Ambient Science, 2015: Vol. 02(1); 01-08
DOI:10.21276/ambi.2015.02.1.ra01

Published by: National Cave Research and Protection Organization, India

ambient SCIENCE
Vol. 02(1):01-08
Year 2015

RESEARCH ARTICLE

Diversity and Abundance of Marine Macroalgae along Borli Coast: a Zone under Western Ghats, Maharashtra, India.

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Study Area: Borli Coast, Raigad, Maharashtra
Coordinates: 18°30'33.9"N, 72°54'59.6"E
Key words: Borli, macroalgae, Phaeophyceae, Chlorophyceae, Rhodophyceae

Abstract

Richness of Marine macroalgae species along the Konkan coastline has been well reported by few researchers. Yet, there are many coastal villages in Konkan where the research is still to be undertaken. Borli is one such village having rocky shore which provides perfect habitat for growth of macroalgae. In our study during (June 2012 to May 2013) we found, total 35 species of marine macroalgae. Rhodophyceae is a dominating class contributing 15 species followed by Phaeophyceae and Chlorophyceae with 12 and 8 species respectively. The algal diversity of Borli coast needs to be documented as this coast is a part of Western Ghats that has solicited the interest from scientist fraternity world over. Further, nearby coasts are frequented by tourists and this coast is quite likely to have an impact of anthropogenic invasion.

Introduction

Marine macroalgae are an important autotrophic component of many coastal ecosystems including oceans, lagoons and estuaries, as they play an important role in the recycling of nutrients and also provide food to a variety of invertebrates (Duggins *et al*., 1989). Besides they also provide medicinal and industrial materials, (Graham *et al.*, 2009) due to which they are of

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ISSN- 2348 5191 (Print) & 2348 8980 (Electronic)

high economic and ecological importance to the environment.

It is well known that the temperature, salinity, pH and dissolved oxygen play important role in survival and growth of marine organisms. Further, their distribution and abundance depends on various physico-chemical parameters of water and sediments which are influenced by anthropogenic activities and natural calamities. Several researchers have studied the diversity of macroalgae on the West and East coast of India (Dhargalkar & Deshmukhe, 1996; Rao *et. al.*, 2011; Sathianaeson & Wesley, 2012; Rath & Adhikary, 2006; Sahyaraj *et. al.*, 2014).The present work envisages seasonal variations and abundance of macroalgae along the coastline of Borli, located in Murud taluka, district Raigad, Maharashtra. The study involved use of standard methods of recording of algal diversity.

Materials and Methods:

Study area: village Borli is covered by Arabian sea on the west and hills (foot hills of Sahyadri mountain ranges) on the east thus, making it a scenic location ideal for weekend picnickers. It is a long stretch of coastline located 20 km away from Alibaug and has a rocky habitat with few sandy patches in between. The area falls under Western Ghats which is a biodiversity hotspot.

The study area showed presence of rich diversity of macroalgae with a probable threat from increasing anthropogenic pressure such as disposal of garbage and debris, so also oil pollution. To quantify the impact, it was necessary to undertake the present study as no previous data is available.

Study was conducted for the period of one year during June 2012 to May 2013. The data were tabulated on monthly basis; results were pooled season-wise and interpreted accordingly. The abundance of macro algae was recorded. Total 10 quadrants of (0.5m × 0.5m) were studied and analyzed (Satyarao *et al.*, 2011). A mixture of copper sulphate, distilled water, glacial acetic acid, 40% formalin, 95% ethyl alcohol was used for the preservation of algae (Sambamurty, 2005). Few algae were preserved in form of herbaria. The physico-chemical parameters such as temperature, pH, salinity and dissolved oxygen of water were also recorded. Biological dissolved oxygen and pH were studied using Multi-parameter Bench Photometer on field (HANNA HI 83206). Salinity was estimated by Argentometric method as described by Trivedi & Goel (1984). Temperature was measured using an alcohol thermometer.

Ecological parameter such as relative frequency was also determined using the formula by Fidelibus & MacAller (1999), given as:

$$\text{Relative frequency} = \frac{\text{Species frequency}}{\text{Total of frequency values for all species}} \times 100$$

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Results and Discussion:

Physico- chemical parameters:

From table 1, it can be observed that highest water temperature of 28.5°C was recorded during pre-monsoon season while, the lowest was 22.6°C during late post monsoon. Throughout the study period pH varied between 7 to 8.5 and dissolved oxygen content was between 5.95 mg/l to 7.3 mg/l. The salinity ranged between 31 ppt to 35 ppt. which has already been reported to be favourable for the growth of macro-algae (Jansi & Ramdhas, 2009).

Occurrence of algae was studied for three classes namely; Chlorophyceae, Rhodophyceae and Phaeophyceae (Fig.-1). The class-wise occurrence revealed the dominance of class Rhodophyceae (15 species) followed by Phaeophyceae (12 species) and class Chlorophyceae (8 species). Similar observations with dominance of Rhodophyceae were recorded at the coast of Dwaraka (Dhargalkar & Deshmukhe, 1996); coast of Orissa (Rath & Adhikary, 2006); coast of Kudunkulam (Sathienason & Wesley, 2012), and coast of Maharashtra (Dhargalkar *et al.*, 2001). According to Bird *et al.*, (1984); and Mathieson (1979), the abundance of red algae increases with depth. In the present study, the abundance was observed at end of mid littoral and start of infra littoral zone which has more depth.

The month-wise occurrence of class Rhodophyceae was higher during the period of January 2013 May 2013 i.e., late post monsoon and pre monsoon season. The month-wise occurrence of class Phaeophyceae was higher during the months of December 2012-May 2013 i.e., late post monsoon and pre-monsoon season. Red and Brown algae were dominant during this period. Abundance of Chlorophyceae was low throughout the study period as compared to other classes except for July 2012 and August 2012. The decline in abundance of Chlorophyceae might be attributed to increase in temperature during pre-monsoon season (Table 1).

Seasonal variations in Relative frequency of all the species:

A total of 35 macroalgal species belonging to 3 classes were recorded (Table 2; Fig.-2). Maximum abundance was seen during late post monsoon and pre monsoon season. *Enteromorpha intestinalis, Enteromorpha compressa, Rhizoclonium spp., Ulva spp., Dictyota dichotoma, Stoechospermum marginatum, Padina spp, Padina tetrastomatic*a, Two species of *Sargassum, Amphiroa spp.* were found to have the highest abundance during late post monsoon and pre-monsoon season (Fig.-3).

The excessive growth of algae was observed from December 2012 to May 2013 i.e. during late post-monsoon and pre-monsoon season. This could be due to settling of algae on the rocky shore. During monsoon, algae showed decline in frequency. Similar trend was found in several other studies conducted on West and East coast of India (Rath & Adhikary, 2006; Prasanna & Rao, 2009; Sarojini *et al.*, 2013). Torrential rain is a peculiarity of study location and most of the intertidal zone is submerged during monsoon period.

Class Chlorophyceae, was represented by *Enteromorpha spp*., Cladophora spp. and Ulva spp. throughout the study period. Caulerpa spp. was not reported in monsoon. *Enteromorpha intestinalis, E. compressa* and *Rhizoclonium spp*. showed high relative frequency throughout the study period except early post monsoon. According to Worm & Lotze (2006) dense

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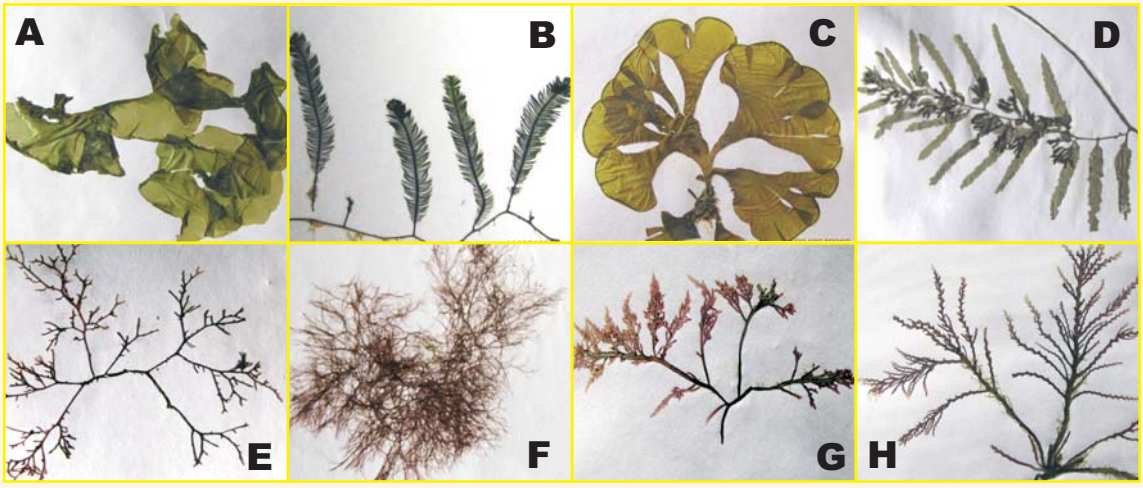

Figure -3: **A**. *Ulva spp*., B. *Caulerpa spp*., **C**. *Padina spp*., **D**. *Sargassum spp*., **E**. *Gracilaria spp.*, **F**. *Ceramium spp.*, **G**. *Laurentia spp.*, **H**. *Acanthophora spp.*

population of *Enteromorpha intestinalis* strongly indicates eutrophication and may indicate changes in the trophic state (increase of nutrient supply) of the habitat. Fang *et al.*, (1993) found that blooms of *Enteromorpha intestinalis* out-compete phytoplankton under conditions of moderate to high nutrient concentrations. Scrosati (2001) observed absence of *Caulerpa sertularioides* associated with relatively low temperatures on sandy beach on south eastern coast of the Baja California Peninsula, Mexico. Thus, the presence of *Enteromorpha intestinalis* indicates increased nutrient concentration. Low algal frequency was reported during monsoon. High tidal activity, heavy rains and insignificant receding of water limited the exploration of the coast. The algae occurring on the rocks could not be recorded as the rocks remained submerged during onset of monsoon.

Even dominant presence of *Ulva spp*. is said to indicate increased nutrient concentration and also freshwater input or pollution. But observations during the present studies suggested no increase in nutrient concentration or fresh water input which could indicate pollution.

Dictyota dichotoma, Padina tetrastomatica, Padina spp. (species unidentified) from class Phaeophyceae were the dominant species found throughout the year. *Dictyota dichotoma* showed highest frequency during early post monsoon season. According to Essaid, (2012) *D. dichotoma* proved to be a valuable indicator of accumulation of heavy metals like cadmium, copper, lead, chromium, and zinc. The abundance of *D. dichotoma* at Borli coast indicates increased heavy metal pollution. *Stoechospermum marginatum*, was absent during early post monsoon. During monsoon, its frequency was remarkably low.

Few species namely, *Dilophus spp., Spatoglossum asperum* were observed only during late post monsoon and pre monsoon season. Two species of Sargassum were reported throughout the study period except early post monsoon season. Both species of Hypnea, were absent during monsoon. *Delecera spp.* was present only during late post monsoon and its distribution

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was also limited.

From class Rhodophyceae, *Centroceros spp, Ceramium spp, Gelidium pulchellum* were recorded throughout the study period. *Acanthophora specigera, Ahnfelcia plicata, Calaglossa leupruneii, Chondria armata, Laurentia pyramidalis* were reported to be present only during late post monsoon and pre monsoon. *Gelidium pulchellum* was present throughout the study period and showed maximum relative frequency during pre-monsoon. *Polysiphonia spp* was not found during monsoon and showed higher relative frequency during late-post monsoon.

Grassilaria corticata showed highest relative frequency among members of Rhodophyceae. It was absent during early-post monsoon. *Grassilaria prolifera* was absent during early post monsoon and showed higher relative frequency during pre-monsoon. According to Hodgson (1981), Oates (1986), Ogata & Matsui (1965), Quadir *et al.* (1979), slight drying of red algae may cause stimulation of photosynthesis, but increasing desiccation causes a dramatic decline. Desiccation may be due to rise in temperature. The temperature during early post monsoon was 25.2° C and salinity was 32.4 ppt while during pre monsoon it was 28° C and salinity was 34.4 ppt (Table 1).

Table 1: Physico-chemical parameters of water at the coast of Borli

	Monsoon	Early post-monsoon	Late post-monsoon	Pre-monsoon
Temp °C.	24.8	25.2	22.6	28.5
DO* (mg/l)	5.95	6.5	7.3	6.5
pH	8.3	7.79	8	8.5
Salinity (ppt)	31.59	32.42	31.59	34.47

*Dissolved Oxygen

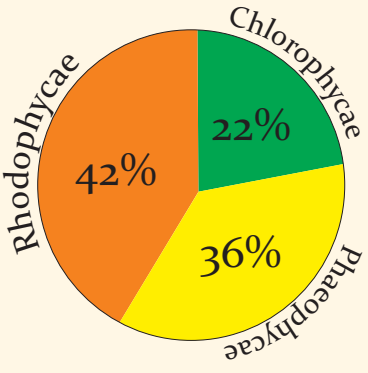

Figure-2: Class-wise abundance of Macro-Algae

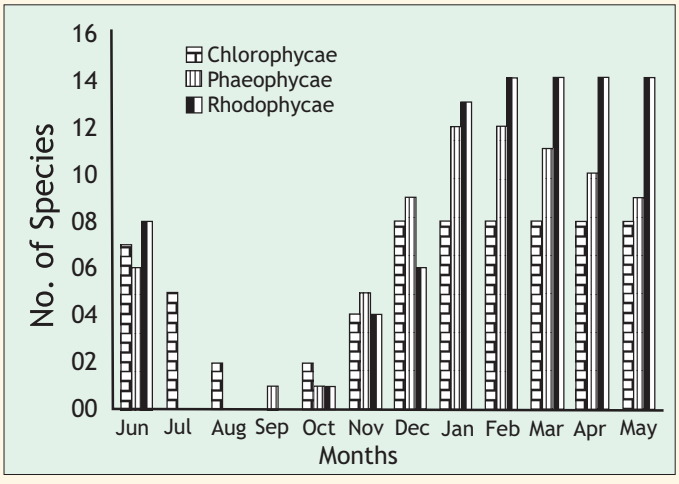

Figure-3: Monthly variations in class-wise occurrence of algae

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Table 2: Seasonal variation in abundance and relative frequency (%) of macro algae at the coast of Borli

S.No		Monsoon	Early-Post monsoon	Late-Post monsoon	Pre-Monsoon
	Chlorophycae				
1	*Caulerpa spp.*	- (0)	+ (1.667)	+ (0.870)	+ (0.636)
2	*Cladophora spp.*	++ (15.762)	++ (16.667)	+ (1.954)	+ (1.475)
3	*Enteromorpha intestinalis*	+ (7.106)	+ (1.667)	+++ (6.551)	+++ (3.996)
4	*Enteromorpha compressa*	++ (7.106)	+ (1.667)	+++ (6.551)	+++ (4.452)
5	*Rhizoclonium spp.*	++ (7.106)	- (0)	+++ (7.011)	++++ (5.292)
6	*Ulva lactuca*	+ (3.101)	+ (1.667)	+++ (3.956)	+++ (4.632)
7	*Ulva spp.*	+ (19.767)	+ (5.556)	+++(3.956)	+++ (3.996)
8	*Chaetomorpha linum*	+ (22.222)	- (0)	++ (3.940)	+++ (5.521)
	Phaeophyceae				
9	*Delecera spp.*	- (0)	- (0)	+ (0.459)	- (0)
10	*Dictyota dichotoma*	+ (0.775)	+ (40.556)	++ (5.728)	+++ (4.199)
11	*Dictyota divaricata*	- (0)	- (0)	+ (2.658)	++ (2.544)
12	*Stoechospermum marginatum*	+ (0.775)	- (0)	++ (4.810)	+++ (3.155)
13	*Dilophus spp.*	- (0)	- (0)	+ (1.590)	++ (1.705)
14	*Hypnea musciformis*	- (0)	+ (1.667)	+ (1.329)	+ (0.636)
15	*Hypnea spp.*	- (0)	+ (1.667)	+ (0.870)	+ (0.203)
16	*Padina spp.*	+ (0.775)	+ (6.667)	++ (6.234)	+++ (4.427)
17	*Padina tetrastomatica*	+ (0.775)	+ (6.667)	++++(7.057)	+++ (4.427)
18	*Sargassum spp.*	+ (0.775)	- (0)	++ (3.497)	+++ (3.360)
19	*Sargassum spp.*	+ (0.775)	- (0)	++ (3.528)	+++ (3.360)
20	*Spatoglossum aspermum*	- (0)	- (0)	++ (1.835)	+ (1.426)
	Rhodophyceae				
21	*Acanthophora specigera*	- (0)	- (0)	++ (2.413)	++ (3.613)
22	*Ahnfecia plicata*	- (0)	- (0)	+ (0.459)	+ (1.272)
23	*Amphiroa spp.*	+ (1.550)	- (0)	+++ (3.758)	+++ (5.750)
24	*Caloglossa leupruneii*	- (0)	- (0)	+ (0.459)	++ (1.069)
25	*Centroceros clavulatum*	+ (1.550)	+ (7.222)	+ (2.508)	+ (4.249)
26	*Ceramium spp.*	+ (0.775)	+ (1.667)	+ (1.376)	++ (3.182)
27	*Chondria armata*	- (0)	- (0)	+ (0.918)	+ (1.272)
28	*Corollina spp.*	+ (1.550)	- (0)	- (0)	- (0)
29	*Gelidium pulchellum*	+ (3.101)	+ (3.333)	+ (2.872)	++ (3.816)
30	*Gelidium spp.*	+ (1.550)	- (0)	+ (1.131)	++ (2.544)
31	*Grassilaria corticata*	+ (2.326)	- (0)	+ (3.038)	++ (5.088)
32	*Grassilaria prolifera*	+ (0.775)	- (0)	+ (0.672)	++ (2.772)
33	*Gratilaupia spp.*	- (0)	- (0)	+ (1.329)	+ (0.839)
34	*Laurentia pyramidalis*	- (0)	- (0)	+ (0.427)	+ (1.908)
35	*Polysiphonia spp.*	- (0)	+ (1.667)	++ (4.257)	+ (3.180)

++++abundant, +++Medium, ++ Avergae, + Meager, - Absent

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Relationship among the physic-chemical parameters and algal diversity:

During monsoon, when temperature (24.8^{O}C.), DO (5.95mg/l) and salinity (31.59ppt) were lower whereas, the pH (8.3) was higher, photosynthetic chlorophyceae were found to be abundant. In the early post-monsoon period the temperature (25.2^{O}C.), DO (6.5mg/l) and salinity (32.42ppt) were slightly on the higher side whereas, the pH (7.79) bit low, the phaeophyceae in particular Dictyota dichotoma dominated the flora. Late post-monsoon showed temperature (22.6^{O}C.) and salinity (31.59ppt) to be little on the lower side while DO (7.3mg/l) and pH (8) slightly higher. The chlorophyceae diversity was observed to be more in this period as compared to phaeophyceae and rhodophyceae. In the pre-monsoon period water temperature (28.5^{O}C.), pH (8.5) and the salinity (34.47ppt) were highest while, DO (6.5mg/l) was relatively low. During this season, abundance of chlorophyceae was more but diversity of Phaeophyceae and Rhodophyceae was found to be high.

The presence of chlorophyceae in the supralittoral zone must be indicative of adaptation of green algae to exposure to light and consequently higher temperature and salinity. This fact was confirmed by presence of green algae during the period of higher temperature, pH and salinity. Diversity of Phaeophyceae was found to be abundant in the mid-littoral region showing that, they can tolerate lesser fluctuation in temperature, DO and salinity. Abundance of brown algae was found to be less during the season of lower DO, higher temperature and salinity. Rhodophyceae are reported mainly from the infra-littoral zone where the fluctuation in parameters is remarkably lower as the area was mostly submerged except when there was extreme low tide. Hence, red algae exhibited maximum diversity during the pre-monsoon season when diversity of the other algae was relatively lower.

The physico chemical parameters such as temperature, salinity, dissolved oxygen & pH were studied. According to a study done by Jansi and Ramdas (2009), atmospheric temperature and water temperature showed significant positive correlation with the biomass of the species from genera Chaetomorpha, Enteromorpha, Gracillaria and Hypnea. It can be seen from the present study that, the pre-monsoon period showed higher no of species when the salinity & water temperature were high. It can be said that the temperature and salinity may be having influence on the occurrence of algae.

Conclusion:

The coastline of Borli is rich in macroalgal diversity. Human interference is posing a threat to the biodiversity of this coast. Hence a continuous and extensive study of the effects of the anthropogenic impacts on biodiversity as well as on nutrient concentrations is necessary. As the villagers are benefitted by tourism, it is not possible to discourage it, but making the tourists aware of the species richness and its importance in nature can bring a change.

Acknowledgements:

Authors are grateful to University of Mumbai for funding the research project which encouraged us to study the biodiversity of Borli coast. Authors are thankful to Dr. (Mrs) M. K. Pejaver Principal, B. N. Bandodkar College for support and encouragement. Special thanks are due to Dr. Geetanjali Deshmukhe, Senior Scientist, CIFE, Mumbai for her help in identification of algal species and to colleagues and Mrs. Sheetal Pachpande for her valuable inputs.

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