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Some Numerical studies on Marine algae of Visakhapatnam Coast

K.Prasanna Lakshmi and G.M.Narasimha Rao

Department of Botany, Andhra University

Visakhapatnam-530 003

Gmnrao_algae@hotmail.com

Abstract

Numerical data were collected for one year from March 2008 to Feb 2009 to study the distribution of Marine algae on the intertidal rocky surfaces of Visakhapatnam Coast, using the 0.5 × 0.5 m quadrant. Total of 31 Marine algal forms were collected in 90 quadrant samples and relative frequency and biomass of these species were estimated. From the relationship obtained between the predicted number of species and number of quadrants, a sample of 30 quadrants was found to the sufficient for quantitative studies on the algal flora of Visakhapatnam coast.

Statistical analysis for comparing the proportions among stations indicates that presence or absence of significance difference between two stations at 5% level of significance. Two Way ANOVA analysis was carried out in three stations for algae reveals that presence or absence of significant difference between Alga, Seasons and Alga + Seasons.

Key words: Marine algae, Numerical studies, Statistical analysis, Visakhapatnam.

Introduction

Biodiversity is the variety variability among living organisms and the ecological complexes in which they occur. Biodiversity of marine algae along the East and West coast regions of India was studied by several authors (Srinivasan, 1946; Gopalakrishnan, 1970; Kalimuthu, 1995; Dhargalkar et al. 2000; Sahoo et al 2003; James, 2004; Venkataraman, 2005; Rath and Adikary 2006 and 2007). Numerical studies on marine algal biodiversity of Indian shores are very limited (Narasimha Rao and Umamaheswara Rao, 1986; Narasimha Rao1994). Marine algal vegetation at Visakhapatnam coast was studied by Umamaheswara Rao and Sree Ramulu, 1964

and 1970. These authors have reported 80 macro and micro algae populations at Visakhapatnam coast. Narasimha Rao(1984) carried out a quantitative study on intertidal organisms at Visakhjpatnam coast ansd reported 38 marine species .

Considering the paucity of information on the biodiversity of marine algae at Visakhapatnam, the present quantitative study was undertaken by selecting the three study sites from the coastal region of Visakhapatnam.

STUDY SITES AND METHODS

Visakhapatnam lies on the east coast of India between the latitudes 17^0 14^1 30^{11} and 17^0 45^1 N and the longitudes 83^0 16^1 25^{11} and 83^0 21^1 30^{11} E. There are no river openings into the sea along the 9.6 km coastline of Visakhapatnam. Much of this coastline is sandy without rocky boulders of various sizes, protruding through the sand. Depending upon physical nature and vertical extent of substratum, three stations were selected in the present study. Fig-1 shows these three stations and third station was selected in this study at Tenneti Park (station-111), which is situated, nearly 4 km north of Visakhapatnam. Description of these three study sites, where sampling was done is given below.

Station - I:

Irregular and much dissected rocky surfaces with large tide pools connected with sea and small shallow pools without any connection with sea, characterize the type of substratum available in this station.

Station - II:

This is the only area where very big boulders extending well above high water level are present. Rocky platforms with good algal growth are also present in this station.

Station - III:

As in station - II, large boulders are present with abundant algal vegetation The composition of vegetation varied from station to station depending upon the vertical height of the substratum and other environmental conditions of the intertidal region.

Sampling of Intertidal Communities:

Plants occurring at different vertical levels of the intertidal rocky surfaces were sampled at random. An aluminum frame of 0.5 x 0.5 m in size was placed on the rocky surfaces, and the vegetation was sampled, following procedure described below. The number of species present in the quadrants

was noted and cover values were estimated for species present in the entire quadrant.

Various species of the community are recorded by different Phytosociological methods, by taking sampling unit like quadrant. Frequency is the number of sampling units (as %) in which a particular species occurs.

Numerical Analysis of Quadrant Data:

To determine whether the quadrants sampled in the present study are sufficient and they provide representative sample of the intertidal plant species, species area curve was plotted, using the formula

$$\left(1-\frac{n}{N}\right)^{q}$$

Where

N = total number of quadrants

n = number of species present in the total number or quadrants

q = serial number of quadrants

Test for proportions between stations was carried out by method followed by S. C., Guptha and V. K., Kapoor, (2007), two way ANOVA methods for three stations were carried out S. C., Guptha and V. K., Kapoor (2006

RESULTS

Composition of algae:

Thirty one marine algal forms were identified in 90 quadrat samples, collected from 3 study sites (Fig-1). Of these 12 species belonging to Chlorophyceae, 4 species belong to Phaeophyceae, 15 species belonging to Rhodophyceae and one species belonging to BGA. All the algae collected in quadrat samples are listed in Table-I. *Lyngbya majuscula* found as epiphyte on *Spongomorpha indica.*

The relative frequency values of different plants estimated from the different stations of the quadrat data are also shown in Table I. In station-I the frequency of *Ulva fasciata* was the highest and the value obtained was 83.3%. For algae like *Gracilaria corticata, Hypnea valentiae* the values obtained were more than 60 % and for *Chaetomorpha antennina, Spongomorpha indica* the values obtained were more than 40 % and for *Gelidium pusillum, Grateloupia filicina, Centroceros clavulatum* the values obtained were more than 30%. In station II, the frequency of *Gracilaria corticata* was highest and value

obtained was 83.3%, for algae like *Spongomorpha indica* the value obtained was 80%, for *Hypnea valentiae* was 70%, for *Ulva fasciata* it was 63.3 %, for *Chaetomorpha antennina* it was 56.6%, for *Gelidium pusillum* and *Pterocladia heteroplatos* it was 43.3% and for *Caulerpa fastigiata* and *Jania rubens* the value obtained was more than 30%. In station-III the relative frequency of the *Gracilaria corticata* was the highest and value obtained was 73.3%, for *Enteromorpha compressa*, it was 60%, for *Ulva* it was 50% for *Spongomorpha indica* and *Hypnea valentiae* it was more than 40%, for algae like *Pterocladia heteroplatos, Caulerpa sertularioides, Grateuloupia filicina* the value obtained were more than 30% and with minimum frequency (20%), was obtained for the species of *Chaetomorpha antennina, Caulerpa taxifolia, Sargassum vulgare, Gelidium pusillum*

Species Area Curve:

Species area curve obtained for algal populations of Visakhapatnam coast is shown in Fig.2. The values plotted are the predicted number of species. The number of species present in quadrats increased rapidly from second quadrat onwards. More than 15 species were found in 30 quadrats sampled. A straight line relationship was obtained from 30th quadrat, indicating that sample size of thirty quadrats of 0.5 m^2 is sufficient for obtaining maximum number of species in the area investigated.

Table- 2 shows biomass values of macro algal species in the three stations. In station-I out of the reported 18 species, maximum biomass values was reported to *Ulva fasciata* (8.33 g/m^2) and minimum values for *Cladophora utriculosa* (0.1 g/m^2) and for *Lyngbya majuscule* (0.13 g/m^2). In station-II out of 27 reported species, maximum biomass values were observed for *Amphiroa fragilissima* (13.4 g/m^2), *Gracilaria corticata* (9.23 g/m^2), and *Ulva fasciata* (7.36 g/m^2) and minimum values for *Chnoospora minima* (0.06 g/m^2), and *Ectocarpus mitchellae* (0.1 g/m^2). In station-III out of 27 species, maximum biomass values were reported to *Spongomorpha indica* (10 g/m^2) and *Gracilaria corticata* (10.3 g/m^2) and minimum values for *Chnoospora minima* (0.03 g/m^2), *Ectocarpus mitchellae* (0.1 g/m^2). Data collected on biomass of algal species in different stations were presented in tables 3A, 3B and 3C. Table-3A shows the biomass of the different species at station-I. Biomass of the algal populations varied seasonally. Maximum biomass was

reported for *Ulva fasciata* (11.3 g/m^2) and minimum (0.4 g/m^2) for *Lyngbya majuscula*. In station-I, among the three seasons, maximum biomass values were reported in winter season and minimum biomass value in summer season (Table-3A).

Table-3B shows the biomass values of species present in station-II (Vuda Park). In this station maximum biomass values were reported for *Amphiroa fragilissima* (16.7 g/m^2). Biomass of different species varied seasonally with maximum biomass values were reported in winter and minimum values in summer. But some species especially *Ulva fasciata* shows maximum in summer season and minimum biomass was reported in winter season.

Table-3C shows the biomass value of species occurring in station III (Tenneti Park). In station-III maximum biomass values were reported for *Caulerpa sertularioieds* (21.5 g/m^2) and minimum for the species *Chnoospora minima* (0.1 g/m^2). In station-III *Gracilaria corticata,*

Spongomorpha indica and *Ulva fasciata* are the dominant forms with biomass of 15.2, 14.3 and 19.1 g/m^2 respectively. Minimum number of species and least biomass of algal forms were reported in summer reason, where as in winter maximum number of species and maximum biomass was reported.

Test for Proportions between Two Stations:

Table-4 shows the values of statistical analysis for comparing the proportions between two stations. In this study 11 species were used for the comparison and reveals that there is no significant difference between two stations at 5 % level of significance. The Z values are less than1.96 are represented with the *. The values in parentheses are P values.

The third column in Table-4 shows the comparison between station-I and II, there is no significant difference between I and II stations for the species like *Ulva fasciata, Chaetomorpha antennina, Pterocladia heteroplatos, Gracilaria corticata, Hypnea valentiae and Bryocladia thawaitesii.* In case of *Enteromorpha compressa, Spongomorpha indica, Gelidiopsis variabilis, Gelidium pusillum* and *Amphiroa fragilissima* significant difference was reported.

The fourth column in Table-4 shows the comparison of station-I and III and there is no significant difference between station-I and III for species like *Gelidiopsis*

variabilis, Gelidium pusillum, Pterocladia heteroplatos, Amphiroa fragilissima, Gracilaria corticata, and Hypnea valentiae. But in the case of *Ulva fasciata, Enteromorpha compressa, Chaetomorpha antennina, Spongomorpha indica* and *Bryocladia thwaitesii* significant different was reported.

Fifth column in Table-4 shows the comparison of station II and III and there is no significant difference between II and III for the species like *Ulva fasciata, Enteromorpha compressa, Gelidiopsis variabilis, Gelidium pusillum, Pterocladia heteroplatos, Amphiroa fragilissima, Gracilaria corticata* and *Hypnea valentiae.* But in the case of *Chaetomorpha antennina, Spongomorpha indica* and *Bryocladia thwaitesii* significant difference was observed (table-4).

Two Way ANOVA Analyses for the Algae:

Table-5 shows the statistical results of two way ANOVA analysis of station-I and the presence or absence of significant differences among algae, seasons and alga + seasons. Table-5 indicates that (1); there is significant difference among algal species in all the seasons because the P value is 0.000000, which is less than 0.05, (2); there is no significant difference between seasons because the P value is 0.373835 which is greater than 0.05 and (3); there is no interaction effect between alga and seasons because the P value is 0.51316 which is greater than 0.05.

Table-6 indicates that (1); there is significance difference between algal species in all the seasons because the P value is 0.001281 which is less than 0.05, (2); there is significant difference between seasons because here also the P value is 0.037407 which is less than 0.05, and (3); there is no interaction effect between alga and seasons because, the P value is 0.317846 which is greater than 0.05.

Table-7 indicates that (1); there is significant difference between algal species in all the seasons because the P value is 0.007037 which is less than 0.05, (2); there is no significant difference between seasons because the P value is 0.715730 which is greater than 0.05 and (3); there is no interaction effect between alga and seasons because the P value is 0.956818 which is greater than 0.05..

DISCUSSION

Numerical data was collected in the present study on marine algae at different

stations of Visakhapatnam coast from March 2008 to February 2009. Frequency and Biomass studies were also undertaken to know the present status of algal distribution and biomass of marine algae along the Visakhapatnam Coast.

Studies on biodiversity of marine algae along the Indian waters were carried out by several authors. In earliar days most of the ecological works on marine algal studies related to intertidal zonation of flora and fauna based on descriptive and quantitative data (Srinivasan 1946; Misra 1960; Umamaheswara Rao 1964; Umamaheswara Rao 1972; Gopalakrishnan 1970). In the recent years attention was focused on the Biodiversity of Marine algal populations at different regions of East and West Coasts of India (Untawale 1989; Kaliperumal 1995; Kalimuthu 1995; Jayachandran 1997; Kaliperumal 1997; Stella Roslin *et al.* 1997; Selvaraj and Selvaraj 1997; Mohammed *et al.* 1999; Dhargalkar *et al.*. 2000; Kekar 2004; Venkataraman 2005; Rath and Adhikary 2007). These studies mainly emphasized on reporting the algal speciess in different localities of Indian waters and its occurrence and seasonal distribution.

The occurrence and seasonal changes in algal biomass of Visakhapatnam coast was studied by Umamaheswara Rao and Sreramulu (1964) and an annotated list of marine algae of Visakhapatnam coast was presented by Umamaheswara Rao and Sreeramulu (1970). In their studies they have reported 80 algal species from Visakhapatnam Coast. Some species such as *C. colabense Derbesia turbinata, Derbesia sp., Trichosolon mucronata, Chaetomorpha torta, C.fritschii of Chlorophyceae* and Phaeophyceae members such as *Giffordia indica, Feldmannia irregularis, F. filter, Myrionema sp., Bachelotia antillarum, Sphacelaria tribuloides, S. furcigera zonaria sp., Rosenvingea nhatrangensis* and Rhodophyceae members such as *Erythrotrichia abscura, Acrochaetium gracile, A. krusadii, A. sanctithomae, A. robustum, Helminthocladia sp., Melobesia sp., Callithamnion sp., Ceramium sp., Spemathmnion sp., Polysiphonia sp*., and *P. platycarpa* were not reported during one year quantitative study on the Marine algae of Viskhapatnam coast. It indicates that the above all species are completely disappearing from the Visakhapatnam coast and only 31 algal forms were reported in this present study.

Frequency of algal populations at different stations (Table-1) shows that more than 50% reduction in the algal species from the Visakhapatnam Coast, when compared to the algal species reported by Umamaheswara Rao and Sreeramulu (1970). Species frequency data varied from Station - I to Station – III. Minimum number of species (18) was reported from Station - I whereas in Station - II and Station - III (27) species were reported. Numerical data on algal populations indicates that the number of species varied from season to season. Maximum number of species (25) was reported in winter months, minimum number of species (14) in summer season. Biomass of algae shows that there is remarkable reduction in the cover of the algal populations at Visakhapatnam coast. In the present study only 5 to 10 algal species have the biomass of above 10 g dry.wt/m^2.

Present quantitative data on frequency and biomass of Marine algae at Visakhapatnam cast reveals that the gradual depletion of Marine algal species from the intertidal rocky surfaces. Important species like *Liagora visakhapatnamensis, Polysiphonia ferulacea Pseudobryopsis mucronata Gracilaria textorii, Dictyota dichotoma,* and *Gracilariopsis sjoestedii* are completely disapperaring from this coast. Some species such as *Porphyra vietnamensis, Caulerpa recemosa, Ectocarpus mitchellae* and *Bangiopsis subsimplex* shows very low biomass values.

Statistical analysis like Test for proportions between two stations (Table-4) indicates that presence or absence of significant difference between Station- I and II, Station- I and III and between Station- II and III. The third column in Table-4 shows the comparison between station-I and II. In this study, *Enteromorpha compressa, Spongomorpha indica, Gelidiopsis variabilis, Gelidium pusillum* and *Amphiroa fragilissima* shows significant difference. The fourth column in Table-4 shows the comparison between station-I and III. In this analysis *Ulva fasciata, Enteromorpha compressa, Chaetomorpha antennina, Spongomorpha indica* and *Bryocladia thwaitesii* shows significant difference. Fifth column in Table-4 shows the comparison of station II and III. In this analysis *Chaetomorpha antennina, Spongomorpha indica* and *Bryocladia thwaitesii* shows significant difference.

Two Way ANOVA Analyses for the algae shows there was significant difference between algal species in all three stations.

In station- I and III there was no significant difference between seasons but in case of station- II significant difference is there and there is no interaction effect between algal species and seasons in all the three stations.

Gradual rise in the atmospheric temperature, impact of the industrial pollution construction of the outer harbour indiscriminate collection of algae and human interference may be the reasons for the loss of biodiversity and disappearing of algal species at Visakhapatnam Coast.

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Table-1

Relative Frequency of the Macro Algae at Three Stations of Visakhapatnam Coast:-

ALGAE	Station-1 (%)	Station-2 (%)	Station-3 (%)
CHLOROPHYCEAE			
Ulvaceae:			
Ulva faciata Delile	83.3	63.3	50
Enteromorpha compressa (L.) Greville	6.6	40	60
Cladophoraceae:			
Chaetomorpha antennina (Bory) Kutzing	43.3	56.6	20
C. brachygona			
Cladophora utriculosa Kutzing	--	3.33	--
Spongomorpha indica Thivy et	3.33	13.3	10
Visalakshi	43.3	80	43.3
Valoniaceae:			
Boodlea struveoides Howe	--	26.6	6.66
Bryopsidaceae:			

Bryopsis pennata Lamouroux	23.3	10	--
Caulerpaceae:			
Caulerpa fastigiata Montagne	--	33.3	16.6
C. recemosa (Forsk.) J. Agardh	--	10	3.33
C. sertularioides (Gmelin*)* Howe	--	26.6	30
C. taxifolia (vahl) C. Agardh	--	--	26.6
PHAEOPHYCEAE			
Ectocarpaceae:			
Ectocarpus mitchellae (Harvey) Hamel (-)	--	3.33	3.33
Chnoosporaceae:			
Chnoospora minima (Hering) Papenfuss (-)	--	3.33	3.33
Dictyotaceae:			
Padina tetrastromatica (Hauck)	--	--	3.33
Sargassaceae:			
Sargassum vulgare C. Agardh	--	--	26.6
RHODOPHYCEAE			
Bangiaceae:			
Bangiopsis subsimplex (Montagne) Schmitz (-)	--	3.33	3.33
Porphyra vietnamensis Tanaka	--	3.33	3.33

et Ho			
Gelidiaceae:			
Gelidiopsis variabilis (Grevelle) Schmitz	13.3	40	20
Gelidium pusillum (Stack house) Le Jolis	33.3	43.3	23.3
Pterocladia heteroplatos Umamaheswara Rao & Kaliperumal	36.6	43.3	33.3
Corallinaceae:			
Amphiroa fragilissima (L.) Lamouroux	23.3	60	36.6
Jania rubens (L.) Lamouroux	--	36.6	30
Grateuloupiaceae:			
Grateloupia lithophila Borgesen	6.6	--	--
Grateloupia filicina (J.V. Lamouroux) C. Agar	36.6	33.3	33.3
Gracilariaceae:			
Gracilaria corticata J. Agardh	63.3	83.3	73.3
Hypneaceae:			
Hypnea valentiae (Turner)	60	70	40

Montagne			
Gigartinaceae:			
Gigartina acicularis (Wulfen) Lamouroux	--	20	16.6
Ceramiaceae:			
Centroceros clavulatum (C.Agardh Montgne)	33.3	20	16.6
Rhodomelaceae:			
Bryocladia thwaitesii(Harvey) De Toni	23.3	26.6	3.33
Cyanophyceae:			
Lyngbya majuscula Harvey ex Gomont	3.33	6.66	--

Table-2. Biomass of the Macro Algae at Three Stations of Visakhapatnam Coast:

ALGA	Station-I (g/m^2)	Station-II (g/m^2)	Station-III (g/m^2)
Ulva fasciata	8.33	7.36	5.6
Enteromorpha compressa	0.26	4.9	4.03
Chaetomorpha antennina	1.53	2.1	0.86
C.brachygona	--	0.13	--
Cladophora utriculosa	0.1	1.6	0.8
Spongomorpha indica	2.1	6.26	10
Boodlea struveoides	--	2.3	0.2
Bryopsis pennata	0.8	0.4	--
Caulerpa fastigiata	--	4.6	2.1
C. recemosa	--	0.6	0.41
C. sertularioides	--	3.2	8.9
C. taxifolia	--	--	3.5
Ectocarpus mitchellae	--	0.1	0.1
Chnoospora minima	--	0.06	0.03
Padina tetrastromatica	--	--	0.6
Sargassum vulgare	--	--	3.6
Bangiopsis subsimplex	--	0.13	0.06
Porphyra vietnamensis	--	0.05	0.06
Gelidiopsis variabilis	0.7	4.1	1.43
Gelidium pusillum			

Pterocladia heteroplatos	1.13	2.63	1.6
Amphiroa fragilissima	1.93	3.9	2.9
Jania rubens	0.93	13.4	6.6
Grateloupia lithophila	--	1.3	3.1
Grateloupia filicina	0.33	--	--
Gracilaria corticata	3.9	1.6	0.8
Hypnea valentiae	4.83	9.23	10.3
Gigartina acicularis	5.06	3.56	3.4
Centroceros clavulatum	1.06	0.3	1.1
Bryocladia thwaitesii	3.63	1.7	1.8
Lyngbya majuscula	0.93	2.8	--
	0.13	0.5	--

Table-3.A. Biomass of the Marine Algae in Three Seasons at station-1(R.K Beach):-

ALGA	Season-1 (g/m^2)	Season-2 (g/m^2)	Season-3 (g/m^2)
Ulva fasciata	11.3	7.4	6.3
Enteromorpha compressa	--	0.4	0.4
Chaetomorpha antennina	1.9	2.3	0.4
Cladophora utriculosa	--	--	0.3
Spongomorpha indica	1.5	0.9	3.9
Bryopsis pennata	0.7	0.6	1.1
Gelidiopsis variabilis	--	1	1.1
Gelidium pusillum	1.5	0.9	1
Pterocladia heteroplatos	1.7	2.2	1.9
Amphiroa fragilissima	0.6	0.5	1.7
Grateloupia lithophila	0.7	0.3	--
Grateloupia filicina	7.5	3.1	1.2
Gracilaria corticata	2.9	4.3	7.3
Hypnea valentiae	4.1	3.1	8
Gigartina acicularis	--	--	3.2
Centroceros clavulatum	3.5	0.9	6.5
Bryocladia thwaitesii	1.5	1.3	--

Lyngbya majuscula	0.4	--	--

Table-3.B Biomass of the Marine Algae in Three Seasons at Station-I (Vudaz Park):-

ALGA	Season-1 (g/m^2)	Season-2 (g/m^2)	Season-3 (g/m^2)
Ulva fasciata	16.7	2.9	2.7
Enteromorpha compressa	10.8	0.3	3.6
Chaetomorpha antennina	1.9	2.5	1.9
C. brachygona	--	0.4	--
Cladophora utriculosa	1.5	--	3.5
Spongomorpha indica	5.9	6.2	6.7
Boodlea struveoides	--	1.4	5.7
Bryopsis pennata	0.4	0.4	0.4
Caulerpa fastigiata	2.9	5.9	5.1
C. recemosa	0.8	0.6	0.4
C. sertularioides	3.7	1.8	4.1
Ectocarpus mitchellae	--	--	0.3
Chnoospora minima	--	0.2	--
Bangiopsis subsimplex	--	--	0.4
Porphyra vietnamensis	--	--	0.15

Gelidiopsis variabilis	4.7	2.7	4.9
Gelidium pusillum	3.9	2.6	1.4
Pterocladia heteroplatos	1.3	5.6	5.0
Amphiroa fragilissima	19.9	12.0	8.3
Jania rubens	2.0	0.8	1.1
Grateloupia filicina	0.5	1.9	2.4
Gracilaria corticata	9.9	11.5	6.3
Hypnea valentiae	4.2	5.6	0.9
Gigartina acicularis	0.2	0.2	0.5
Centroceros clavulatum	--	2.7	2.4
Bryocladia thwaitesii	5.0	2.5	0.9
Lyngbya majuscula	0.3	0.5	0.7

Table-3.C Biomass of the Marine Algae in Three Seasons at Station-III (Tenneti Park):

ALGA	Season-1 (g/m^2)	Season-2 (g/m^2)	Season-3 (g/m^2)
Ulva fasciata	9.1	1.5	6.2
Enteromorpha compressa	2.6	3.2	6.3
Chaetomorpha antennina	0.3	0.9	1.4
Cladophora utriculosa	2.6	--	--
Spongomorpha indica	14.3	13.1	2.7
Boodlea struveoides	--	0.4	0.4

Caulerpa fastigiata	--	4.4	1.9
C. recemosa	0.5	--	0.4
C. sertularioides	21.5	2.0	3.3
C. taxifolia	2.3	7.1	1.2
Ectocarpus mitchellae	--	--	0.3
Chnoospora minima	--	0.1	--
Padina tetrastromatica	--	--	2.0
Sargassum vulgare	2.2	4.1	4.5
Bangiopsis subsimplex	--	--	0.2
Porphyra vietnamensis	--	--	0.2
Gelidiopsis variabilis	1.9	1.3	1.1
Gelidium pusillum	3.7	0.5	0.8
Pterocladia heteroplatos	4.2	2.6	2.0
Amphiroa fragilissima	5.7	6.8	7.5
Jania rubens	6.5	1.4	1.5
Grateloupia filicina	--	0.5	1.9
Gracilaria corticata	8.0	15.2	7.8
Hypnea valentiae	3.2	4.3	2.9
Gigartina acicularis	0.5	2.0	0.8
Centroceros clavulatum	1.5	--	3.9
Bryocladia thwaitesii	--	--	--

Table-4. Test for Proportions between Two Stations

Alga	Station 1&2	Station 1&3	Station 2&3
Ulva fasciata	1.80(0.072)*	2.93(0.003)	1.05(0.293)*
Enteromorpha compressa	-3.32(0.001)	-5.31(0.0001)	-1.58(0.114)*
Chaetomorpha antennina	1.04(0.297)*	2.01(0.045)	3.15(0.002)
Spongomorpha indica	-3.15(0.002)	-3.15(0.002)	-3.15(0.002)
Gelidiopsis variabilis	-2.45(0.014)	-0.70(0.487)*	1.73(0.083)*
Gelidium pusillum	-2.73(0.006)	-1.01(0.313)* 0.80(0.423)*	1.68(0.093)*
Pterocladia herteroplatos	0.53(0.597)*	-1.14(0.225)*	0.27(0.787)*
Amphiroa fragilissima	-3.10(0.002)	-0.84(0.402)*	1.86(0.063)*
Grcilaria corticata	1.80(0.072)*	1.58(0.114)*	0.95(0.344)*
Hypnea valentiae	0.82(0.414)*	2.38(0.017)	0.245(0.014)*
Bryocladia thawaitesii	0.30(0.765)*		-2.68(0.007)

* Represents that there is no significant difference between two stations at 5% level of significance. The values in the parentheses are P values.

Table-5. Two-Way ANOVA Table for Station-I

Effect	SS	Degree of Freedom	M.S.S	F ratio	P value
Alga	1874.206	10	187.421	13.3343	0.000000
Seasons	27.752	2	13.876	0.9872	0.373835
Alga+Seasons	449.848	20	22.492	1.6003	0.051316
Error	4174.500	297	14.056		

SS = Sum of Squares, M.S.S = Mean Sum of Squares

Table-6. Two-Way ANOVA Table for Station-II

Effect	SS	Degree of Freedom	M.S.S	F ratio	P value
Alga	3412.87	10	341.29	3.01102	0.001281
Seasons	753.19	2	376.59	3.32251	0.037407
Alga+Seasons	2560.75	20	128.04	1.12961	0.317846
Error	33663.80	297	113.35		

SS = Sum of Squares, M.S.S = Mean Sum of Squares

Table-7. Two-Way ANOVA Table for Station-III

Effect	SS	Degree of Freedom	M.S.S	F ratio	P value
Alga	3738.61	10	373.861	2.48896	0.007037
Seasons	100.59	2	50.294	0.33483	0.715730
Alga+Seasons	1567.01	20	78.351	0.52161	0.956818
Error	44611.70	297	150.208		

SS = Sum of Squares, M.S.S = Mean Sum of Squares