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STUDIES ON SOME BIOLOGICAL PARAMETERS OF COASTAL WATERS AROUND CORAL REEFS OF ANDAMAN ISLANDS, INDIA

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ABSTRACT

The status of Andaman waters around Coral reef Island involving study of six stations for biological parameters viz. phytoplankton for species composition, density, pigment, their productivity, biomass and total bacterial count in the surface and sediment water were investigated for pre-monsoon and post-monsoon seasons. Post-monsoon data shows dominance of phytoplankton counts over pre-monsoon study. Diatoms were more common than flagellates and dinoflagellates. Phaeophytin values were consistently higher than chlorophyll, these indicate abundance of detritus and degraded chlorophyll in water. The highest number of heterotropic bacteria counts were recorded in nutrient agar (N.A) medium for both season. There were also higher counts of coliform and pathogenic bacteria for post-monsoon season at one station-HAV-IV. Sediment samples from pre monsoon shows higher counts of pathogenic bacteria at most season, whereas, in post-monsoon sediment, samples show general absence of these organism. It may be due to untreated effluents and other discharges. The overall study suggests a trend towards unproductive status of water quality around coral reef island which may be due to improper management of biological system.

INTRODUCTION

The coral reef of Andaman islands is perhaps the richest in India and amongst the most diverse in the world. Coral reef is believed to be the most productive marine ecosystem with annual gross production of 2000-5000 g cm^{-2} $year^{-1}$. The reef is the home for a wide range of marine creatures which thrive due to the abundance of food and nutrients. These include echinoderms, porifers, coelenterates (sponges etc.), molluscs (shells, clams, etc.) and other invertebrates. Besides, the coralline habitat is the rich harvest of pelagic fishes. In Andamans,

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the coral formation is fringing type, and grow offshore. It varies greatly from small cluster near the shore, to a longitudinal barrier reefs (up to 320 km in length) extending deep into the sea. It offers substantial protection from seaward erosion of coastal areas and support tourism. Over the years, coral reef formation had come under severe threat due to increasing human population and pressures building along coast owing to anthropogenic activity like clearing mangrove forest and unauthorized encroachment/acquisition of land for human settlement, agriculture and fuel purpose. The government lease of land activity for industrial purpose is a worst scenario. The effluent discharge, domestic waste, silt deposition, drilling and dredging waste, marine outfalls from tanker accidents and oilspills had lead to the destruction of coral by chocking and leaching action. Concern have been raised on the environment stress of the island fauna (Rao and Dev Roy, 1985, Chandrasekara Rao, 1988) and the growing need to protect of coral reef island (Purvaja and Ramesh, 1993; Zingde, 1997). The mass bleaching event around the coral island, worldwide is phenomenal (Wilkinson, 1998). In the present study, some vital biological parameters conducive as identification aids towards destruction of water quality around coral reef island of Andamans have been highlighted.

MATERIALS AND METHODS

Biological parameters :

Plankton :

Planktons were collected from surface water using Heron type nets with a mouth area of 0.197 m^3 and a flow meter attached. These nets had respectively mesh sizes of 55 and 220 microns for phytoplankton collections. Nets were towed in surface water in a circular fashion around the point of sampling at a boast speed of approx. 1 knot. Nets were towed for 8-10 min at most locations and for 15 minutes where plankton was poor. The plankton were fixed on board in 5% Lugol's iodine. In the laboratory, plankton samples were transferred to measuring cylinders allowed to settle, and the displacement measured. Biomass was estimated using calculation based on the displaced volume of plankton and the volume of sea water that flowed through the net. The plankton soup was suitably diluted and counts were made at low power on a CETI microscope with an attached video monitor, using a sedgewick-Rafter counting chamber. Taxonomic placement of the organism was made using suggested literature on phytoplankton (Santhanam &. al., 1987; Santhanam, 1998).

Productivity :

Productivity measurements were made through light and dark bottle method in which oxygen composition value were estimated by winkler method, converted for carbon equivalent. Light and dark bottles were incubated on board, simulated *in-situ* for 4 hours. Productivity were reported as $mgC/m^3/day$, where day is taken as 12 (daytime) hours.

Pigments :

Water samples were filtered through 0.45 μ membrane filter extracted with aqueous acetone, homogenized, refrigerated in dark for 24 hours and the optical densities measured at specific wavelength (750, 665, 645, 630 and 510) for the estimation of chlorophyll a and phaeophytin ($mg/m/^3$).

Bacteriological tests :

Surface water samples were collected using clean, pre-sterilized glass containers. Sediment samples were taken from the central portion of a peterson's grab (area 0.07 m^2) with a sterile spathula and transferred immediately to sterile petriplates. In the lab, samples were processed immediately for bacterial analysis. All bacterial enumeration done in this work used agar pour plating. In all 7 different media were used in order to test for a wide range of organism, including pathogens. The different media used and the types of bacteria grew are as follows : 1) Nutrient agar – Total Viable Count or Heterotrophic bacteria (TVC); 2) Macconkey Agar – total coliforms (TC) and *Escherichia Coli* like organism (ECLO); 3) LD Agar – *Shigella* like organism (SHLO); *Salmonella* like organism (SLO) and *Proteus Klebsiella* like organism (PKLO); 4) TCBS Agar – *Vibrio Cholerae* like organism (VCLO); *Vibrio Parahaemolyticus* like organism (VPLO); 5) Cetrimide Agar – *Pseudomonas Aeruginosa* like organism (PALO); 6) M-Enterococcus Agar – *Streptococcus Faecialis* like organism (SFLO); 7) M-FC-Agar – *Escherichia Coli* like organism (ECLO).

RESULTS

The species composition and population density for phytoplankton are shown in Table 1& 2. During the study periods, diatoms were most common than dinoflagellates both in terms of species composition and density. Pre-monsoon data showed *Rhizosolenia delicatula*

and *Coscinodiscus subtilis* among diatoms and *Ceratium tripos* among dinoflagellates as dominant phytoplankton organism. For post-monsoon observation *Rhizosolenia delicatula, Chaetoceros compressus, Coscinodiscus subtilis, Ceratium tripos, Biddulphia mobiliensis* and *Leptocylindrus danicus* were dominantly present. However all these forms are exceptionally high at station CII-I and CII-II. In addition to these, there were also other organism that contributed significant to phytoplankton population. The dinoflagellate – *Peridinium ornithocercus* formed up to 50% of the population at HAV. I., while, the diatoms – *Biddulphia mobiliensis* contributed to about 23% at HAV IV. Pre-monsoon data showed plankton counts (No/100 m^3) to be poor, whereas, dominance of phytoplankton counts were recorded for post monsoon data at most of the stations. Results of baceteriological tests are presented in Table 3& 4 for surface water and sediments. Counts on Nutrient Agar were consistently higher in samples from all stations than that of other media during both the seasons. In surface water, highest count of Coliform and pathogenic bacteria (a few hundred/ml) were noted at HAV IV during post-monsoon season. Sediment samples for pre-monsoon season showed significant counts of pathogenic bacteria at most stations, whereas, in post-monsoon sediment samples showed a general absence of these organisms. Biological production are shown in Table 5 & 6. Pigment data were limited to post-monsoon samplings only. Phaeophytin values were consistently higher than those of Chlorophyll. Pooled data for two seasons indicate primary production values vary between 131 to 476 mg C/m^3/day. Seasonal variations for phytoplankton biomass was not discernable and pooled values varied between 0.04 to 0.39 ml/100/m^3.

DISCUSSION

Earlier information on seawater characteristics of Andaman sea were limited to the studies by National Institute of Oceanography cruises of RV Gaveshani during 1979-80 and the 56th cruise for FORV Sagar sampada during 1988-89. Based on the information gathered from the above two cruises, the Andaman sea have been described to be oligotrophic in nature with lower rates of primary and secondary productivity and a possible presence of substantial amounts of detritus to supplement the nutritional inadequacy. Sengupta & al. (1981) and Mathew and Pillai (1990) have reported that nitrate-nitrogen composition was very low and almost undetectable in the surface waters. This unique characteristic has shown to be in accordance with the lower primary production rates measured in surface waters

Table 1. Population count and composition of Phytoplankton at different sations of Andaman islands (pre-monsoon)

Species	HAV-I		HAV-II		HAV-III		HAV-IV		CII-I		CII-II	
	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp
Green algae	–	–	30	0.35	–	–	700	1.57	700	2.90		–
Bacteriastrum delicatulum	750	1.3	–	–	–	–	–	–	–		–	–
Biddulphia mobiliensis	750	1.3	61	0.71	3750	15.91	2100	4.72	700	2.90	–	–
Ceratium tripos	7500	12.9	1889	22.07	7500	31.83	–		4900	20.29	–	–
Chaetoceros compressus	5000	8.6	183	2.14	1875	7.96	4200	9.45	2800	11.59	–	–
Coscinodiscus subtilis	10000	17.2	2163	25.27	240	1.02	10500	23.62	2800	11.59	–	–
Dinophysis diegenesis	–	–	–	–	–	–	350	0.79	–	–	–	–
Leptocylindrus danicus	1500	2.6	640	7.48	600	2.55	1400	3.15	1050	4.35	–	–
Nitzschia seriata	375	0.6	121	1.41	300	1.27	–	–	–	–	–	–
Peridinium ornithocercus	1500	2.6	61	0.71	600	2.55	2800	6.30	–	–	–	–
Planktonnella sol	–	–	–	–	–	–	350	0.79	–	–	–	–
Pleurosigma sp	–	–	609	7.12	450	1.91	700	1.57	–	–	–	–
Rhizosolenia delicatula	30000	51.6	2377	27.77	7500	31.83	14700	33.07	8400	34.78	–	–
Sachroendrella sp.	–	–	–	–	300	1.27	–	–	–	–	–	–
Skeletonema costatum	750	1.3	365	4.26	150	0.64	6300	14.17	2100	8.70	–	–
Thallessionema nitzschioides	–	–	30	0.35	–	–	–	–	–	–	–	–
Thallassiothrix longissima	750	1.3	–	–	–	–	–	–	–	–	–	–
Trichodesmium erythriae	750	1.3	30	0.35	300	1.27	350	0.79	700	2.90	–	–
Total	58125	100	8569	100	23565	100	44450	100	24150	100	–	–

Table 2. Population count and composition of Phytoplankton at different sations of Andaman islands (post-monsoon)

Species	HAV-I		HAV-II		HAV-III		HAV-IV		CII-I		CII-II	
	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp	No/100 m³	% comp
Actinocyclus ellipticus	720	1.25	–	–	–	–	–	–	–	–	–	–
Bacteriastrum delicatulum	–	–	–	–	–	–	1108	1.34	–	–	–	–
Biddulphia mobiliensis	720	1.25	192	0.74	5030	7.30	18845	22.65	37936	9.34	2727	3.16
Ceratium tripos	1440	2.50	3077	11.87	10815	15.69	6651	8.06	12645	3.11	11592	13.44
Ceratocorys sp	960	1.67	384	1.48	2012	2.92	886	1.07	1580	0.39	340	0.39
Chaetoceros compressus	5760	10	1538	5.93	2263	3.28	2438	2.96	126456	31.13	13979	16.21
Climacodium frauenfeldianum	–	–	–	–	1257	1.82	–	–	–	–	–	–
Coccolithus huxleyi	480	0.83	348	1.34	1257	1.82	–	–	–	–	–	–
Coscinodiscus subtilis	14641	25.42	5001	19.29	1509	2.19	6429	7.80	11064	2.72	6478	7.51
Dinophysis diegenesis	240	0.42	–	–	3772	5.47	–	–	–	–	–	–
Hemidesmus cuneiformis	–	–	–	–	1257	1.82	1108	1.34	–	–	681	0.79
Isthmia inervis	–	–	–	–	–	–	–	–	–	–	340	0.39
Leptocylindrus danicus	1680	2.92	1923	7.42	1006	1.46	1995	2.42	98793	24.32	17048	19.77
Nitzschia seriata	–	–	192	0.74	–	–	–	–	–	–	340	0.39
Peridinium ornithocercus	29042	50.42	1346	5.19	4527	6.57	–	–	790	0.19	2045	2.37
Pleurosigma sp	–	–	1346	5.19	–	–	–	–	1580	0.39	1704	1.98
Protopteridinium sp	–	–	769	2.97	754	1.09	1108	1.34	1580	0.39	3068	3.56
Rhizosolenia delicatula	–	–	4039	15.58	25152	36.50	36168	43.82	110649	27.24	23526	27.28
Skeletonema costatum	240	0.42	769	2.97	1509	2.19	1551	1.88	2371	0.58	–	–
Thallassionema nitzschioides	–	–	4808	18.55	2012	2.92	–	–	–	–	340	0.39
Thalassiosira rotula	–	–	–	–	503	0.73	4212	5.11	–	–	1704	1.98
Thallassiothrix longissima	240	0.42	–	–	4275	6.20	–	–	–	–	340	0.38
Trichodesmium erythriae	1440	2.50	192	0.74	–	–	1330	1.68	790	0.19	–	–
Total	**57603**	**100**	**25924**	**100**	**68910**	**100**	**82469**	**100**	**406234**	**100**	**86252**	**100**

Table 3. Bacterial count for pre-monsoon around coral reefs of Andaman islands

Media	Bacteria Type	HAV-I		HAV-II		HAV-III		HAV-IV		CII-I		CII-II	
		Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g
Nu. Aagr	TVC	8	103.04×10^4	49	–	78	667.6×10^2	72.2	48.4×10^2	44	317.6×10^4	ND	ND
Mac. A	TC	12	12.44×10^2	–	–	–	25.35×10^2	16	8.14×10^2	4.5	84.7×10^2	"	"
Mac. A	ECLO	10	38.88×10^2	28.6	–	–	171.8×10^2	9	33.2×10^2	7.9	148.2×10^4	"	"
MFc. A	ECLO	39.3	43.07×10^3	4	Corals	10.3	39.44×10^2	5	4.56×10^2	2.3	24.2×10^2	"	"
XLD A	SHLO	11.6	60.48×10^2	4.3	–	9.3	25.35×10^2	26.6	13.4×10^2	23.6	39.3×10^2	"	"
XLD A	SLO	26.3	15.6×10^3	–	–	–	–	–	11.76×10^2	4.3	–	"	"
XLD A	PKLO	34	12×10^2	3.6	–	11.3	84.52×10^2	15	7.58×10^2	6.3	78.6×10^2	"	"
TCBS A	VLO	2.6	–	–	–	5	–	2	–	3.2	–	"	"
TCBS A	VPLO	17	–	5	–	5.6	–	6	6.86×10^2	30.6	21.108×10^2	"	"
TCBS A	VCLO	15	–	7	–	10	28.69×10^2	7	–	1.6	–	"	"
Ent. A	SFLO	1	–	2.4	–	–	–	1	–	5.7	–	"	"
XLD A	PKLO	4	–	–	–	2	–	–	4.08×10^2	2.3	–	"	"

Table 4. Bacterial count for post-monsoon around coral reefs of Andaman islands

Media	Bacteria Type	HAV-I		HAV-II		HAV-III		HAV-IV		CII-I		CII-II	
		Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g	Water CFU/ml	sediment CFU/g
Nu. Aagr	TVC	950		80	1.8×10^4	840	2.4×10^4	2399	1.32×10^4	1290	1.4×10^4	1460	
Mac. A	TC	52		16	–	68	–	302	–	11	–	4	Rocky
Mac. A	ECLO	22	Corals	–	–	65	–	160	–	9	–	12	
MFc. A	ECLO	5.5		4	–	14	–	420	–	23	–	1	
XLD A	SLO	32		17	–	120	–	230	–	–	–	2	
XLD A	PKLO	15		9	2×10^3	14	–	166	–	7	–	1	
TCBS A	VLO	3		5	–	17	–	129	–	8	–	9	
M. Ent. A	SFLO	18		–	–	4	1×10^3	325	–	1	–	1	
CET A	PLO	6		–	–	2	–	160	–	2		3	

Table 5. Biological production (pre-monsoon)

Station code	Chlorophyll - a mg/m³	Phaeophytin mg/m³	Primary production mgC/m³/day	Biomass phytoplankton ml/100 m³
HAV I(S)	–	–	406	0.36
HAV II(S)	–	–	301	0.06
HAV III(S)	–	–	160	0.18
HAV IV	–	–	220	0.15
CII I	–	–	181	0.28
CII II	–	–	–	–

– : Not detected

Table 6. Biological production (pre-monsoon)

Station code	Chlorophyll - a mg/m³	Phaeophytin mg/m³	Primary production mgC/m³/day	Biomass phytoplankton ml/100 m³
HAV I(S)	6.11	23.28	320	0.24
HAV II(S)	3.83	44.50	151	0.15
HAV III(S)	2.33	54.28	234	0.18
HAV IV	5.75	37.15	476	0.11
CII I	8.37	16.67	131	0.39
CII II	8.38	20.64	234	0.04

(Bhattathiri and Devassy, 1981). Vertical profile data indicate a depth-wise increasing trend in nutrients (Sengupta & al. 1981) and productivity (Devassy and Bhattathiri, 1981). Slow regeneration of nitrogenous matter due to limited mixing has been hypothesized as a cause for the poor inorganic nitrogen concentration in surface waters. An interesting feature of the present data is the ratio of phaeophytin to chlorophyll-a, which was always more than 1. It indicates the abundance of detritus and predominance of degraded chlorophyll in the waters (Kabawatta & al. 1993; Gopinathan & al. 1994). Interestingly, the ratio was particularly very high in the North reef coral island where plankton was exceptionally poor and productivity just moderate. Phytoplankton density was found to be very low. Counts were less than a hundred at HAV II for pre-monsoon sampling. These numbers per liter compare with a few thousands of phytoplankton reported by Devassy & Bhattathiri (1981) for Andaman waters, numbers between 10^4 and 10^6 (except in monsoon) for Pichavaram mangrove area (Mani, 1994) and numbers of the order of 10^3 for the Mauritius area (Devassy and Goes, 1991). It would be appropriate to classify marine location in terms of productivity, using phytoplankton density as a gauge. According to present investigation any coastal seawater location containing less than about 10^4 phytoplankton density per liter is bound to be less productive. Whether, the low numbers of phytoplankton in this work are characteristic of only the seasonal study or are a characteristic feature of the Andaman waters that contributes to the low productivity remains to be studied. Present results show prevalence of diatoms over flagellates and dinoflagellates in contrast to observation by Devassy and Bhattathiri (1981) the flagellates (especially *Trichodesmium* sp.) were predominantly present in the work by the above authors. Dinoflagellates (*e.g.*, Ceratium, Ornithocercus) did form an important constituent at some locations, but were generally lower than in the earlier reported quoted above. A sharp contrast in test sites with regard to distance from shore appears to be the prime reason for the incompatible results from the two studies. As for bacteriological data, the high numbers of coliform and pathogenic bacteria in surface seawater at HAV IV (post-monsoon) is of concern. The general absence of these bacteria in the sediment during the same period is a possible indicator that they are introduced into the marine system through untreated effluents and other discharges in and around Havelock jetty.

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