



SEAWEEDS OF KARWAR BAY, ARABIAN SEA, WEST COAST OF INDIA- A DIVERSITY PROFILE

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ABSTRACT

The Karwar Bay (14° 49'06" N to 14° 50'12" N and 74°03'30" E to 74° 05' 54" E) is rich in Seaweeds (marine algae) distribution and these macroalgae showed their diversification with respect to environmental condition of the biotope. In the present investigation, 32 species of seaweeds were recorded belonging to 19 genera comprising red, brown and green groups. The dominant species recorded were *Sargassum sp.*, *Ulva fasciata*, *U. lactuca*, *Padina sp.*, *Caulerpa sp.* Among three groups, Chlorophyceae comprised of six genera, Phaeophyceae five and Rhodophyceae eight genera were recorded during the present study tenure. Relative density, diversity index, species evenness, species richness and similarity index of seaweeds were greatly varied with respect to the seasons. The wet & dry weight and moisture content also showed seasonality in their variation with respect to the habitat. There is great magnitude of variation was found in seaweed abundance and distribution with space and time. An attempt was made to explain the relationship between the environmental condition and macro algae.

KEY WORDS: Macroalgae, Rockyshore, Biodiversity, Karnataka.

INTRODUCTION

Seaweeds are larger marine plants-may be more obvious but they contribute only 2% to 10% of the ocean's primary productivity. The single celled diatoms and dinoflagellates are classified as unicellular algae. Seaweed is the informal name for large marine multicellular algae, possessing chlorophyll and capable of photosynthesis but lacking vessels to conduct sap. Marine angiosperms are not considered seaweeds. Seaweed does not require great strength to support itself because it has nearly the same density as the surrounding seawater. More of its bulk can thus be dedicated to photosynthesis less to non productive support structures. Indeed productivity in some seaweed beds may be the highest of any autotrophic community on Earth. Zones or bands of dominant seaweeds are plainly visible on the sloping near shore seafloor to the limit of light penetration. The vertical distribution of large marine plants depends in part on the pigments they possess. Green algae (Chlorophytes) lack accessory pigments and are rarely found more than 10 metres below the surface whereas brown algae (phaeophytes) can be obtained from the surface down to about 30 metres. Red algae (rhodophytes), can function from the surface to the photosynthetic record depth of 268 metre *i.e.*, 879 feet.

Wave shock, varying salinity and pH, the presence of grazers from land and sea, the drying effects of sun and wind, abrasion by waterborne particles of sand all these factors and many more affect the location of intertidal plants. Seaweeds have gathered much scientific and industrial concern as human food, livestock feed and fertilizer (Jansi and Ramadhas, 2009). The distribution of seaweeds in the Karwar bay (Arabian Sea), has been studied earlier (Mishra, 1981). The present study was

carried out on the temporal variations of the seaweeds diversity, species richness at different areas of Arabian Sea (Karwar bay), along with hydrographical parameters during 2001-02.

MATERIALS & METHODS

Hydrography

Water samples were collected from the two study stations located in the Karwar bay (Figure 1), the Devagad Island (stn.1:14°49'06" N & 74°03'30" E) and the Kurumagad Island (stn.2: 14°50'12" N & 74°05'54" E) during September 2001 to September 2002 at a regular monthly interval to study hydrographic condition. Samples were collected using the Casella bottle (aqua sampler) to a depth usually not deeper than one metre from the surface layer of sea bed. Samples were collected from the same stations using the GPS instrument at the same time of the day, each month throughout the study period. The water samples were transferred to a separate clear polythene bottle for estimation of different hydrographic parameters. Air temperature was recorded by using the ordinary thermometer, whereas the Water temperature was recorded using the thermometer inserted within the Casella bottle. Salinity was determined by Mohr Knudsen method as described by Strickland and Parsons (1975). Dissolved oxygen content in the water sample was estimated by the Winkler's method as per the procedure described by Strickland and Parsons (1975). The pH of the water sample was estimated in site using the portable pH meter (model LI-120). Amount of suspended matter in the bay (inshore) water sample was estimated by filtering one litre of sea water through pre weighed Whatman G/F filter paper which was dried to constant weight at 90-105°C and

reweighed the difference between the initial and final values which gives the weight of the suspended matter (Rama Rao *et al.*, 1985). Light penetration at study site recorded using the Secchi disc (Welch, 1952), the readings were computed to the Poole and Atkins (1927) equation to

get sunlight attenuation depth. For estimation of different nutrients (phosphate, nitrite and silicate), the standard methods were followed as described by Strickland and Parsons (1975) & APHA (1980).

Fig.1. Map showing the location of study sites in the Karwar Bay, Karnataka, West Coast of India



Seaweeds

There are different methods to collect seaweeds, of which, in the present study a random sampling method was opted as it is more common and easy to study the seaweeds in the field (Gowda and Renukumar, 1999). In this method, a quadrat method opted for evaluating the density profile of seaweeds at study sites. Total numbers of seaweeds were counted and recorded in the quadrat (1 x 1m), based on this relative density, abundance frequency and dominant species were calculated later. Standing crop of given quadrat were estimated following standard method (Gowda and Renukumar, 1999). Collected seaweed samples were then transferred to the polythene bags, preserved in 5% formaldehyde solution for further identification in the laboratory. Numerical abundance of each species was recorded and expressed as number of species per square meter (n/m^2). Seaweeds reflect the ecological and environmental status and were calculated in terms of number of individuals or specimens (N), number of species (S), total abundance (A), Margalef species richness (d), Pielous evenness (J'), Shannon index (H) at each site (Clarke and Gorley, 2001). Bray Curtis similarity for species diversity for all the species of seaweed was determined analytically using PRIMER-v5.

RESULTS & DISCUSSION

Hydrography

In both site, minimum temperature was recorded in August and maximum during April and May. Comparatively higher temperature was recorded at Kurmagad area. In Kurmagad area single peak was observed during May whereas in Devgad area two peaks were noticed during January and April. More or less similar trend was noticed in the salinity profile at study stations but comparatively higher saline regime was noticed at Devgad island area. Over the year, salinity ranged between 10.31 and 30.25 psu at Devgad and 5.52 to 23.18 psu at Kurmagad area with annual mean of 23.74 and 16.79 psu respectively. In both study area, minimum and maximum saline regime was recorded during August and May. During the study period, in both study areas, the dissolved oxygen content

varied considerably but it registered high values and wide fluctuation at Kurmagad area (2.71-6.11 mg/l). In Devgad area, high oxygen content was recorded in January (4.23 mg/l) whereas in Kurmagad area it showed bimodal peak one registering in December (5.51mg/l) and another in August (6.11 mg/l). The pattern of pH variation was similar at both areas but values varied considerably ranging from 8.1 to 8.49 and 8.04 to 8.48 at Devgad and Kurmagad area. Not much variation was noticed in both study areas but comparatively high suspended matter was recorded at Kurmagad area. The suspended matter values ranged from 0.2562 to 35.62 gm/l and 0.2712 to 0.4746 gm/l with annual mean of 0.3051 and 0.3432 gm/l at Devgad and Kurmagad area respectively. The vertical extinction coefficient values did not vary much between the study areas but comparatively higher values were encountered at Kurmagad area. Overall, the values varied between 0.38 & 2.86m and 0.482-4.3m at study site 1 & 2. In both areas, the maximum value was registered during March (2.86 & 2.43) month only. The phosphate-phosphorus concentration showed similar pattern of distribution at both study stations but comparatively higher concentration was recorded at Devgad area (2.34 $\mu\text{g at/l}$). The values ranged from 1.71 to 2.88 and 1.17 to 1.94 $\mu\text{g at/l}$ at Devgad and Kurmagad area respectively. In both study areas minimum concentration was recorded during December-January (first peak) and April-May (second peak). This nutrient salt also showed more or less similar pattern of distribution in its concentration at both study areas but high concentration was recorded at Devgad area (1.78 $\mu\text{g at/l}$) than Kurmagad (1.56 $\mu\text{g at/l}$). In both study areas, minimum concentration occurred during September (1.41 & 1.15 $\mu\text{g at/l}$) but maximum (first peak) was observed during December in Devgad (2.15 $\mu\text{g at/l}$) whereas at Kurmagad during January (1.96 $\mu\text{g at/l}$) period. The second peak was observed in April month at both areas. Though the silicate concentration showed uniform pattern of distribution in both study areas, but comparatively higher concentration of this nutrient salt was observed at Kurmagad area. In Devgad area, this nutrient salt varied between 94.25 and 165.45 $\mu\text{g at/l}$

whereas at Kurmagad it ranged from 112.19 to 188.19 μg at/l with annual mean of 137.16 and 145.60 μg at/l respectively. In both areas, maximum concentration of this salt was noticed during south west monsoon period.

Seaweed abundance and diversity

High abundance was recorded at station 1 (Devagad area) compared to station 2, which is located at closer proximity of Kali river mouth. Among three seasons, maximum density of seaweeds was recorded during post and pre monsoon at both study areas. Comparatively higher density (192 & 151no/m²) was noticed during post monsoon followed by pre monsoon (171 & 124/m²) and lower density during south west monsoon season (123 & 74m²) at both stations.

Totally, 32 species of seaweeds were recorded during present study (Table 1), of which 13 species belongs to Chlorophyceae viz., *Enteromorpha clathrata*, *Ulva fasciata*, *U. lactuca*, *U. rigida*, *Chaetomorpha media*, *C. linum*, *Cladophora sarcenica*, *Caulerpa peltata*, *C. racemosa*, *C. scalpelliformes*, *C. sertularoides*, *C. taxifolia* and *Codium elongatum*. In brown algae, 8 species - *Dictyota bartayresiana*, *D. dichotoma*, *Padina gymnospora*, *P. tetrastomatica*, *Sargassum asperum*, *S. cinerium*, *S. polycystum*, *S. tenerimum*. In red algae, 7 species viz., *Gracillaria cortica*, *G. verrucosa*, *Amphiroa fragilissima*, *Hypnea musciformis*, *Gelidiopsis intricata*, *G. variabilis* and *Ceramium cruciatum*.

At station 1, maximum density of seaweeds species recorded during post monsoon was *Caulerpa peltata* (38/m²), *Padina tetrastomatica* (33/m²) *Ulva fasciata* (25/m²). During pre monsoon, dominant species were *Padina tetrastomatica* (45/m²) followed by *Chaetomorpha linum* (24/m²) remaining species did not contribute much to the total density of seaweed. In southwest monsoon period total density of seaweed was comparatively low, among which dominant species *Sargassum polycystum* (36/m²) followed by *Chaetomorpha media* (21/m²) respectively. During southwest monsoon, only ten species contributed to the total density of seaweeds whereas during post and pre monsoon, 21 & 19 species.

At station 2, maximum seaweed density was recorded during the post monsoon followed by pre monsoon season but during south west monsoon very low density was recorded. During post monsoon period, *Caulerpa peltata* (28/m²), *P. tetrastomatica* (21/m²) were found in high density whereas during pre monsoon season, 18 species were recorded of which *P.tetrastomatica* (28/m²), *U. fasciata* (21/m²) species contributed much to the total density of this macro algae community. Only six species were recorded during southwest monsoon among these *Cladophora sarcenica* (22/m²), *S. polycystum* (22/m²) followed by *Chaetomorpha media* (18/m²) were found dominant species.

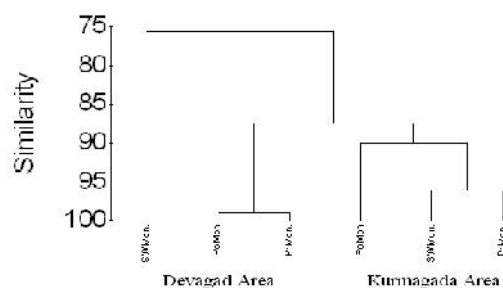


FIGURE 2. Dendrogram of seasonal clustering of seaweeds with Bray-Curtis similarity indices

TABLE 1. Distribution of Seaweeds (Macrophyte algae) in the Karwar Bay, Arabian Sea

Seaweed Species	#1	#2	Seaweed Species	#1	#2
<i>Enteromorpha clathrata</i>			<i>P. tetrastomatica</i>		
<i>Ulva fasciata</i>			<i>Spatoglossum asperum</i>		
<i>U. lactuca</i>			<i>Sargassum cinerium</i>		
<i>U. rigida</i>		x	<i>S. ilicifolium</i>	x	
<i>Chaetomorpha media</i>			<i>S. polycystum</i>		
<i>C. linum</i>		x	<i>S. tenerimum</i>		x
<i>Cladophora sarcenica</i>	x		<i>S. wightii</i>		x
<i>Caulerpa peltata</i>			<i>Gracillaria corticata</i>		
<i>C. racemosa</i>			<i>G. verrucosa</i>		x
<i>C. scalpelliformis</i>		x	<i>Grateloupia liathophila</i>	x	
<i>C. sertularoides</i>			<i>Amphiroa fragilissima</i>		x
<i>C. taxifolia</i>			<i>Cheilosporum specatabile</i>	x	
<i>Codium elongatum</i>		x	<i>Hypnea musciformis</i>		x
<i>Dictyota bartayresiana</i>		x	<i>Gelidiopsis intricata</i>		x
<i>D. dichotoma</i>		x	<i>G. variabilis</i>		x
<i>Padina gymnospora</i>			<i>Ceramium cruciatum</i>		x

On the basis of Bray-Curtis similarity index applied for seaweeds abundance, with single linkage cluster mode, post & pre monsoon were grouped in to one cluster (98.86%) and south west & pre monsoon as the second

cluster at 96.1% similarity at Devagad and Kurmagad areas respectively (Figure 2). The higher similarity between post & pre monsoon season at Devgad area may be due to ideal condition of environment establishing

Seaweeds of Karwar Bay

favourable regime of temperature, salinity and nutrients. Since the second study site located at the closer proximity of the estuary, the floral species might have been adapted to the lower saline condition and escalated their density to greater extent. It is surmised from these data that, pre and

post monsoon seasons are favorable period for seaweeds to escalate their growth rate as well as relative density. In addition to this, the sunlight is another factor which governs and will prosper these macrophytic flora especially in inter tidal zone.

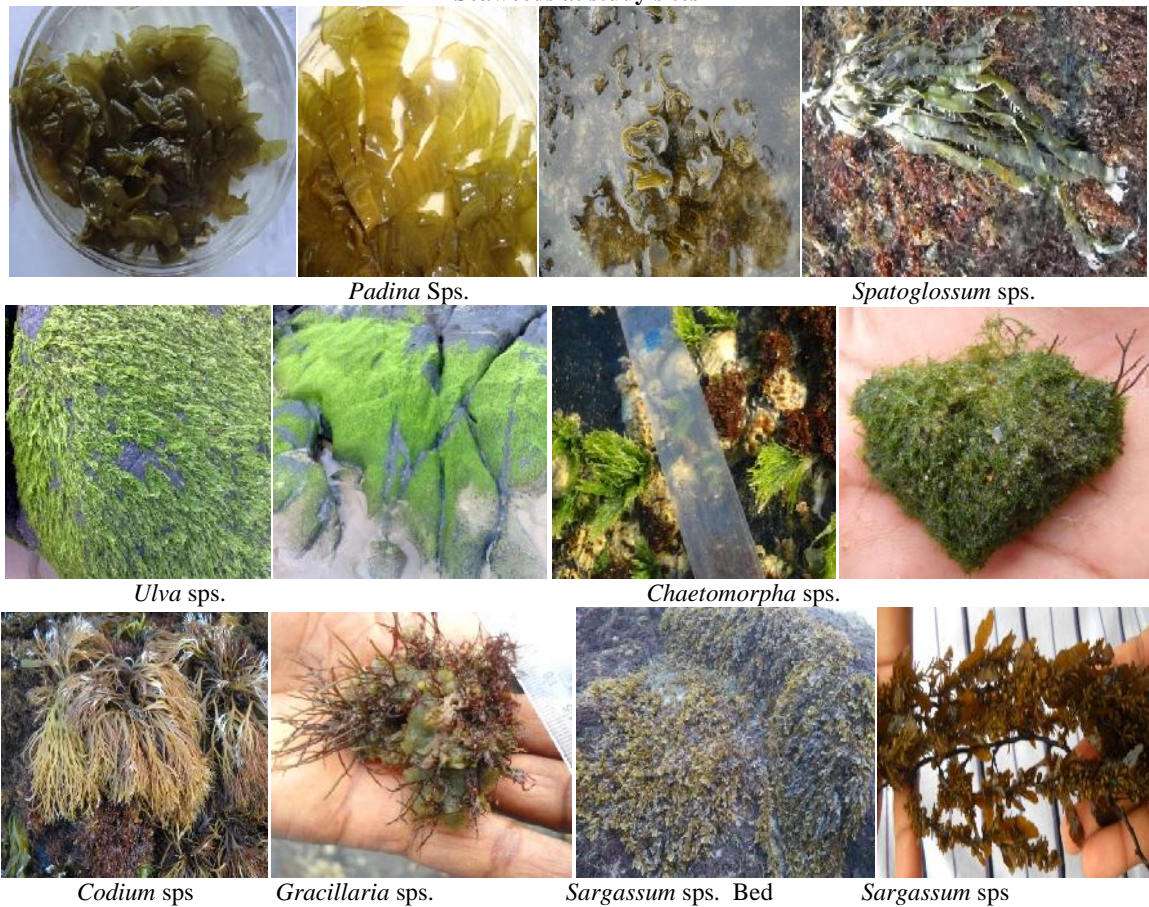
TABLE 2. Number of species (*S*), number of specimens (*N*), Margalef species richness (*d*), Pielous evenness (*J'*) and Shannon index (*H'*) of macrophytic algae in the Devagad and Kurmagad area, Karwar bay, Arabian Sea

Seasons	<i>S</i>	<i>N</i>	<i>d</i>	<i>J'</i>	<i>H'</i> (loge)
Devagad area					
Post monsoon	22	192	3.994	0.8419	2.602
Pre monsoon	19	191	3.427	0.7748	2.281
SW monsoon	10	123	1.870	0.8428	1.941
Kurmagad area					
Post monsoon	12	151	2.192	0.934	2.321
Pre monsoon	18	124	3.527	0.8534	2.467
SW monsoon	6	74	1.162	0.8103	1.452

The present study indicates higher seaweed diversity in the Karwar bay as compared to earlier reports (Mishra, 1981). The species diversity of seaweeds was estimated based on the Margalef species richness (*d*) and Shannon index (*H'*). At stn.1, the species richness value ranged from 1.87 (southwest monsoon) to 3.994 (post monsoon) whereas at stn.2 it was 1.162- 3.527 during south west and pre monsoon respectively. Shannon index (*H'*) values ranged

from 1.941 – 2.602 during south west and post monsoon (#1) and 1.452 – 2.467 in south west and pre monsoon (#2) area respectively (Table 2). In general the richness and diversity was higher during post and pre monsoon period when nutrient availability was more which supports growth of these macrophytic algae in inshore waters of Karwar. For healthy environment *H'* and *d* are considered to be in the range of 2.5 to 3.5 (Magurran, 1988).

Seaweeds at study sites





Seaweed mat

As there is high temperature profile during pre and post monsoon season, the atmospheric and water temperature could be another factor to register high density of these weeds in the area. Similar observations were made by Jansi and Ramadhas (2009) in the Manakkudy estuary who pointed out that, they observed significant positive correlation with the biomass of *Chaetomorpha aerea*, *Gracillaria verucosa* and *Hypnea musciformis*. Salinity showed highly significant positive correlation with the biomass of four species of seaweeds. It has been reported that *Chaetomorpha aerea*, *Enteromorpha compressa*, *Gracillaria verucosa* and *Hypnea musciformis*. could tolerate wide range of salinity (13 to 40psu) and water temperature of 25-33°C (Balakrishnan *et al.* (1992). *G. verrucosa* has been reported to be the most common species of the south west and West coast of India (Rama Rao, 1977) whereas *Chaetomorpha* is known to occur as the pest of *Gracillaria* under culture (Chian, 1981). Jansi and Ramadhas (2009) have pointed that four types of seaweeds occurred in abundance when the level of nutrients (ammonia, nitrate and phosphate) remained moderately high. Similar observation has been reported in the south eastern part of Tamilnadu (Yogamurthy, 1982). In the present investigation also, similar findings were observed. The silicate level remained very low during period of high biomass production of these seaweeds exhibiting negative correlation with salinity (Jansi and Ramadhas, 2009).

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