+	+	+	-	-	-	-	-	+	+	+	+
Spatoglossum variabile	+	+	+	-	-	-	-	-	+	+	+	+
Spatoglossum qaiserabbasii	+	-	-	-	-	-	-	-	-	-	+	+
Spatoglossum shameelii	+	+	-	-	-	-	-	-	-	-	-	+
Spatoglossum asperum	+	+	+	-	-	-	-	-	-	-	-	-
Stoechospermum marginatum	+	-	-	-	-	-	-	-	+	+	+	+
Stokeyia indica	+	+	+	-	-	-	-	-	-	-	+	+
Stypopodium shameelii Nizamuddin	+	+	-	-	-	-	-	-	-	-	+	+
Stypopodium zonale	+	+	-	-	-	-	-	-	-	-	+	+

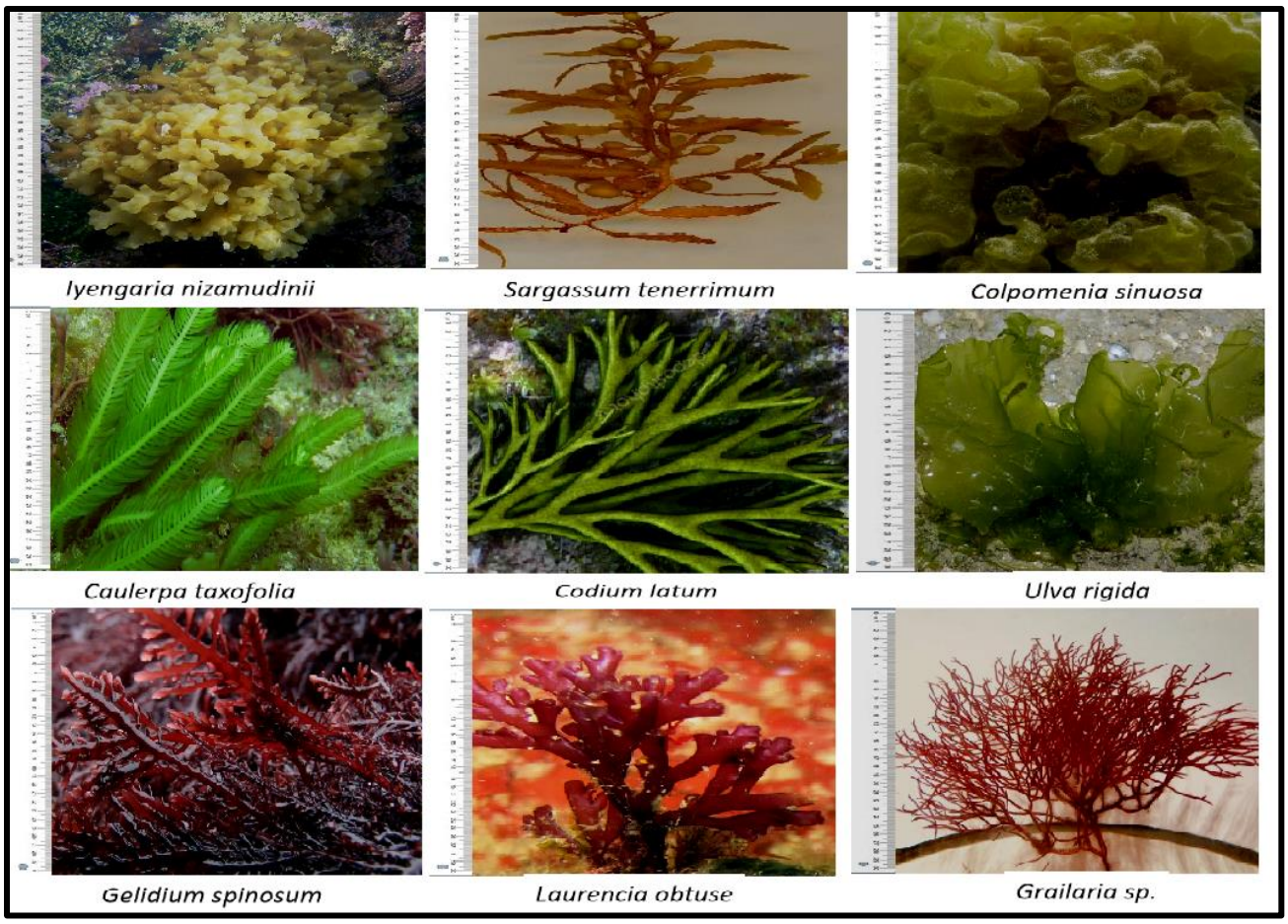

Plate 1. Species composition and dominancy among the sampling sites.

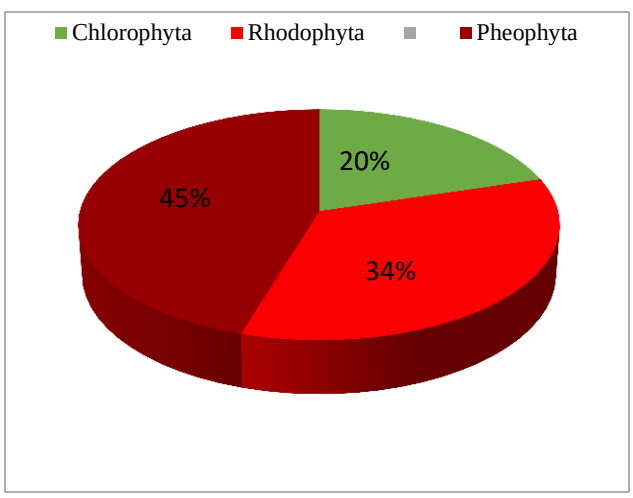

Fig. 2. Shows percentage wise dominance of macro algae groups in the study area of Sindh coast.

Results and Discussion

The seaweeds arrangement at Sindh coast has added to the presence of expanded seaside environments of shifted geomorphological provisions in the presence of rough stones to rough stages with lagoons of various sizes. One more significant element of this coast is the event of month to month variation in the average drift levels and affidavit of silt at waterway mouths in certain areas particularly Buleji (Karachi), Manora (Karachi) and Paradise point (Karachi) stations. These shoreline qualities at Sindh impact occasional and sharp dispersion of macro algae.

From the current findings an aggregate of 64 seaweeds species were noted having a place with three phyla *i.e.*, 20% species composition (13 species) to Chlorophyta, 20% species composition (29 species) to Phaeophyta and 34% species composition (22 species) to Rhodophyta. However, monthly dispersion design demonstrated that species % of Phaeophyta was highest as compared to other phyla (Table 2 and Fig. 2).

From the Sampling sites (Fig. 1 and Plate 1) it is elucidated that significant occurrence of macro algae was seen in Manora and Buleji where 20 common species *i.e.*, *Colpomenia sinuosa, Dictyota dichotoma, D. indica, D. hauckiana, Lobophora variegata, S. filifolium, S. boveanum, S.tenerrimum, S. vulgare, Iyengaria nizamudinii, I. stellata, Cystoseira indica, P.adina pavonica, P. gymnospra, Spatoglossum variabile, S.typopodium zonale, Stokyia indica, Halymenia porphyroides* and *Jania adherence* were appeared as dominant. However, 14 species were common in Sandspit, Hawksbay and Paradise point including *Caulerpa taxifolia, Udotea indica, Cystoseira indica, Colpomenia sinuosa, Dictyota indica, Iyengaria* spp., *Sargassum* spp., *Padina* spp., *Gelidium pusillum, Jania adherense, Laurencia pinnatifida* while *Codium iyengarii* and *Dictyota indica* were most common in Sonehra point

and Mubarak Village Although, *Entomorpha flexsousa* was dominant in Chach Jaan Khan, Shahbandar and K.T. Bandar. There is no study available that covers the entire Sindh coast although, researchers have done a lot of anatomical, morphological, and taxonomic work along specific areas of the Karachi coast. However, Saifullah, (1973) reported 48 spp., from Buleji, Karachi, Hameed & Ahmed (1999 a,b) proposed 85 spp., from Buleji, Abbas, (2010) reported 36 spp., of Pheophyta from Karachi coast, Nazim e*t al.,* (2012) revealed 58 types of marine algae from Buleji, Karachi Sindh coast and Qari, (2017) put forth 60 spp., from Nathiagali ocean side, Karachi. Rather than the above findings the current review has recorded 64 species from Sindh coast. This demonstrates a declining pattern of algal growth and species richness of seaweeds of the Sindh coastline. Alpha diversity between communities range from 3 to 56 mentioned in Table 1. The Results of S2 (Shah Bandar, Sujawal) showed poorest alpha diversity while S7 (Buleji, Karachi) exhibited maximal alpha diversity. S8 (Paradise point), S9 (Sonehra point) and S10 (Mubarak village).

Beta diversity between communities range from 0 to 59 mentioned in Table 4. The minimum beta diversity was recorded for S1 (Chah jaan khan) and S3 (Keti bandar) while maximum beta diversity was found for community 1 and 7, 3 and 7. The other pair of communities intermediate levels of beta diversity, In general beta diversity was observed to be in moderate order. Gamma diversity for the entire survey of communities was found to be 66 species.

During the study period, monthly variation in seaweeds composition were seen though, Chlorophyta members were dominant from June to August, while Phaeophyta members were at peak from November to March. These findings are in line with Thakkar *et al*., (2008) that occurrence of algae on the coastal line is due certain factors like natural senescence of seaweeds, strong currents primarily forced by tides may contribute to the uprooting and subsequent drifting of seaweeds on to the beach. This ultimately causes changes in floristic features of the existing algal beds.

Blue-green algae, is considered as biological indicator of pollution and bears a great commercial and industrial value (Patterson, 1996; Gandhi *et al*., 2020). But less importance is given to it in Pakistan, especially in Sindh coastline. Due to anthropogenic activities and industrial effluents, this important flora is almost depleted from Sindh therefore in current study it is not considered.

Variation in tides on coast: The scope of elevated tides during study time was observed as 2.1 to 3.8 m (July and August 2020 individually). Though, scope of low tides fluctuated from 0 to -0.20 m (December 2020 and January 2021, separately). There was a significant month to month variation in the spring and jump drift levels on shore, since the mean tide levels and mean ocean level differs from one month to another.

Seasonal observations on seaweeds: The current observations uncovered that recovery of ocean growth bunches with strength of Chlorophyta individuals was in the long periods of May and June. On the other hand from July to September there was a decrease in Chlorophyta development (Table 3). Although, the dominating months of Phaeophycota was November to March whereas, Rhodophycota was found in all season like winter and summer in moderate amount.

Table 3. Showing monthly variation in the biomass (g/m2 per month) of seaweeds between the months February to January from the coast of Sindh.

Biomasses	F	M	A	M	J	J	A	S	O	N	D	J
Fresh weight (g)	175.2	163.4	115.7	66.3	7.5	6.8	13.2	70.6	94.9	112.4	152.8	168.5
Dry weight (g)	46.4	30.5	28.4	22.5	2.8	2.5	4.4	23.6	27.9	30.4	34.7	39.6

Table 4. Matrix of beta diversity between the Algal assemblages surveyed. Algal the communities are designated as 1-10 (S1 to S 10).

	1	2	3	4	5	6	7	8	9	10
1										
2	2									
3	0	2								
4	45	45	45							
5	27	25	27	32						
6	29	27	29	32	50					
7	59	57	59	26	40	36				
8	35	33	35	28	40	38	30			
9	19	17	19	36	24	26	44	32		
10	16	14	16	37	27	29	47	33	13	

Conclusion

The proposed study illustrated that the largest number of species were recorded at Buleji (Karachi), though the least number of species were accounted for from Shah Bandar (Sujawal). Highest biomass recorded in the month of February and lowest in the month of July. Observations on nature of seaweeds from Sindh Coast, their conveyance and regionalization design with occasional varieties lead us to reason that there is a high strength of seaweeds during November to February and less in the middle of June to August. This data might be useful to address the effective ocean growth resources at all sampling sites of the Sindh coastline. Current study may be additionally utilized in cultivating financially significant ocean growth, by giving data on the best states of seaweeds production.

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