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Comparative Study of Marine Microalgal Abundance and Diversity along Coastal Region of Raigad District, Maharashtra

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ABSTRACT

Marine algae considered as one of the major living resources of the seas. In present study marine microalgal and chlorophyll 'a' concentration were correlated with different environmental parameters along Shrivardhan and Alibag intertidal areas during the post and pre-monsoon season. The study recorded 33 species of microalgae from Shrivardhan in which diatoms comprised 28 species (85%), dinoflagellates 1 species (3%), Cyanophyceae 2 species (6%) and Chlorophyceae 2 species (6%). In Alibag out of 22 species, diatoms comprised 19 species (86%), Cyanophyceae 2 species (9%) and Chlorophyceae 1 species (5%). Along Shrivardhan microalgal distribution and biomass is positively correlated with DO (0.133), pH (0.288), Nitrate (0.057) and Chlorophyll 'a' (0.316) and negatively correlated with Salinity (-0.303), water temperature (-0.706) and phosphate (-0.139). Along Alibag microalgal biomass is positively correlated with DO (0.789), Salinity (0.608), pH (0.961), nitrate (0.350), phosphate (0.060) and Chlorophyll 'a' (0.549) and negatively correlated with water temperature (-0.792). Different diversity indices for microalgae such as Species richness (d), Pielou's evenness (J'), Shannon's index (H') and Simpson's diversity index (1-λ) were calculated and it was found that Shrivardhan intertidal area was more diversified than Alibag.

Key words: *Intertidal areas, Microalgae, Chlorophyll 'a', Diversity Indices.*

INTRODUCTION

Marine intertidal ecosystem is very dynamic, that is the area between sea and terrestrial environment. The environmental condition of the intertidal water is much different from the adjacent sea water due to the occurrence of relatively large amount of nutrients and governed by tidal impact. The tidal pools of the intertidal regions provide an ideal condition for the growth of marine algae along the intertidal area. Marine algae considered as one of the major living resources of the seas. They play an important role of primary producers and food for marine grazers - grazing on both micro and macro algae[5].

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Marine algae provide ecologically and economically valuable resources which are being used all over the world for different purposes[21]. They are found in unicellular forms such as *Chlorella* and diatoms (microalgae) to multicellular forms such as the giant kelp (macroalgae). Microalgae are unicellular species which exist individually, or in chains or groups, found in both fresh water and marine systems. In Indian coastal waters the species composition and seasonal variation of microalgae abundance have been studied for freshwater and marine environment[11,17,16]**.** The biodiversity of microalgae denotes the health indices and it is a very important factor determining the productivity of an aquatic ecosystem and is very much influenced by the seasonal events[10,18]. Availability of nutrients plays a key role in microalgal abundance, growth and metabolism and the substances like nitrogen, phosphorous and silicon are considered as limiting nutrient than others[18]. The microalgae have potential in the aquaculture as they are used as a feed for aquatic animals[4]. The aquatic organisms including fishes depend on plankton for their growth and development and thus comprise as an important component of the food web[20,8,17,2]. Chlorophyll '*a*' is a widely distributed photosynthetic pigments in green plants, used for estimation of microalgal biomass and primary production[3,15,19].

Although both the macro as well as microalgae in the dynamic intertidal region contribute to the productivity, mostly seaweeds had been recorded earlier, therefore in order to understand the total availability, distribution and for future utilization of microalgae, this study was undertaken.

MATERIALS AND METHODS

DESCRIPTION OF STUDY SITES

The study was conducted during post and pre-monsoon season along Shrivardhan (18º02'00"N and 73º01'00"E) and Alibag (18º38'29"N and 72º52'20"E) intertidal areas, both are located in Raigad District of Maharashtra state. The intertidal areas are exposed during the low tide and filled at the time of high tide. Nine stations were selected from each sampling sites of Alibag and Shrivardhan.

PHYSICO-CHEMICAL PARAMETERS AND NUTRIENT ANALYSIS

Physico-chemical parameters were analyzed using APHA[1], 2012. Nutrient, Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) water samples were analyzed with the help of nitrate and phosphate test cells provided by MERCK Company, Germany with the help of spectrophotometer of model number 5000.

MICROALGAE ANALYSIS

For microalgae, 500 ml water samples were collected during the low tide condition from tidal pools and near the sea front and are allowed to settle by mixing 1ml Lugol's solution. The microalgal samples were analyzed using Sedgwick-Rafter counting chamber.

CHLOROPHYLL '*a*' ESTIMATION AND DATA ANALYSIS

Chlorophyll '*a*' concentration was determined spectrophotometrically[14] using a HACH DR/5000 spectrophotometer (Model 19600-00). The data were analyzed by using Primer v6 software.

RESULTS AND DISCUSSION

Physico-chemical parameters

The value of DO, salinity, pH, water temperature, nitrate, and phosphate were recorded in range and the not much significant difference was found along both the intertidal areas of Shrivardhan and Alibag during the post and pre-monsoon season (Table 1). Similar observations of these physicochemical parameters were observed along Mumbai coast[7,9]. The DO value range recorded from 2.6 to 3.2 ppm during post monsoon and 2.4 to 2.8 ppm during pre-monsoon along Shrivardhan intertidal area while 2.4 to 3.2 ppm during post monsoon and 2.8 to 3 ppm during pre-monsoon along Alibag intertidal area. Salinity value range recorded from 34 to 36 ppt during post monsoon and 35 to 36 ppt during pre-monsoon along Shrivardhan intertidal area while 34 to 35 ppt during post monsoon and 35 to 36 ppt during pre-monsoon

along Alibag intertidal area.The pH value ranges recorded from 7.5 to 8 during pre-monsoon along Shrivardhan intertidal area while 7.6 to 7.8 during post monsoon and 7.7 to 7.9 during pre-monsoon along Alibag intertidal area. The range of surface temperature of the sea water was recorded from 27 to 30.5 ºC during post monsoon and 24 to 31 ºC during pre-monsoon along Shrivardhan intertidal area while 28 to 31 ºC during post monsoon and 27 to 31 ºC during pre-monsoon along Alibag intertidal area. Nutrient like nitrate-nitrogen value range was recorded from 0.45 to 0.52 mg/l during post monsoon and 0.38 to 0.51 mg/l during pre-monsoon along Shrivardhan intertidal area while 0.39 to 0.44 mg/l during post monsoon and 0.33 to 0.43 mg/l during pre-monsoon along Alibag intertidal area. The range of phosphate-phosphorus value was recorded from 1.16 to 1.23 mg/l during post monsoon and 0.78 to 1.17 mg/l during pre-monsoon along Shrivardhan intertidal area while 1.12 to 1.33 mg/l during post monsoon and 0.72 to 1.02 mg/l during pre-monsoon along Alibag intertidal area (Table 1).

Microalgal biomass

Along Shrivardhan intertidal area the total average microalgal density was recorded in the range from 234 to 293 no./l^3 during post monsoon and 250 to 342 no./l^3 during pre-monsoon (Table 1). It was also found that the microalgal density was positively correlated with Chlorophyll '*a*' (0.316), DO (0.133), pH (0.288), nitrate (0.057) and negatively correlated with Salinity (-0.303) and water temperature (-0.706) (Table 2). The maximum microalgal density was reported in post-monsoon season which may be due to deposition of allochthonous nutrients during the monsoon season, also the positive correlation between microalgal density and water quality parameters shows that the optimum level of available nutrient, DO, and pH value favours the microalgal growth along the Shrivardhan intertidal area[12]. Along Alibag intertidal area the total average microalgal density was recorded 220 to 311 no./l^3 during post monsoon and 259 to 352 no./l^3 during pre-monsoon (Table 1). In Alibag the microalgal density was positive correlated with DO (0.789), pH (0.961) and Chlorophyll 'a' (0.549), Salinity (0.608), Phosphate (0.060) and Nitrate (0.350) but negatively correlated with water temperature (-0.792) (Table 3). The higher microalgal density in post monsoon season was might be due to the deposition of nutrients by the rainfall during monsoon season also ocean currents and upwelling brings nutrients up to the surface water which favours the microalgal growth. The positive correlation of microalgal density with water quality parameters such as DO, pH and optimum level of an available nutrient, support the growth of microalgae[12].

Chlorophyll '*a*'

Chlorophyll '*a*' is the major photosynthetic pigments found in microalgae and other green plants**.** The concentration of Chlorophyll '*a*' ranged from 7.29 to 12.57 µg/l during post monsoon and 8.54 to 10.37 µg/l during pre-monsoon along Shrivardhan intertidal area. It was also found that Chlorophyll '*a*' was positively correlated with DO (0.417), pH (0.302), microalgal density (0.316), Phosphate (0.386) and negatively correlated with water temperature (-0.149) and Salinity (-0.771) (Table 2). The maximum concentration was might be due to the abundance of macroalgae, microalgae and other Chlorophyll *a* containing organisms. Along Alibag intertidal area the concentration of Chlorophyll '*a*' ranged was reported from 7.13 to 8.46 µg/l during post monsoon and 7.47 to 8.40 µg/l during pre-monsoon (Table 1). In Alibag Chlorophyll '*a*' was positively correlated with microalgal density, salinity (0.852), pH (0.600) and negatively correlated with water temperature (-0.196) (Table 3). The maximum concentration was might be due to the abundance of macroalgae, microalgae and other Chlorophyll '*a*' containing organisms. The abundance of microalgae due to the availability of optimum level of pH and DO concentration may be the reason for the increase in Chlorophyll '*a*' level.

Diversity indices

Different diversity indices like Shannon's index (H'), Simpson's diversity index (1-λ), Pielou's Evenness index (J') and Species richness (d) were used for calculation of species diversity of microalgae in a particular habitat (Table 4). The highest Shannon's index H' value is the indicator of the most stable condition of the particular area. H' value will maximum only when all the species in the sample are represented by the same number of individuals. The value of H' was highest during the pre- monsoon season in both the sampling site indicate the most stable condition might be due to the availability of nutrients and favorable temperature which promote the growth of microalgae. A similar result was observed along Mumbai coast[9]. In Shrivardhan intertidal area the highest H' value was recorded 3.281 whereas in Alibag it was 2.938, indicate Shrivardhan intertidal area is more stable than Alibag intertidal area. The higher value of Simpson's index shows the higher species diversity and lower value shows the lower diversity. The value of (1- λ) was found maximum during pre- monsoon season in both the sampling site. The maximum value of (1- λ) during the pre-monsoon season along the Mumbai coast also reported[**9**]. In Shrivardhan intertidal area 1- λ value was recorded 0.950 whereas in Alibag it was 0.941 indicate higher species diversity along Shrivardhan intertidal area. Pielou's Evenness index (J') refers that how close in numbers each species in an environment is. The maximum value for (J') was recorded during the post-monsoon season along Shrivardhan intertidal area and pre-monsoon season along Alibag intertidal area. In Shrivardhan, it was recorded 0.942 and in Alibag, it was 0.950. Species richness (d) is the number of different species in a given area. The maximum value for (d) was recorded during the pre-monsoon season along both the intertidal areas may be due to the nutrient stress condition which prevents grazers grazing on microalgae[13]. In Shrivardhan the'd' value was recorded 2.534 and in Alibag, it was found 1.663, indicate maximum microalgal species richness along Shrivardhan intertidal area than Alibag intertidal area.

The present study reported that the species contribution of diatoms was higher among all microalgal groups in both the sites of Shrivardhan and Alibag (Fig. 1). Total 33 species of microalgae from Shrivardhan and 22 species from Alibag intertidal area were recorded. Out of 33 species from Shrivardhan diatoms comprised 28 species, dinoflagellates 1 species, Cyanophyceae 2 species and Chlorophyceae 2 species (Table 5). In Alibag out of 22 species, diatoms comprised 19 species, Cyanophyceae 2 species and Chlorophyceae 1 species (Table 5).The study reported that among diatoms groups *Navicula* sp., *Nitzscia* sp., *Licmophora* sp., and *Pleurosigma* sp., were the dominant species found in both the sampling areas[9]. Seasonal fluctuation of microalgae density was reported during the study period along both the intertidal area. Similar observation was also reported in Mumbai water[6].

The maximum numbers of microalgal density were reported in the lower zone of the intertidal region which may be due to the availability of more nutrients for a longer time. The present study reported that the total microalgal density was higher in pre-monsoon season along both the intertidal areas which may be due to the optimum level of different water quality parameters, the ocean currents, and upwelling which brings nutrients up to the surface water and favors the microalgal growth. Benthic microalgal distribution mostly depends upon depth and sediment load[10]. Similar results were also reported along Mumbai coast and they found that microalgal recruitment, density, and productivity in term of chlorophyll '*a'* in intertidal areas *viz.* Aksa and Bandra differ by Kumar *et al* [9]. Seasonal fluctuation of microalgae density was also reported[10,18,9].

Table 1: Range of physico-chemical parameters of water, chlorophyll *a* and microalgae during post and pre- monsoon along Shrivardhan and Alibag intertidal areas

Parameters	Post-Monsoon		Pre-Monsoon	
	Shrivardhan	Alibag	Shrivardhan	Alibag
DO (ppm)	2.6-3.2	2.4-3.2	2.4-2.8	2.8-3.0
Salinity (ppt)	34-36	34-35	35-36	35-36
pH	7.5-7.8	7.6-7.8	7.6-8.0	7.7-7.9
Water temperature (^{o}C)	27-30.5	28-31	24-31	27-31
Nitrate (mg/l)	0.45-0.52	0.39-0.44	0.38-0.51	0.33-0.43
Phosphate (mg/l)	1.16-1.23	1.12-1.33	0.78-1.17	0.72-1.02
Chl. *a* (µg/l)	7.29-12.57	7.13-8.46	8.54-10.37	7.47-8.40
Microalgae (no./l^3)	234-293	220-311	250-342	259-352

Table 2: Correlation coefficient (r) between different water quality parameters and biological parameters along Shrivardhan intertidal area

	DO (ppm)	Salinity (ppt)	pH	Water temperature (^{o}C)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll 'a' (µg/l)	Microalgae density (no./l^3)
DO (ppm)	1.							
Salinity (ppt)	0.001	1.						
pH	-0.317	0.001	1.					
Water temperature (^{o}C)	-0.595	0.090	0.305	1.				
Nitrate (mg/l)	0.557	0.059	-0.874	-0.559	1.			
Phosphate (mg/l)	0.368	-0.160	0.001	0.265	0.219	1.		
Chl. *a* (µg/l)	0.417	-0.771	0.302	-0.149	-0.192	0.386	1.	
Microalgae (no./l^3)	0.133	-0.303	0.288	-0.706	0.057	-0.139	0.316	1.

Table 3: Correlation coefficient (r) between different water quality parameters and biological parameters along Alibag intertidal area

	DO (ppm)	Salinity (ppt)	pH	Water temp. (^{0}C)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll '*a*' (µg/l)	Microalgae (no./l^3)
DO (ppm)	1							
Salinity (ppt)	0.447	1						
pH	0.684	0.612	1					
Water temperature (^{0}C)	-0.692	-0.193	-0.632	1				
Nitrate (mg/l)	0.033	-0.227	0.480	-0.333	1			
Phosphate (mg/l)	0.145	-0.200	0.050	-0.325	0.557	1		
Chlorophyll '*a*' (µg/l)	0.096	0.852	0.600	-0.196	0.084	-0.117	1	
Microalgae (no./l^3)	0.789	0.608	0.961	-0.792	0.350	0.060	0.549	1

Table 4: Seasonally different diversity indices calculated for microalgae along Shrivardhan and Alibag intertidal areas

Season	Station	d	J'	H'	1-λ
Post Monsoon	Shrivardhan	2.002	0.942	3.063	0.943
Pre-monsoon	Shrivardhan	2.534	0.938	3.281	0.950
Post Monsoon	Alibag	1.612	0.946	2.895	0.939
Pre-monsoon	Alibag	1.663	0.950	2.938	0.941

Table 5: Identified microalgal taxa from Shrivardhan and Alibag intertidal area

SHRIVARDHAN Taxon		ALIBAG Taxon	
S. No.	**Diatoms**	**S. No.**	**Diatoms**
1.	*Achnanthes sp.*	1.	*Achnanthes sp.*
2.	*Amphora sp.*	2.	*Amphora sp.*
3.	*Biddulphia sp.*	3.	*Biddulphia SP.*
4.	*Cocconeis sp.*	4.	*Cyclotella sp.*
5.	*Cyclotella sp.*	5.	*Cymatopleura sp.*
6.	*Cymatopleura sp.*	6.	*Grammatophora* sp.
7.	*Cymbella sp.*	7.	*Gyrosigma sp.*
8.	*Dictyocha fibula*	8.	*Licmophora sp.*
9.	*Dictyoneis marginata*	9.	*Navicula sp.*
10.	*Diploneis bombus cleve*	10.	*Nitzschia sp.*
11.	*Fragillaria sp.*	11.	*Odontella sp.*
12.	*Grammatophora oceani*	12.	*Pleurosigma sp.*
13.	*Gyrosigma sp.*	13.	*Podocystis sp.*
14.	*Licmophora sp.*	14.	*Pseudonitzshia sp.*
15.	*Navicula sp.*	15.	*Rhabdonema sp.*
16.	*Nitzschia sp.*	16.	*Rhizosollenia sp.*
17.	*Odontella sp.*	17.	*Synedra capitata*
18.	*Pannularia sp.*	18.	*Synedra Sp.*
19.	*Phormidium sp.*	19.	*Thalassionema sp.*
20	*Pleurosigma sp.*		**Cyanophyceae**
21.	*Podocystis*	20.	*Oscillatoria sp.*
22.	*Pseudo- nitzschia sp.*	21.	*Phormidium sp.*
23.	*Rhabdonema sp.*		**Chlorophyceae**
24.	*Rhizosollenia sp.*	22.	*Chlorella sp.*
25.	*Skeletonema sp.*		
26.	*Synedra capitata*		
27.	*Synedra Sp.*		
28.	*Thalassionema sp.*		
	Dinoflagellates		
29.	Prorocentrum sp.		
	Cyanophyceae		
30.	*Oscillatoria sp.*		
31.	*Phormidium sp.*		
	Chlorophyceae		
32.	*Actinestrum sp.*		
33.	*Chlorella sp.*		

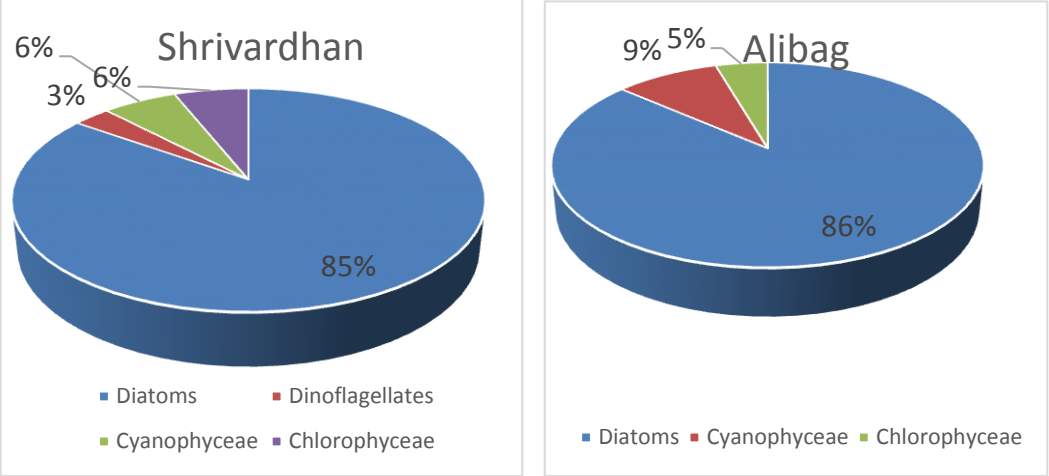

Fig. 1: Contribution of microalgal species along Shrivardhan and Alibag intertidal area

CONCLUSION

In present study the marine microalgal diversity and chlorophyll, '*a*' concentration were correlated with different environmental parameters.The study along Shrivardhan and Alibag intertidal areas reported very less amount of microalgal density, particularly in the Alibag intertidal areas. It may be due to the increased industrialization and population seems to have affected the seawater quality also more sandy than the rocky intertidal area at Alibag giving less biodiversity. Though these areas are good recreational spots of Raigad district, Maharashtra and is often visited by tourists and have longer exposure time that results in displacement of spores for growth which altering the algal species diversity and giving an indication of possibility of entire ecosystem being disappeared so, it is necessary to do future planning for its conservation and restoration.

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