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Numerical Studies on Marine Macro Algae Species Richness and Diversity Patterns in Visakhapatnam Coast, Bay of Bengal, India

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ABSTRACT:

Visakhapatnam coastline offer a variety of habitats from outcrops of rocky boulders, crevices to intertidal rock pools, which are support the growth of abundant and diversified marine algae species. This study on species richness and diversity will help us to obtain insights into the range of variation in seaweed communities at Visakhapatnam Coast. A total of 48 seaweed species of which, 18 species belongs to Chlorophyta, 9 species to Phaeophyta and 21 species to Rhodophyta were recorded in the present study. Species richness is affected by seasonality and tidal inundation, where, species evenness is relatively unaffected by the rare species in the quadrat and by spatial distribution.

INTRODUCTION:

Seaweeds refer to several species of marine macro algae that are differentiated in to three distinct divisions: (i) Chlorophyta (green algae), (ii) Phaeophyta (brown algae) and (iii) Rhodophyta (red algae). Seaweeds are among the most important primary producers and act as ecological engineers on rocky coasts of the World's Oceans. Most of the seaweeds are growing in the intertidal zones, throughout the World, although some species occupy the supra-littoral and sub-littoral zones of the sea. The studies on seaweed communities in the tropical areas have drawn lesser attention and inadequate (Wong *et al.,* 2012).

Moreover, the information pertaining to the sustenance of marine macro algae communities with diversity patterns is still lacunae and yet to be quantified further the species richness and diversity, especially in the east coast of India. The Visakhapatnam coastline has favoured for the growth of rich algal flora due to presence of diversified rocky shoreline habitats conditions and 80 algae species have been reported by the earlier studies of Umamaheswara Rao and Sreeramulu (1964 & 1970) from this coast.

Frequency and biomass studies of algal distribution at Visakhapatnam coast were undertaken by Prasanna Lakshmi and Narasimha Rao (2009) and no other quantitative works on marine macro algae were found in this coast. The occurrence and seasonal changes in algal biomass of Visakhapatnam coast was studied earlier by Umamaheswara Rao and Sreeramulu (1964) but they have not enumerated the species richness and diversity of seaweed communities with their occurrence and seasonal variations in this part of coastline.

Thus, the present study was conducted in ten sampling stations with distinct landform characteristics and differences in their environmental conditions have been selected to examine the species richness and diversity of the seaweed communities. This study on species richness and diversity will help us (i) to obtain current and detailed baseline records, (ii) for comparisons of contemporary and historical data to highlight changes in the flora, (iii) to obtain insights into the range of variation in seaweed communities and (iv) to identify the pinpoint sites of high species diversity and richness for protection and conservation purposes.

MATERIALS AND METHODS:

Study Area:

The study area of Visakhapatnam Coast of Bay of Bengal is located in North Eastern part of Andhra Pradesh between 17^{o}15' and 18^{o} 32' Northern latitude and 82^{o} 54' and 83^{o} 30' in Eastern longitude to a total

length of 132km shoreline offer a variety of habitats from outcrops of rocky boulders, crevices and intertidal rock pools for the growth of abundant and diversified marine algae species. The principle rocky types of these formations are described as Archaean khondalites and leptynites (Umamaheswara Rao and Sreeramulu, 1964).

For conducting field survey, ten field stations were established in the rocky coastal areas of Visakhapatnam from south to north is governed by distinct land form characteristics and differences in their environmental conditions. The detail descriptions of geomorphology and topography of each field station of the study area are as follows:

S.No	Field Stations	Geomorphology and Topography of the Coastline
I	Bangarammapalem	Large rocky boulders, hillocks ebbing into sea at Sarada river mouth
II	Rambilli	Rocky boulders of various sizes spread horizontally
III	Pudimadaka	Rocky platform with big inter tidal pool basins
IV	Appikonda	Large rocky boulders with smooth surface substratum
V	Yarada	Rocky platform with small basin like pools
VI	Ramakrishna Beach	Shingle area with small rocks and pebbles in the vicinity of Visakhapatnam
VII	Tenneti Park	Large rocky platforms with small basin like pools
VIII	Rushikonda	Shingle area of horizontal plane with sand and pebbles
IX	Thotlakonda	Large rocky platform with tidal pools connected to sea
X	Bheemunipatnam	Large rocks with small basin like pools and existence of Gosthani river mouth.

Figure 1: Map showing the study area of Visakhapatnam cost with field stations

Field Survey and Data collection:

Field surveys were conducted for data collection during leap tide periods (maximum low tides) from October, 2012 to September, 2014 at four seasons, which are classified into: (i) October- December, (ii) January-

March. (iii) April- June and (iv) July-September, Each field station was visited seasonally in fortnight intervals for documentation of species occurrence, percentage cover, abundance and dominance. The specie's cover was calculated by using quadrat sampling method, which have been stratified up to mid littoral zone and infra littoral fringe areas. Sampling in supralittoral fringe was not carried out as the algal growth is negligible in this zone.

Based on the standard methods given by Saito and Atobe, (1970)**,** the composition and cover percentage of macro algae species was recorded by using 20 randomly laid quadrates of 50 cm^2 sizes with 25 subdivisions at each sampling station and the seaweed species coverage with corresponding indices in each of the 25 subdivisions were also recorded.

The parameter obtained from each quadrat with respect to coverage (as C; expressed in %) is used to compute for the area in the substratum occupied by the species based on the following formula:

$$C(`\%) = (qn_5xc_5)+(qn_4xc_4)+(qn_3xc_3)+(qn_2xc_2)+(qn_1xc_1)$$

Where, qn_n is the number of subdivisions in which a species appeared to have the corresponding area. For convenience to generate the degree of macro algae cover on the substratum, the index numbers 5, 4, 3, 2, 1 were assigned for recording the data in the field. The indices and its representative multipliers are given in Table 1.

Table 1: Indices of macro algae cover on the substratum and its representative multiplier

Indices	Degree of algal cover on the substratum	Multiplier, C_n
5	Covering 1/2-1 of the substratum surface	3.0
4	Covering 1/4-1/2 of the substratum surface	1.5
3	Covering 1/8-1/4 of the substratum surface	0.75
2	Covering 1/16-1/8 of the substratum surface	0.375
1	Covering less than 1/16 of the substratum surface	0.1875

Data on other composition of sea weeds such as density, relative density, frequency, relative frequency, dominance, relative dominance and importance value index (IVI) were also calculated. Representative seaweed samples were preserved in 5.0 % saline formalin solution and later were identified with the descriptions and taxonomic keys given by previous authors Umamaheswara Rao and Sreeramulu (1964 & 1970), Narsimha Rao (1989) and Satya Rao (2011)**.**

Sea water tides on Visakhapatnam coast are semi diurnal with two spring tides and two leap tides in a day. Tidal data is obtained from the office of Director, Geodetic and Research Branch (G & RB), Survey of India, Dehradun.

RESULTS AND DISCUSSION:

The present study was enumerated a total number of 48 marine macro algae species in Visakhapatnam rocky coast, during the period of study between October, 2012 and September, 2014. As per phyla wise representation, 18 species belongs to Chlorophyta (Green algae), 9 species to Phaeophyta (Brown algae) and 21 species to Rhodophyta (Red algae). Among these, the species *viz*. *Ulva fasciata*, *Ulva lactuca, Enteromorpha compressa*, *Chaetomorpha antennina*, *Cladophora socialis*, *Spongomorpha indica*, *Amphiroa fragilissima, Gracilaria corticata, Gracilaria textori, Padina tetrastromatica, Caulerpa taxifolia* and *Caulerpa sertularioides* were found to be dominant in rocky shores and submerged hard surfaces of Visakhapatnam coast.

In group wise abundance, the phyla Rhodophyta was recorded with highest number of algal species of 45.0 %, followed by Chlorophyta with 36.0 % and Phaeophyta members of 9.0 % contribution respectively.

Importance Value Index (IVI):

The percentage cover, density, relative density, frequency, relative frequency, dominance, relative dominance and importance values for each macro algal species were calculated for all sampling stations in four seasons. Highest percentage cover was observed in Season III (October-December) followed by Season IV (January-March). Low values of percentage cover were observed in Season II (July-September) and Season I (April-June). The species *Ulva fasciata, Cladophora socialis, Amphiroa fragilissima, Gracilaria corticata* are

abundant at all field stations with highest Importance Value Index (IVI) (41.24, 38.54, 27.13 and 22.08) among all macro algal species. The IVI for seaweed species at different sampling stations is given in Table 2.

Table 2: Site wise indices of Importance values of macroalgae at ten Field stations at Visakhapatnam Coast, Bay of Bengal, India

S.No	Seaweeds species	IMPORTANCE VALUE INDEX									
		S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
	CHLOROPHYTA										
1	*Ulva fasciata* Delile	41.24	29.91	33.41	61.06	28.6	25.11	30.35	27.62	32.16	31.94
2	*Ulva lactuca* Linnaeus	0	0	0	0	0	1.47	4.573	0	3.014	0
3	*Enteromorpha compressa* Linnaeus	43.34	27.47	22.87	0	21.51	23.75	23.78	26.88	19.26	21.69
4	*Enteromorpha intestinalis* Linnaeus	0	0	0	0	1.94	5.16	0	0	2.084	0
5	*Chaetomorpha antennina* (Bory de Saint-Vincent) Kutzing	36.14	16.17	12.44	0	14.24	11.04	9.50	14.15	8.124	14.59
6	*Chaetomorpha brachygona* Harvey	0	0	0.51	0	0	0	0	0	0.39	0.41
7	*Chaetomorpha torta* (Farlow) McClatchie	0	0	0.46	0	1.56	1.85	0.41	1.35	1.56	1.03
8	*Cladophora socialis* Kutzing	21.46	27.13	21.74	0	20.5	21.72	24.3	23.86	17.94	21.18
9	*Cladophora utriculosa* Kutzing	0	0	1.10	0	0	0	0	0	0.83	0
10	*Cladophora fascicularis* Kutzing	0	0	0.96	0	1.45	2.25	2.02	0	0.62	0
11	*Cladophora colabense* Borgesen	0	0	0.19	0	0	0	0	0	0	0
12	*Boodlea struveoides*M.A. Howe	0	0	3.78	0	2.13	0	0	0	1.69	2.08
13	*Spongomorpha indica* Thivy & Visalakshmi	0	13.14	15.28	0	16.32	13.23	13.42	11.52	12.6	13.17
14	*Bryopsis pennata* J.V. Lamouroux	0	3.21	2.82	0	4.05	3.41	3.39	2.84	4.28	2.38
15	*Caulerpa fastigiata* Montagne	0	10.06	6.7	0	7.03	11.82	9.58	8.83	9.24	9.54
16	*Caulerpa racemosa* J. Agardh	0	35.92	13.81	0	13.93	14.63	14.86	27.47	9.71	6.71
17	*Caulerpa sertularoides* (S.G.Gmelin) M.A.Howe	0	0	8.82	0	8.72	8.30	9.08	8.61	9.65	8.56
18	*Caulerpa taxifolia* (M. Vahl) C. Agardh	0	11.08	9.72	0	8.99	9.78	12.08	9.73	11.46	6.61
	PHAEOPHYTA										

19	*Ectocarpus mitchellae* (Harv.) Hamel	0	3.16	7.59	0	3.80	6.19	5.37	2.76	7.85	8.41
20	*Choonospora minima* (Hering) Papenfuss	0	0	2.04	0	2.51	1.14	1.15	0	1.05	1.75
21	*Dictyota dichotoma* (Hudson) J.V Lamouroux	0	0	4.06	0	5.25	0	0	0	2.34	0.58
22	*Padina tetrastromatica* Hauck	0	17.15	7.87	0	10.38	14.35	12.4	15.12	11.28	5.86
23	*Sargassum vulgare* C. Agardh	0	5.01	3.039	0	2.72	4.39	3.17	4.41	1.95	2.1
24	*Sargassum ilicifolium* (Turner) C.Agardh	0	9.18	9.11	0	10.73	10.71	10.16	8.07	6.65	9.56
25	*Sargassum polycystum* C.Agardh	0	0	5.17	0	2.51	0	0	0	3.42	2.98
26	*Sargassum tenerrimum* J.Agardh	0	0	4.92	0	1.86	0	0	0	3.82	3.91
27	*Giffordia indica* (Sonder) Papenfuss & Chihara	0	0	0.45	0	0.36	1.87	1.19	0	0	0
	RHODOPHYTA										
28	*Porphyra vietnamensis* T.Tanaka & Pham-Hoàng Ho	0	0	1.01	0	0.43	0.32	0.3	0.24	0.77	0.3
29	*Bangiopsis subsimplex* (Montagne) F.Schmitz	0	0.45	0.76	0	0.97	1.05	0.55	0.39	1.44	0.62
30	*Gelidiopsis variabilis* (Greville ex J.Agardh) F.Schmitz	0	8.05	5.55	0	6.43	4.45	5.16	7.06	6.21	4.07
31	*Gelidium pusillum* (stackhouse) Le Jolis	0	0	6.53	0	5.21	2.27	2.39	0	6.47	6.2
32	*Pterocladia heteroplatos* (Børgesen) Umamaheswara Rao & Kaliaperumal	0	0.74	3.53	0	4.66	5.75	7.52	1.56	5.97	6.53
33	*Amphiroa fragilissima* (Linnaeus) Lamouroux	0	21.5	14.07	183.6	17.48	17.93	19.23	22.08	17.38	16.77
34	*Jania rubens* (Linnaeus) J.V. Lamouroux	0	0	5.85	0	9.38	6.82	8.18	4.75	7.37	7.74
35	*Grateloupia lithophila* Børgesen	0	9.37	7.79	0	9.39	8.43	6.78	8.26	9.15	11.79
36	*Grateloupia filicina* (J.V.Lamouroux) C.Agardh	0	0	5.5	0	6.18	7.12	5.62	9.75	9.16	10.55
37	*Gracilaria corticata* J. Agardh	0	19	10.06	38.54	11.59	16.44	11.51	16.76	12.85	15.911

38	*Gracilaria textori* Suring	0	17.76	9.42	0	14.34	14.29	11.26	15.62	13.38	15.77
39	*Gracilaria edulis* (S.G.Gmelin) P.C.Silva	0	0	2.01	0	1.76	2.44	1.31	0.78	1.77	1.24
40	*Hypnea valentiae* (Turner) Montagne	32.87	0	9.00	0	5.75	8.91	13.74	6.52	9.19	11.78
41	*Hypnea musciformis* (Wulfen) J.V Lamouroux	0	0	2.25	0	0.15	0	0	0	1.63	0.18
42	*Gigartina acicularis* (Roth) J.V.Lamouroux	0	1.59	2.72	0	1.93	2.32	2.17	1.39	2.82	3.76
43	*Liagora visakhapatnemensis* Umamaheswararao	0	0	0.3	0	0.85	0.76	0.49	0.27	0.24	0.83
44	*Liagora erecta* Zeh	57.18	0	0.56	0	0	0	0	0	0.35	0
45	*Centroceras clavulatum* (C.Agardh) Montagne	0	9.55	7.59	0	6.51	6.04	8.68	8.39	7.76	7.61
46	*Bryocladia thwaitesii* (Harvey) De-Ton	67.77	3.40	3.02	0	5.94	2.51	4.33	2.97	3.16	3.21
47	*Wrangelia argus* (Montagne) Montagne	0	0	1.39	0	0	0	0	0	0.26	0.13
48	*Acanthophora spicifera* (Vahl) Borgesen	0	0	2.02	0	0	0	0	0	0	0

S I- Bangarammapalem; S II-Rambilli; S III-Pudimadaka; S IV-Appikonda; S V-Yarada S VI-RK Beach; S VII-Tenneti Park; S VIII-Rushikonda; S IX-Thotlakonda; S X-Bheemunipatnam.

Percentage Cover:

Seaweed cover was highest in Season III (October-December) followed by Season IV (January-March). Low values of percentage cover were observed in Season II (July-September) and Season I (April-June). Two way ANOVA results for percentage cover for different field stations at all seasons indicate that there was significant difference among algal percentage cover for all field stations, because the P value is 8.9E-17, which is much less than 0.05 and calculated F value (104.98) > Critical F value (2.355). The analysis also show that there was significant difference in algal cover in all seasons as P value is 4.9E-10, which is much less than 0.05 and calculated F value (45.275) > Critical F value (3.009) (Table 3).

Table 3 Seaweed cover at different seasons at Visakhapatnam coast

S.No	Sampling Stations	Season 1	Season 2	Season 3	Season 4
1	Bangarammapalem	16.563	14.277	23.813	21.313
2	Rambili	32.175	39.024	59.069	56.987
3	Pudimadaka	70.531	82.999	95.296	93.386
4	Appikonda	2.375	3.375	6.500	6.125
5	Yarada	69.561	81.652	88.006	82.428
6	RK Beach	51.798	65.492	88.522	87.166
7	Tenneti Park	68.112	77.313	91.167	90.962
8	Rushikonda	35.933	45.999	66.869	64.091
9	Thotlakonda	68.253	80.985	93.363	91.822

10	Bheemunipatnam	60.048	63.408	90.777	87.125

ANOVA: Two-Factor Without Replication

Source of Variation	SS	df	MSS	Fcalc	P-Value	Fcrit
Field Stations	22338.2	8	2792.28	104.98	8.9E-17	2.355
Seasons	3612.72	3	1204.24	45.275	4.9E-10	3.009
Error	638.354	24	26.598			

SS - Sum of Squares; df – Degrees of Freedom; MSS – Mean of Sum of Squares; Fcalc – Calculated F- Value; Fcrit – Critical F value

Tidal Changes on the Coast:

There is a considerable monthly variation in the spring and leap tide levels on this coast, since the mean tide levels and mean sea level varies from month to month (Umamaheswara Rao. and Sreeramulu, 1964). The range of high tides during the study period was observed as 1.08m-1.53m (February, 2014 and November, 2013 respectively), whereas, range of low tides vary from 0.04m-0.58m (February, 2014 and March, 2014 respectively). Yearly variations of 2013 and 2014 in the low and high tide levels are also evident from the graph given in Figure 2.

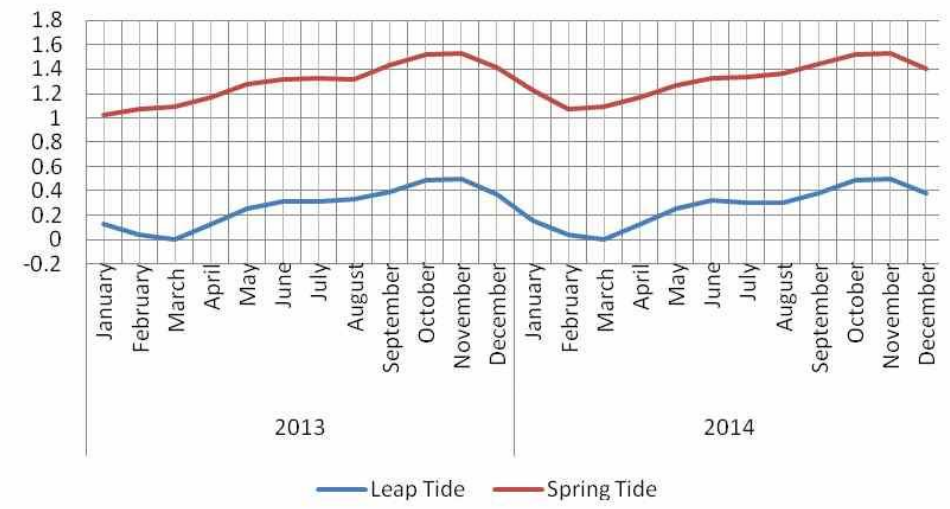

Figure 2: Graph representing Tidal data of Visakhapatnam coast

From the curves it is clear that the duration of submergence was high in two periods, one in June (with an increase from May) and the other in October-November (with an increase from September). Minimum submergence was observed in the month of February. During winter months the percentage emersion is less when the temperature falls to the minimum. The conditions in summer months are just the opposite with the result the algae migrates to lower levels on the shore to overcome desiccation due to higher temperature and increased percentage emersion.

The present study findings were correlated with the tidal periodicity cycles of Visakhapatnam coast revealed that maximum algal growth was observed during winter months from December to January rather than the summer months of April and May, as tidal periodicity and duration of submergence of intertidal zone have greatly influence on the establishments of marine algae on the substratum. These findings were supported by the similar results of Rama Ro (1968).

Species Richness (SR) and Diversity (H^I):

In quantification, species diversity is an important property of communities because it is often related to their functioning and potential for change. Diversity is a measure of how likely two randomly selected individuals in a community belong to different species. Thus, diversity is affected by two other properties of communities: richness, which is the total number of species, and evenness, which is the degree of similarity in abundance among the species (Ricardo *et al.,* 2011).

In species richness and diversity, highest number (45 species) was observed at Station III (Pudimadaka) in Season IV, whereas, lowest number (3 species) was recorded at Station IV (Appikonda) in Seasons I and II. In our study, we found that the species richness is greatly affected by seasonality with a gradual increase from 25 to 45 in Pudimadaka from September to February and then gradual decrease was observed from April to June (Table 3).

Table 4: Seasonal wise variation of percentage cover (%), Species Richness (SR), Shannon-Weiner Diversity Index (H^I) and Evenness (e) of marine macro algae in Visakhapatnam coast

	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
SEASON I : April-June										
Species Richness(SR)	7	13	25	2	25	23	22	17	23	22
Shannon-Weiner Diversity (H^I)	1.7902	2.298	2.8084	0.6876	2.7798	2.7746	2.6634	2.5628	2.7662	2.6465
Evenness(e)	0.92	0.8959	0.8725	0.992	0.8636	0.8849	0.8617	0.9046	0.8822	0.8562
SEASON II : July-September										
Species Richness(SR)	7	16	28	2	27	24	26	21	27	26
Shannon-Weiner Diversity (H^I)	1.7998	2.4381	3.078	0.5909	3.0404	2.9288	2.9275	2.6275	2.9225	2.8741
Evenness(e)	0.9249	0.8793	0.9238	0.8525	0.9225	0.9216	0.8985	0.863	0.8867	0.8822
SEASON III: October-December										
Species Richness(SR)	7	23	44	3	39	34	34	31	42	40
Shannon-Weiner Diversity (H^I)	1.7697	2.8239	3.4394	0.8762	3.3754	3.2705	3.2156	3.0423	3.4184	3.3344
Evenness(e)	0.9094	0.9006	0.9089	0.7976	0.9214	0.9274	0.9119	0.8859	0.9146	0.9039
SEASON IV : January-March										
Species Richness(SR)	7	23	45	3	39	35	35	31	43	37
Shannon-Weiner Diversity Index(H^I)	1.8716	2.8818	3.4342	0.6269	3.3447	3.2673	3.1984	3.0947	3.3394	3.2675
Evenness(e)	0.9618	0.9191	0.9022	0.5706	0.913	0.919	0.8996	0.9012	0.8919	0.9049

S I-Bangarammapalem; S II-Rambilli; S III-Pudimadaka; S IV-Appikonda; S V-Yarada S VI-RK Beach; S VII-Tenneti Park; S VIII-Rushikonda; S IX-Thotlakonda; S X-Bheemunipatnam.

In all seasons, highest Shannon-Weiner Diversity Index (H^l) was observed for Station III with 2.8084, 3.078, 3.4394 and 3.4342; and lowest Shannon-Weiner Diversity index was observed for Station IV with 0.6876, 0.5909, 0.8762 and 0.6269 (Table 3). Evenness (e) of macroalgae in all field stations range from 0.5706 to 0.992 was observed. No prominent variation or trend is observed for species evenness at sampling stations of Visakhapatnam coast. These findings indicated that the species evenness is relatively unaffected by the rare species in the quadrat and by spatial distribution, which is supported by Ricardo *et al.,* (2011).

An annotated list prepared by Umamaheswara Rao and Sreeramulu, (1970) for Visakhapatnam coast recorded with 80 algal species, however, the present study observed 48 species in different seasons, revealed that a reduction in 40.0% composition of marine algae species over a period of four decades. The present study is also resembled in similarity of occurrence of 31 species were reported by Prasanna Lakshmi and Narasimha Rao (2009) from the urban beaches of Visakhapatnam coast.

The present study findings revealed that the following species such as: *Derbesia turbinata, Derbesia sp., Trichosolon mucronata, C.fritschii* of Chlorophyceae and *Feldmannia irregularis, F. filter, Myrionema sp., Bachelotia antillarum, Sphacelaria tribuloides, S. furcigera zonaria sp., Rosenvingea nhatrangensis* of Phaeophyceae and *rythrotrichia abscura, Acrochaetium gracile, A. krusadii, A. sanctithomae, A. robustum, Helminthocladia sp., Melobesia sp., Callithamnion sp., Ceramium sp., Spemathmnion sp., Polysiphonia sp*., and *P. platycarpa* of Rhodophyceae have not been observed, where these species were once conspicuous in their presence from the studies of Umamaheswara Rao and Sreeramulu, (1970) at Visakhapatnam coast.

Whereas, two new species recorded in the present study are, (i) *Ulva lactuca* and (ii) *Enteromorpha intestinalis,* were not observed by earlier studies. Thus the present quantitative data on frequency and biomass of Marine algae at Visakhapatnam coast reveals that a gradual depletion of Marine algal species from the intertidal rocky surfaces was observed during the study period.

SUMMARY AND CONCLUSION:

Sea water tides on Visakhapatnam coast are semidiurnal with two spring tides and two leap tides a day and the duration of submergence was high in two periods, one in June (with an increase from May) and the other in October–November (with an increase from September).

Numerical studies for intertidal marine algae in ten sampling stations (Bangarammapalem, Rambilli, Pudimadaka, Appikonda, Yarada, R.K. Beach, Tenneti Park, Rushikonda, Thotlakonda and Bheemunipatnam) on the coastline of Visakhapatnam were conducted. Percentage cover, density, relative density, frequency, relative frequency, dominance, relative dominance and importance value were calculated for all sampling stations. IVI values for algal species varied for each field station. Mostly *Ulva fasciata, Enteromorpha compressa, Amphiroa fragilissima* and *Gracilaria corticata* showed higher IVI values compared to other species. In our observations, we found the species richness is affected by seasonality and tidal inundation.

The species richness was observed gradually increase from September to February and then a gradual decrease from April to June. Evenness for all field stations ranges from 0.5706 to 0.992. Shannon-Wiener Diversity index (H^l) was varied in each field station at different seasons. Lowest diversity index was observed in Appikonda and Bangarammapalem field stations, whereas highest index was found in Pudimadaka, Yarada and Thotlakonda field stations. Same trends were also observed in percentage cover for all field stations in the present study.

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