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Status, distribution and diversity of some macroalgae along the intertidal coast of Okha, Gulf of Kachchh, Gujarat in India

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Abstract

The Coast of Okha (22°28'N and 69°05'E) situated at the mouth of "Gulf of Kachchh" on the north western most part of Saurashtra in Gujarat. The coast harbours a great variety of seaweeds, gastropods and corals at exposed intertidal zone. The present study highlights seaweed occurrence, distribution and diversity along the coast. The experiment carried out from November-2016 to October – 2017. The coast was divided into three zones vertically to observe differences of seaweed abundances and diversity along the coast i.e. Zone 01 (0-250mt vertical stretch from HHTL to lower intertidal zone), Zone 02 (250-500mt distance from shore) and Zone 03 (500-750mt). In the present study, a random quadrat sampling method with vertical transect method was opted. The different species of seaweeds found within 1.0 m² quadrat were collected along with their holdfast or rhizoid. Of the total recorded 39 species of seaweeds, chlorophytes showed maximum species i.e. 16, followed by Rhodophytes (13 species) and Phaeophytes (10 species). The All the zones were covered by seaweeds in different proportions and densities. The chlorophytes preferred upper stretch of the coast followed by Phaeophytes and Rhodophytes at mid-intertidal and Low-intertidal zones. The *Caulerpa sertularioides*, *Caulerpa racemosa*, *Ulva lactuca*, *Ulva clathrata* and *Ulva fasciata* showed maximum abundance followed by *Spatoglossum asperum*, *Sirophysalis trinodis*, *Cystoseira indica*, *Sargassum marginatum* var. *dioitis*, *Sargassum tenerrimum*, *Sargassum swartzii*.

Keywords: gulf of kachchh, seaweeds, abundance, diversity

Introduction

There are many different fundamentals of diversity. The major four theoretical components viz. compositional diversity, structural diversity, the degree to which the entities differ and functional diversity forms the whole diversity on earth (Sala and Knowlton, 2006) ^[1]. In ecological studies, it is often the transformation of the entire community that matters, not simply the variation in one or a few species. The change in environmental factors associated with tides makes the intertidal zone most vulnerable and extreme of any marine environment. One of the important component of marine biodiversity is intertidal zone which resided by many flora and fauna. The intertidal seaweed flora offers food, oxygen, shelter, hiding places and attachment platforms to the many intertidal organisms which is one of the vital phenomenon for the coastal biodiversity. There are about 8,000 species of marine macroalgae along the world's coastline and they may extend as deep as 270m (Luning, 1990) ^[2]. Intertidal areas are the most accessible of marine habitats and because of this ready access offer a significant opportunity to observe and document the effects of climate change over the intertidal biodiversity. There are many scientists surveyed intertidal biodiversity of Okha (Kohn, 1969; Misra, 1960; Chauhan and Mairh, 1978; Thakur *et al.*, 2008; Bhanderi and Trivedy, 1975 and Murthy *et al.*, 1978) ^[3-8] indicated presence of rich seaweed diversity and abundances. The rocky Okha coast of Gulf of Kachchh having many advantageous coastal features including semi-diurnal tides, clear water, gradual slope towards the sea, numerous tidepools and puddles supports rich biodiversity of the intertidal populations.

Materials and Methods

The seaweeds were collected monthly at intertidal zone as and when maximum exposure available. The random 45 quadrates of 1.0 m² were applied at each zone. The number of seaweeds frond calculated to observe population densities at each zone. The samples were collected at a minimum tidal height to get maximum exposure of the coast. The seaweeds were

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primarily identified with quick reference keys and photographic plates (Krishnamurthy and Joshi; Joshi and Dodiya, 2012)^[9, 10], and transferred to laboratory in 5.0% formaldehyde solution in zip locked plastic bags. Then seaweeds were identified with standard taxonomic keys from

standard reference manuals and website portals (Dhargalkar and kavlekar, 2004, Biodiversity Portal of India, WoRMS)^[11-13]. The sampling collection method and vertical zonation distribution was illustrated in the figure 1.

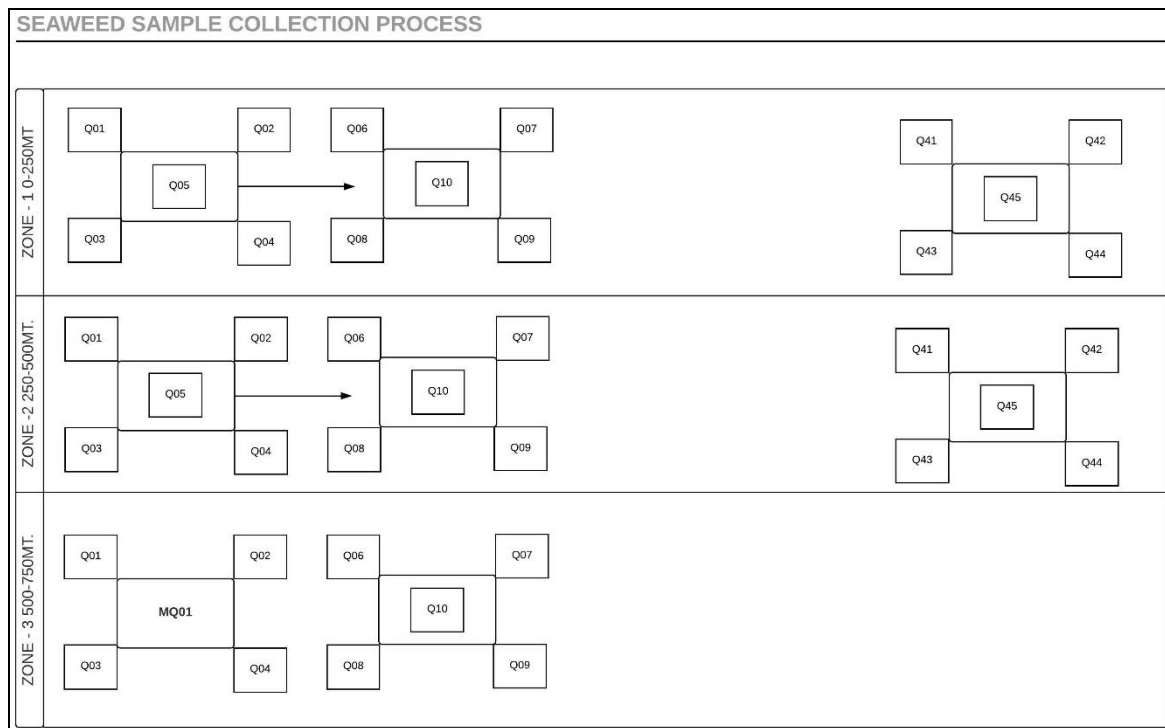


Fig 1: Sample collection protocol

Results and Discussion

Among the total 39 seaweeds recorded, 16 species from Chlorophytes, 10 species of Phaeophytes and 13 Species from Rhodophytes observed (Table 1.). The maximum species

were recorded from the Ulvaceae (6 Species) family, followed by Caulerpaceae (4 Species), Sargassaceae (4 Species) and Dictyotaceae (4 species).

Table 1: Recorded seaweed species classification

Species	Order	Family
Class: Chlorophyceae		
<i>Caulerpa racemosa</i>	Bryopsidales	Caulerpaceae
<i>Caulerpa sertularioides</i>	Bryopsidales	Caulerpaceae
<i>Caulerpa veravalensis</i>	Bryopsidales	Caulerpaceae
<i>Caulerpa taxifolia</i>	Bryopsidales	Caulerpaceae
<i>Codium elongatum</i>	Bryopsidales	Codiaceae
<i>Halimeda macroloba</i>	Bryopsidales	Halimedaceae
<i>Halimeda tuna</i>	Bryopsidales	Halimedaceae
<i>Cladophora vagabunda</i>	Cladohorales	Cladophoraceae
<i>Boodlea composita</i>	Cladophorales	Siphonocladaceae
<i>Phyllocladon pulcherrimum</i>	Siphonocladales	Boodleaceae
<i>Ulva intestinalis</i>	Ulvales	Ulvaceae
<i>Ulva lactuca</i>	Ulvales	Ulvaceae
<i>Ulva reticulata</i>	Ulvales	Ulvaceae
<i>Ulva rigida</i>	Ulvales	Ulvaceae
<i>Ulva clathrata</i>	Ulvales	Ulvaceae
<i>Ulva fasciata</i>	Ulvales	Ulvaceae
Class: Phaeophyceae		
<i>Iyengaria stellata</i>	Chordariales	Scytosiphonaceae
<i>Dictyota ciliolata</i>	Dictyotales	Dictyotaceae
<i>Padina boergesenii</i>	Dictyotales	Dictyotaceae
<i>Padina tetrastromatica</i>	Dictyotales	Dictyotaceae
<i>Spatoglossum asperum</i>	Dictyotales	Dictyotaceae
<i>Cystoseira indica</i>	Fucales	Cystoceiraceae
<i>Sirophysalis trinodis</i>	Fucales	Sargassaceae
<i>Sargassum marginatum</i>	Fucales	Sargassaceae
<i>Sargassum tenerrimum</i>	Fucales	Sargassaceae

<i>Sargassum swartzii</i>	Fucales	Sargassaceae
Class: Rhodophyceae		
<i>Porphyra vietnamensis</i>	Bangiales	Bangiaceae
<i>Centroceras clavulatum</i>	Ceramiales	Ceramiaceae
<i>Ceramium tenerrimum</i>	Ceramiales	Ceramiaceae
<i>Polysiphonia denudata</i>	Ceramiales	Rhodymeniaceae
<i>Spyridia alternans</i>	Ceramiales	Ceramiaceae
<i>Amphiroa anceps</i>	Corallinales	Corallinaceae
<i>Halymenia venusta</i>	Cryptonemiales	Halymeniaceae
<i>Halymenia porphyriiformis</i>	Cryptonemiales	Halymeniaceae
<i>Hypnea musciformis</i>	Gigartinales	Hypneaceae
<i>Gracilaria corticata</i>	Gracilariales	Gracilariaceae
<i>Dermonema virens</i>	Nemaliales	Liagoraceae
<i>Scinaia carnosa</i>	Nemaliales	Scianiaceae
<i>Botryocladia leptopoda</i>	Rhodymeniales	Rhodymeniaceae

The Chlorophytes showed maximum population density at the upper stretches of the coast. *Caulerpa sertularioides* showed maximum population density 16.72 ± 12.60 at the zone 01 followed by 13.17 ± 9.24 and 2.70 ± 5.21 at Zone 02 and Zone 03 respectively. The zone 01 also occupied abundantly by *Caulerpa racemosa*, *Ulva lactuca*, *Ulva clathrata* and *Ulva fasciata* with mean values 16.04 ± 13.64 , 10.95 ± 11.59 , 6.79 ± 7.39 and 6.17 ± 5.63 respectively (Table 2). The Zone 02 showed higher diversities of both Phaeophytes and Rhodophytes than Chlorophytes. The *Spatoglossum asperum* showed highest population density of 10.58 ± 7.45 followed by *Sirophysalis trinodis*, 9.87 ± 8.12 ; *Cystoseira indica*, 9.63 ± 6.23 ; *Sargassum marginatum* var. *diotis*, 9.46 ± 7.61 ;

Sargassum tenerrimum, 9.12 ± 7.41 and *Sargassum swartzii*, 9.06 ± 7.27 .

The rhodophytes exhibited very good diversity all along the coast, especially at Zone 02 and Zone 03, lower intertidal zone. The quantitative aspects of Rhodophytes showed higher population densities of *Gracilaria corticata*, *Polysiphonia denudata* and *Amphiroa anceps* followed by *Halymenia porphyriiformis*, *Spyridia alternans* and *Porphyra vietnamensis*. Total 13 species of red seaweeds recorded at the study area, of which most of them showed presence at Zone 01 and Zone 02. The population densities were highest at the Zone 03 and Zone 02 while Zone 01 showed the scanty distribution of Rhodophytes.

Table 2: Seaweed species population densities (No./M²)

Seaweed Species	Zone 01		Zone 02		Zone 03	
	Mean	SD	Mean	SD	Mean	SD
<i>Caulerpa racemosa</i>	16.0	13.6	11.9	10.31	2.09	4.29
<i>Caulerpa sertularioides</i>	16.7	12.6	13.1	9.24	2.70	5.21
<i>Caulerpa veravalensis</i>	5.34	4.09	4.71	3.86	1.49	2.67
<i>Caulerpa taxifolia</i>	5.12	4.22	5.53	3.93	1.86	3.24
<i>Codium elongatum</i>	3.97	4.10	3.99	4.03	1.13	2.51
<i>Halimeda macroloba</i>	4.17	4.50	3.18	3.54	1.66	3.13
<i>Halimeda tuna</i>	4.01	4.16	3.27	3.75	1.11	2.11
<i>Cladophora vagabunda</i>	4.57	4.42	4.24	4.37	1.36	2.60
<i>Boodlea composita</i>	4.73	4.25	3.85	3.46	1.41	2.97
<i>Phyllocladon pulcherrimum</i>	4.15	3.56	3.66	3.36	0.83	2.10
<i>Ulva intestinalis</i>	5.03	4.70	3.98	3.80	0.77	2.08
<i>Ulva lactuca</i>	10.9	11.5	7.18	6.41	1.67	4.06
<i>Ulva reticulata</i>	4.53	4.18	3.97	3.95	0.93	2.24
<i>Ulva rigida</i>	4.30	3.42	4.18	3.55	1.72	3.31
<i>Ulva clathrata</i>	6.79	7.39	5.00	4.46	1.46	2.94
<i>Ulva fasciata</i>	6.17	5.63	6.57	5.03	1.87	3.47
<i>Iyengaria stellata</i>	1.62	3.52	6.50	5.48	3.10	4.31
<i>Dictyota ciliolata</i>	1.60	3.48	6.58	4.18	2.76	3.39
<i>Padina boergesenii</i>	1.28	3.29	6.41	5.09	4.44	5.25
<i>Padina tetrastrumatica</i>	2.12	4.99	9.61	7.95	4.20	5.76
<i>Spatoglossum asperum</i>	2.04	5.12	10.5	7.45	4.92	4.88
<i>Cystoseira indica</i>	1.76	4.02	9.63	6.23	3.52	5.09
<i>Sirophysalis trinodis</i>	3.02	5.88	9.87	8.12	4.26	5.30
<i>Sargassum marginatum</i>	1.96	5.00	9.46	7.61	2.88	3.72
<i>Sargassum tenerrimum</i>	1.25	3.69	9.12	7.41	4.71	5.41
<i>Sargassum swartzii</i>	1.81	4.44	9.06	7.27	4.20	5.00
<i>Porphyra vietnamensis</i>	0.21	1.31	5.02	4.60	7.52	5.03
<i>Centroceras clavulatum</i>	1.38	3.60	6.07	6.18	5.96	6.14
<i>Ceramium tenerrimum</i>	0.05	0.58	5.14	6.06	6.63	6.22
<i>Polysiphonia denudata</i>	0.09	1.00	3.49	5.37	11.8	10.1
<i>Spyridia alternans</i>	0.47	2.13	5.27	6.52	8.50	7.91
<i>Amphiroa anceps</i>	1.05	2.82	3.14	5.24	10.5	8.03
<i>Halymenia venusta</i>	0.61	2.32	6.99	5.18	8.20	6.01

<i>Halymenia porphyroides</i>	0.54	2.14	6.26	6.23	8.58	6.89
<i>Hypnea musciformis</i>	0.05	0.57	2.93	4.01	6.16	4.42
<i>Gracilaria corticata</i>	0.26	1.98	7.76	8.11	11.91	8.88
<i>Dermonema virens</i>	0.51	1.87	5.25	4.39	6.38	4.59
<i>Scinaia carnosa</i>	0.05	2.90	2.22	3.21	4.45	2.71
<i>Botryocladia leptopoda</i>	0.23	3.70	4.2	5.21	5.96	4.97

The Zonal abundance distribution (% of total species individuals fronds) also supported a wide range of fluctuations in densities of seaweeds at different zones (Figure 2). The chlorophytes exhibited maximum percentages of total

individual fronds recorded in entire study at Zone while at the same time Phaeophytes showed maximum presence at Zone 02. The lower-intertidal zone-3 was found with maximum abundances of red seaweeds.

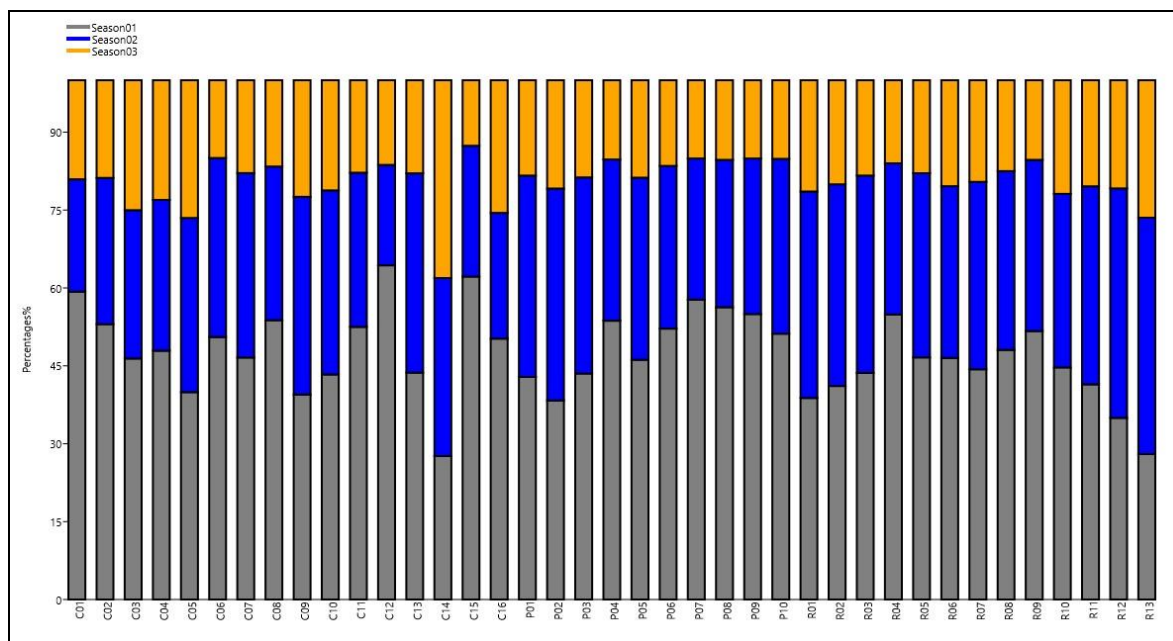


Fig 2: Seasonal seaweed abundance distribution (% of total species individuals)

The Bray-Curtis similarity and Distance matrix seaweed cluster analysis at different zones was conducted and dendrogram prepared for graphical presentation (Figure 3).

long period of desiccation for the Phaeophyceae and Rhodophytes.

Table 3: Zone similarity – Distance matrix

Step	Clusters	Distance	Similarity	Joined 1
1	2	37.38786	62.61214	2
2	1	39.60712	60.39288	1
Similarity Matrix				
	Zone 01	Zone 02	Zone 03	
Zone 01	*	60.3929	32.4273	
Zone 02	*	*	62.6121	
Zone 03	*	*	*	

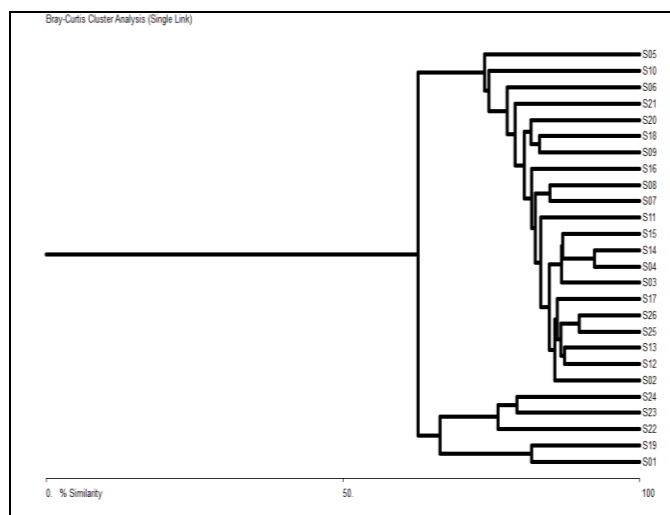


Fig 3: Dendrogram showing bray-curtis similarity-distance matrix

The seaweed cluster analysis in relation to different zonation showed the similarity of 60.40% (Table 3) of Zone 01 to the Zone 02, while Zone 03 had exhibited only 32.43% similarity to Zone 01. The Zone 02 and Zone 03 showed 62.61% similarity. This zonation pattern gives a prompt indication towards preferences for the water inundated areas to avoid

Conclusion

The Okha coast harbours a rich biodiversity of seaweeds. The rocky shore with many tidepools, Puddles and Gradual slope towards the sea supports a preferred habitat for the seaweeds. The intertidal zone with different exposure to desiccation and direct sunlight leads to zonation patterns among the seaweed species. The upper horizontal stretches of the coast were found mostly occupied by chlorophytes, while the mid-intertidal and low-intertidal zones preferred by phaeophytes and rhodophytes.

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