

ECOLOGICAL STUDY OF INTERTIDAL MARINE ALGAE OF KONKAN

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DEVOTION



**This Research Work is dedicated with
Graciousness and Approbation
to my Parents**

Late Mrs. Anagha

and

Late Arch. Arvind

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GENERAL INTRODUCTION:

Algae are a primitive group of plants, which resides in the fresh water and marine water, as well as wet surfaces of the soil. Algae shows the variations in its habit as; macro algae such as, green algae (Chlorophyta), brown algae (Phaeophyta), red algae (Rhodophyta), and microalgae such as blue – green algae (Cyanophyta).

Throughout the world, each continent has the distribution of coasts with diversity of seashores like, rocky, sandy and coral reefs. The benthic macro algae are salient biological component of the intertidal rocky shore.

The coastal area in India is extremely vast generating more scope for research in the field of marine algae, which will be unending. Considering the coast of India, Boergesen F. (1930) has made radical contribution to the study of seaweed. Researchers like, Balkrishnan M.S. and Kinkar V.N. (1981), Chaugule B.B. and Gunale V.R. (1981), Deodhar H.D. (1987), Dixit S.C. (1964-73), Iyengar M.O.P. (1927), Krishnamurthy V. (1954), Misra J.N. (1960), Umamaheshwar Rao M. (1972), Dhargalkar V.K. *et al.* (2001), few to name, who had made rich research in marine algae. These researchers have made investigation on the Indian coasts with reference to Taxonomy, Vertical Distribution, Seasonal Variation, Diversity of Algae, etc.

Dixit S.C. (1973) has published his paper with title, ‘A species list of Indian marine algae – I to IV’, in which he had listed all the species of marine algae found around the Indian coasts. In his classic paper he had mentioned about the scarcity of the availability of literature on Indian marine algae. But in the recent years, extensive study has been done on the marine algae along the Indian coasts.

Dhargalkar V.K. *et al.* (2001) had carried comparative study on the distribution and abundance of marine macro algae along the Maharashtra coast. As their survey reveals that, there exists a cyclic change in the distribution, abundance

and reproductive feature in the algal species as well as there a resistance could be developed in the marine macro algal species against the extreme environmental conditions.

Venkatraman K. And Wafar M. (2005) in their exclusive study on the, 'Coastal and Marine Biodiversity of India', have mentioned that, along the coast of Maharashtra about 159 algal species has been found and there is a need of the extensive study of biodiversity of the seaweeds along the coast.

Since the study of the ecology of marine algae on the West coast of Maharashtra is limited, it persuades the author to carry out the present research work on the west coast especially North Ratnagiri district of Konkan. The west coastline of Maharashtra is extended over 760 km. As per the North Ratnagiri district is concerned the pattern of zonation of intertidal marine algae and the physico-chemical parameters are not studied. The North Ratnagiri shows variety of rock shores and is favourable for the abundant growth of marine algae.

REVIEW OF LITERATURE:

Every coast shows diversity of the seashore like, rocky, sandy, reefs, etc., which harbours various life forms including algae. Earlier researchers constrained their work by describing the location of marine algae along the seashores, and steadily studies of a strip of seashore or the rock pool were undertaken for the distribution of marine algae along the rocky seashores.

Wahlenberg G.E. (1812) materializes the zonation of marine algae for the first time, based on studies on Norway coast. Kirtikar K.R. (1887) read out the paper on marine algae collected by Honourable Justice Birdwood, of Ratnagiri coast.

Svedelius N. (1906a) made important contribution to the ecology of marine algae of the India region.

Boergesen F. (1927) worked for the detailed studies of coast of then Bombay Presidency and published a series of papers enlisting the marine algae occurring on the same coast (1930 – 1934).

Iyengar M.O.P. (1927) published a short note on marine algal vegetation of Krusadai Island and its ecology, from South India.

Stephenson T.A. and Stephenson A. (1949), with distinctive studies on the rocky shore of Britain, North America, South America, Indian Ocean and Australia have published a classical paper on the Universal Features of Zonation of Organisms between tidemarks on Rocky Coasts. They suggested the following five zones viz.

1. Supralittoral zone: The maritime belt lying near the sea, above tide marks, but subject to some maritime influence. The lower limit of this zone is the upper limit of the one below.

2. Supralittoral fringe: From the upper limit of Barnacles to the nearest convenient landmark. This is the upper limit of Littorinae. High water of spring tides invades at least the lower part of this zone.
3. Midlittoral zone: From the upper limit of Barnacles down to the upper limit of zone below. This belt tends to be covered and uncovered every day, at least in parts.
4. Infralittoral fringe: From the upper limit of any convenient organism to extreme low water level of spring tides, or to the lowest level of ever visible between waves. This zone uncovers only at the major tides, and sometimes only in calm weather.
5. Infralittoral zone: From the extreme low water of springs to a depth which has yet to be settled – it may be to the edge of the continental shelf or to the lower limit of seaweed vegetation.

Simultaneously in 1945, Biswas K. had published a census of marine algae of western coast of India. Whereas during the decade of 1960s and 1970, Dixit S.C. published four volumes of species lists of Indian marine algae determined by Boergesen F. (1930).

In addition, various researchers have done vivid work on marine algae of Maharashtra like Dixit S.C. (1964, 1968, 1970, 1973), Misra J.N. (1960), Balakrishnan *et al.* (1974, 1981), Chaugule B.B. and Gunale V.R. (1981), Chaugule B.B. and Deodhar H.D. (1985), Deodhar H.D. (1987), Phanse S. (2000).

According to Krishnamurthy V. and Subbaramiah K. (1965), intensive studies on the ecology of intertidal algae of India were very few. They stated that, no account has been taken of the shore type in describing the ecological formation and association. In their intrinsic study they considered the ecological parameters in the

different types of shore and their role is emphasised in studies on ecology of intertidal algae. They had published the paper on the importance of shore-types in intertidal ecology of Indian marine algae. In their classic paper, they divided the four basic types of shore and are distinguished along the Indian coasts, as, 1) sandy shores, 2) rocky shores, 3) coral formations, and 4) estuarine regions.

Umamaheshwar Rao M. (1972) studied the ecological observation of some intertidal marine algae on the Mandapam coast. Where he evaluated the relationship between the variation in the periods of the submergence and emergence caused by the tides and zonation and seasonal changes in the algal growth. He confirmed that, the seasonal changes in the algae observed in relation to the variation in the exposure and submergence and other factors further confirmed that the seasonal tide behaviour and other changes in the physical conditions of the marine environment brought about by the monsoons are responsible for the fluctuations in the growth and abundance of the intertidal algae.

Allender B.M. (1977) in his exclusive study on the brown alga *Padina japonica* demonstrated that, the algal species grown best when continuously submerged, and growth rates decreased with increased emersion up to a clear zonation boundary. Thus, high temperature has reduced the emersion tolerance, and was therefore an important factor in tropical intertidal zonation.

Murthy M.S., Bhattacharya M. and Radia P. (1978) had carried out the ecological studies of intertidal algae at Okha, Gujarat. In their extensive study, the monthly fluctuation in biomass and zonation, and environmental factors acting upon the intertidal algae at Okha coast were described. The results showed that the *Sargasum* was the only species contributes maximum to the total biomass. They also stated that, the diversity was increased from the onset of winter when the biological

activity of the algae was accelerated. Their study resulted that the temperature, both of the air and seawater and dissolved oxygen content are the critical factors, which governed the distribution of the algae.

Druehl L.D. and Green J.M. (1982) studied the vertical distribution of intertidal seaweeds as related to patterns of submersion and emersion. Where they assessed and quantified the effects of waves on aspects of tides, which determine the degree of stress to which intertidal organisms are subjected. In this study, algal distributions on the three transects over 6 years showed a significant correlation with some aspects of their submersion or emersion accounts, which are important in influencing the vertical distribution of intertidal seaweeds.

Ramalakshmi Y. and Chauhan V.D. (1992) carried out the ecological study of *Sargassum swartzii* on the coast of Port Okha; Gujarat. The study showed that, the distribution of macroalgae on the coast of Port Okha was not indicative of any particular zonation pattern. The relative frequency and density of the species was higher during the months of July-September and Poisson's distribution analysis indicated the regular distribution of *Sargassum swartzii* occurrence.

Venkatraman K. and Wafar M. (2005) have recorded about 217 genera and 844 species of algae, which are distributed along the seashore of India. The abundance of these species can be seen as Rhodophyta – 434, Chlorophyta – 216, Phaeophyta - 191 and Xanthophyta – 3 and some of the Cyanophyta. Among these, 159 marine algal species are recorded from Maharashtra coast.

Ellis D.V. (2003) has carried out the monitoring procedure for the recovery of biodiversity after a shoreline ecosystem has been destroyed by smothering. He used the Stephenson's concept of a global pattern of intertidal zonation. The concept has been used at Island Copper Mine on the Pacific Coasts of Canada to monitor

biodiversity development along the rocky – stony shoreline face of a coastal waste rock dump. According to his studies the zonation pattern represents the equilibrium state for a rocky shore ecosystem anywhere in the world. An old concept of zonation pattern described by Stephenson has found a new use for assessing biodiversity recovery on a smothered shoreline.

Fujita Daisuke *et al.* (2004) have studied the vertical distribution and zonation of marine algae in Sargassum forests at Abugashima Island in western Toyama Bay. The studies resulted that, along a belt transect, nine zones were recognized and a total of 61 species and 2 encrusting taxa were identified. Species diversity indices were larger in deeper zones. Cluster analysis using coefficient of community redivided the nine zones into five structural zones; *Sargassum piluhfera* zone (0-0.5m in depth, lined with articulated corallines), *Sargassum horneri* zone (0.5-1.9m in depth), *Sargassum confusum* zone (1.9-3.6m in depth), *Sargassum macrocarpum* zone (3.6-11.3m in depth) and *Sargassum yendoii* zone (11.3-16.7m).

Marine algae play an important ecological, economical role in human life as marine algae have been used throughout the world, as food and in industry. Marine algae are consumed as a regular part of human diet in coastal China since 850 BC. Seaweeds can be used for the reduction of nitrogen and phosphorus content of effluents in sewage treatments of various industries. Since majority of the algae are extremely tolerant to heavy metals, this potential of the algae could be a useful phytoremediation technology to restore water quality.

Exceptionally little work has been done on the ecology of the algal flora and the zonation of the intertidal algae on the rocky coasts in the different parts of the world. The work done on ecology of marine algae of Indian coastline is very scrappy. Very little work has been done on ecology of intertidal marine algae along the west

coast of Maharashtra. In Konkan region, especially in north Ratnagiri district, only taxonomy of marine algae has been studied by Phanse S. (2000) and marine macroalgal diversity along Maharashtra coast Dhargalkar V.K., Untwale A.G. and Jagtap T.G. (2001).

However, the distribution and zonation pattern of the marine algae has not been studied along the entire west coast of Maharashtra except Mumbai (Deodhar H.D., 1987). At present, the North Ratnagiri district has very few industries that influence the marine flora and fauna. One of them is Ratnagiri Gas and Power Pvt. Ltd. located near Dabhol, and another O. P. Jindal's JSW Power project at Jaigad near Hedavi. Many more industries, particularly in power sector are likely to be established along the coast of Ratnagiri district. These industries may have impact on the algal flora of this coast.

MATERIALS AND METHODS:

In the North Ratnagiri district, Dapoli and Guhagar talukas are the best harbours for the lush growth of intertidal marine algae. Both the talukas are situated at the distance of about 130 km and 170 km respectively, south of Mumbai, on the west coast of Maharashtra.

The detailed ecological study of marine algae has been carried out at one station in each taluka. Two sites were selected for the above investigation, of which Hedavi is the first site and will be presented as Site – 1, and Kolthare is the second site and will be presented as Site – 2. Both sites are situated on the west coast of Maharashtra state on the North Ratnagiri district. The Site – 1 is situated at the longitude of 17° 21' 30.53 N and latitude of 73°12'57.77 E, and Site – 2 is situated at the longitude of 17° 39'36.43 N and latitude of 73°07'35.38 E. Both sites show high rocky shore and are quite reachable during the research work.

Coast at both the sites is built up of Brown/ Black Basalt, and the region under study shows a great slop towards the sea. The area between extreme high tide mark and extreme low tide mark consists of some small and large pools, some gullies. At both sites near the shoreline, large rocks and boulders are found.

A line transect was placed perpendicular to the shoreline. Starting from the boulders, a line transect of about 60 meter length was fixed for monthly observations.

At Site – 1 along the line transect, between 1st and 2nd meters large boulders are present. The area between 2 to 13 meters lacks pools and pits, and the surface is moderately flat. From 13 to 18 meter a medium sized pool is present. From 18 to 22 another rock pool is present. From 29 to 35 meters third rock pool is present. From 35 to 39 meters the slop of the surface is very sharp. The surface between 39 to 50 meters is moderately flat and devoid of pool and pits.

At Site – 2 along the line transect, between 1 to 2 meters large boulders are present and show some deposition of soil. Between 2 to 13 meters, the rocky surface is straight and devoid of pools and pits. From 13 to 15 meters, a rock pool of depth of 0.50 to 0.65 meters with some deposition of silt is present. Surface from 15 to 17 meters is flat, and another rock pool is present between 17 to 20 meters. From 20 to 23 meters surface shows slope. Third rock pool is present 23 to 26 meters. Rocky surface from 26 to 36 meters is moderately flat and does not shows pools and pits. The line from 36 to 52 meters shows gradual slope with some small pits.

Monthly observations were carried out at the suitable low tides, refereeing the tide time tables published by the Government Port Authority at Ratnagiri. Record of the occurrence of algae, along the line transect, was done for 18 months from June 2009 to November 2010. During each visit, depending upon the height of water, readings were taken from 1st meter up to the distance which was exposed during the low tide. The names of algal species occurring along the line were noted down.

The profile of the shore along the line transect was charted by using a method called “The Emery Profile Method” as described by Dawes C.J. (1981). To measure the shore profile a simple method is applied, in which only two wooden rods, each 5 ft long and about one inch by one inch in cross-section are used. Notches are made with cuts at 1 ft intervals along each rod, with smaller notches at 1/10 ft intervals throughout at least a foot at one end. A minor elaboration is made with a small wooden pad about 4 inches in thickness.

For measuring, the rods are held vertically, one rod length apart in a line to be extended across the beach. The observer holding the landward rod aligns his eye with the top of the seaward rod at the horizon. He then reads and records the distance down from the top of his own rod of the point which is intersected by the line of sight.

Assuming the line of sight to be level, this distance is a measure ($a = b =$ recorded level change) of the difference in elevation of the beach at the two points that are 5 ft apart. Profile is measured by moving the wooden rods toward the sea.

For fixing the direction of slope the principle has been adopted that, notes are made of the differences in elevation as minus or plus according to whether the seaward rod is lower or higher than the landward rod. Eventually, the differences in elevation are summed up and plotted against horizontal distance and obtained the profile of each site.

Figure No. A. Emery Profile Method

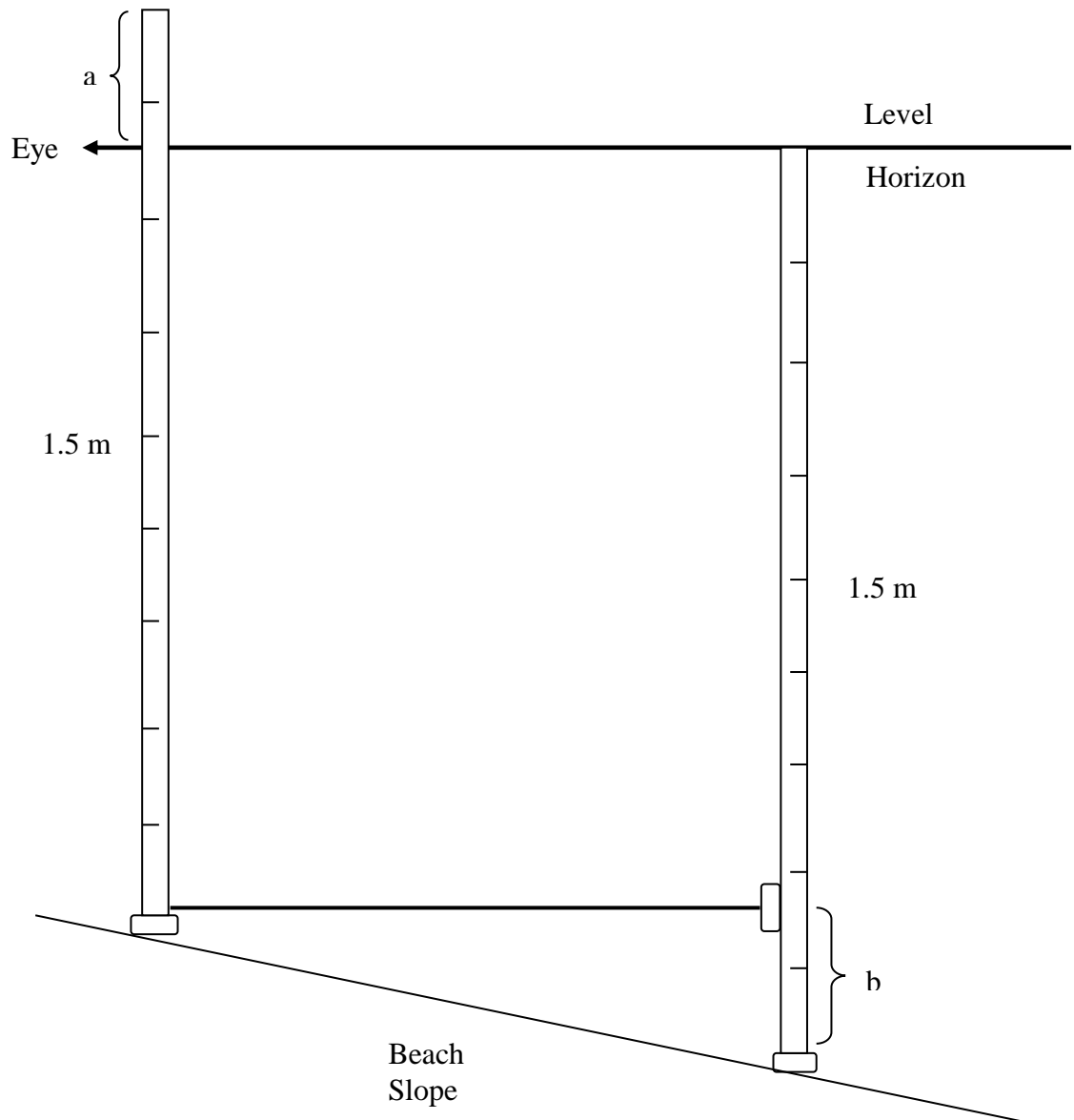
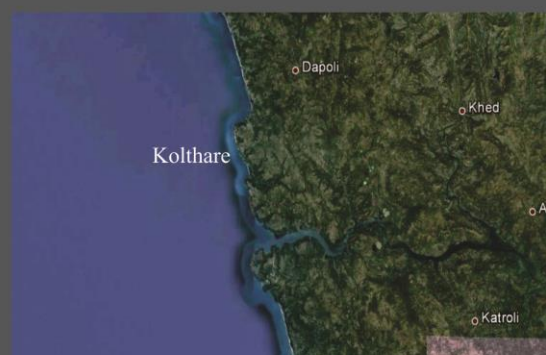


Plate No. 1 Map of Site



Guhagar Taluka Showing
Site - 1 Hedavi



Dapoli Taluka Showing
Site - 2 Kolthare

Plate No. 2
Materials and Methods



Author Measuring the Shore Profile



Author Noting Algal Species

Table No. 1.A

List of algae encountered along the line transact of observation at Site – 1

(Hedavi)

Sr. No.	Name of Algae
01	<i>Chaetomorpha linum</i> (Muell.) Kuetz.
02	<i>Enteromorpha flexuosa</i> (Wulf.) J. Ag.
03	<i>Spongomorpha indica</i> Thivy et Visalakshmi.
04	<i>Ulva lactuca</i> Linn.
05	<i>Cladophora fascicularis</i> (Mert.) Kuetz.
06	<i>Dictyota divaricata</i> Lamouroux
07	<i>Dictyota dichotoma</i> (Hudson) Lamouroux.
08	<i>Padina tetrastrumatica</i> Hauck.
09	<i>Stoechospermum marginatum</i> (C. Ag.) Kuetz.
10	<i>Sargassum cinereum</i> J. Ag.
11	<i>Sphacelaria furcigera</i> Kuetz.
12	<i>Spatoglossum asperum</i> J.Agardh
13	<i>Catenella rapens</i> (Lightf.) Batters.
14	<i>Champia compressa</i> Harvey.
15	<i>Centroceros clavulatum</i> (C. Ag.) Mont.
16	<i>Gelidium pusillum</i> (Stackhouse) Le Jolis.
17	<i>Gracilaria corticata</i> J. Ag.
18	<i>Grateloupia filicina</i> (Wulf) G. Ag.
19	<i>Hypnea valentiae</i> (Turn.) Mont.
20	<i>Jania rubens</i> Lamour
21	<i>Laurencia obtusa</i> (Hudson) Lamouroux.
22	<i>Porphyra vietnamensis</i> Tanaka et Ho.

Table no. 2.A

List of algae encountered along the line transact of observation at Site – 2

Sr. No.	Name of Algae
01	<i>Chaetomorpha linum</i> (Muell.) Kuetz.
02	<i>Enteromorpha flexuosa</i> (Wulf.) J. Ag.
03	<i>Spongomorpha indica</i> Thivy et Visalakshmi.
04	<i>Ulva lactuca</i> Linn.
05	<i>Cladophora fascicularis</i> (Mert.) Kuetz.
06	<i>Dictyota divaricata</i> Lamouroux
07	<i>Dictyota dichotoma</i> (Hudson) Lamouroux.
08	<i>Padina tetrastromatica</i> Hauck.
09	<i>Stoechospermum marginatum</i> (C. Ag.) Kuetz.
10	<i>Sargassum cinereum</i> J. Ag.
11	<i>Sphacelaria furcigera</i> Kuetz.
12	<i>Catenella rapens</i> (Lightf.) Batters.
13	<i>Champia compressa</i> Harvey.
14	<i>Centroceros clavulatum</i> (C. Ag.) Mont.
15	<i>Dasaya spp.</i>
16	<i>Gelidium pusillum</i> (Stackhouse) Le Jolis.
17	<i>Gracilaria corticata</i> J. Ag.
18	<i>Grateloupia filicina</i> (Wulf) G. Ag.
19	<i>Hypnea valentiae</i> (Turn.) Mont.
20	<i>Jania rubens</i> Lamour
21	<i>Laurencia obtusa</i> (Hudson) Lamouroux.
22	<i>Porphyra vietnamensis</i> Tanaka et Ho.

OBSERVATIONS:

Site – I (Hedavi).

Date of Observation: 25th July 2009.

	Time	Height
Tide: Low Tide:	06:45 hrs.	0.35 m.
	19:45 hrs.	0.46 m.
High Tide:	00:50 hrs.	2.31 m.
	13:15 hrs.	3.09 m.

It was the first visit to Site – I (Hedavi) for the study of distribution of marine algae along the line transact. The reading was taken up to 46 meters.

Along the line, up to 17 meters not a single alga could be seen. *Enteromorpha flexuosa* and *Jania rubens* were present between 18 to 22 meters, in the initial stages of growth.

Rock between 23 to 27 meters, does not show the growth of any algal species. From 28 meters onwards, up to 31 meter *Gelidium pusillum* was present in the thick patches. The line between 32 and 34 meters does not show algal growth. Further, from the 35 meters *Gelidium pusillum* was occurring continuously up to 46 meters. At 35th and 36th meters *Chaetomorpha linum* was present.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 2.7 to 2.9 meters.
2. *Gelidium pusillum* : 0.9 to 3.1 meters.

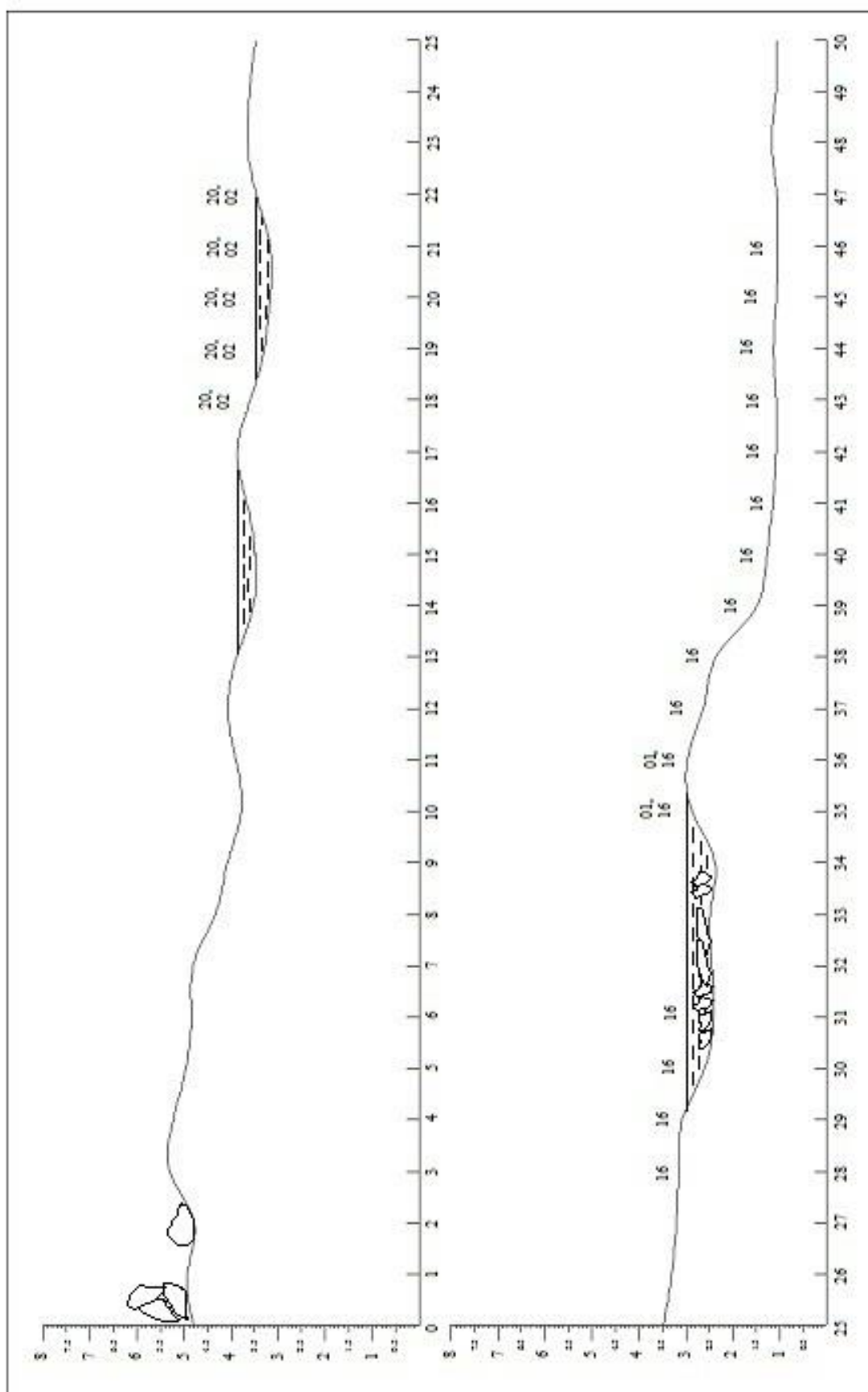


Figure No. 1 Profile of the Shore of Hedavi indicating meter wise distribution of algal species – Month: July 2009

Figures No. A.c.1: Vertical Distribution of Algae at Site – 1: July 2009

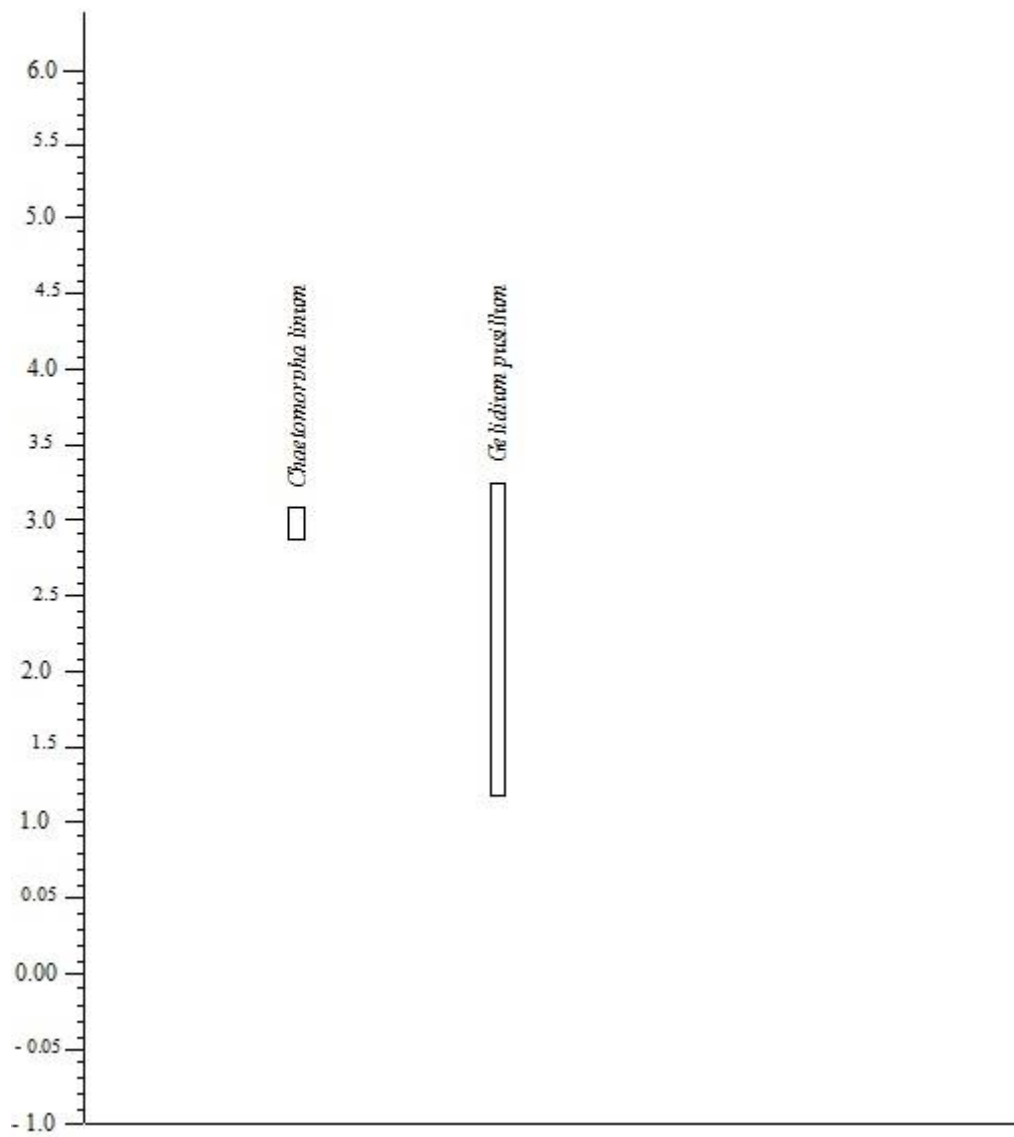
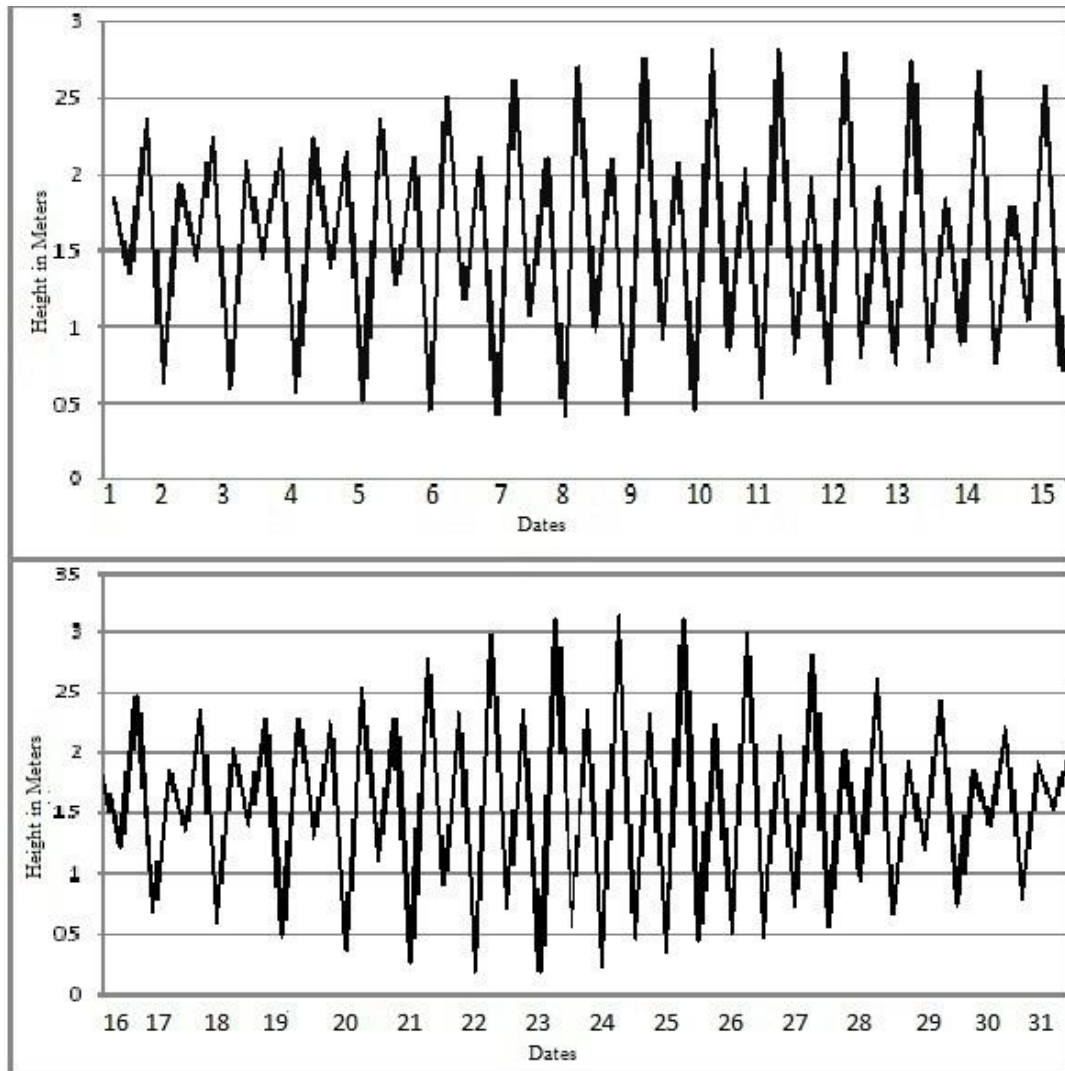


Fig .No. 21. Marigram at Site - 1: July 2009.



Site – I (Hedavi).

Date of Observation: 23rd August 2009.

	Time	Height
Tide: Low Tide:	06:25 hrs.	0.44 m.
	19:00 hrs.	0.32 m.
High Tide:	00:25 hrs.	2.46 m.
	12:50 hrs.	3.02 m.

This was the second reading at the Site – I. Heavy rains; high wind velocity and strong wave action of sea water restricted the author to take reading up to 39 meters only.

From meters 1 to 5 a dense population of fully grown *Enteromorpha flexuosa* was present. *Porphyra vietnamensis* was present from 6 to 25 meters and again from 28 to 34 meters, on the sharp edges of the rocky surface of the shore. The 26th and 27th meters lack algal cover. *Sphacelaria furcigera* was present between 35 and 39 meters. *Gracilaria corticata* was also present between 35 and 39 meters. The tide time and height of water was not much suitable for reading beyond 39 meters. *Gelidium pusillum* was observed growing from 35 to 39 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 4.8 to 5.4 meters.
2. *Sphacelaria furcigera* : 1.4 to 2.9 meters.
3. *Gracilaria corticata* : 1.4 to 2.9 meters.
4. *Gelidium pusillum* : 1.4 to 2.9 meters.
5. *Porphyra vietnamensis* : 2.3 to 4.8 meters.

Site – I (Hedavi).

Date of Observation: 6th September 2009.

	Time	Height
Tide: Low Tide:	05:20 hrs.	0.58 m.
	18:00 hrs.	0.45 m.
High Tide:	11:45 hrs.	2.85 m.
	23.55 hrs.	2.35 m.

It was the end of the rainy season along the coast of the site. *Enteromorpha flexuosa* was present from 1 to 5 meters, which was in abundance. *Porphyra vietnamensis* was present from 6 to 25 meters. The 26th and 27th meters did not show presence of any algal species. The same species continues to grow from 28 to 34 meters with dense population.

Chaetomorpha linum again reappeared in this month from 35 to 39 meters. *Sphacelaria furcigera* was also present in the same area along the line between 35 and 37 meters. *Gelidium pusillum* occurred between 36th and 42nd meters.

The author could take reading up to 42nd meter only, due to heavy rains.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 4.8 to 5.4 meters.
2. *Sphacelaria furcigera* : 2.6 to 2.9 meters.
3. *Gelidium pusillum* : 1.1 to 2.9 meters.
4. *Porphyra vietnamensis* : 3.1 to 4.8 meters.

Site – I (Hedavi)

Date of Observation: 6th October 2009.

	Time	Height
Tide: Low Tide:	04:45 hrs.	0.90 m.
	16:55 hrs.	0.13 m.
High Tide:	10:30 hrs.	2.65 m.
	23:25 hrs.	2.67 m.

Due to end of the rainy season in this month, *Porphyra vietnamensis* was appeared to be migrated to completely submerged area. *Enteromorpha flexuosa* was present between 1st and 3rd meters, where its density was comparatively reduced. The line on the rocky surface between 4th and 18th meters did not show any algal species. *Jania rubens* and *Spongomorpha indica* were lushly growing in the rock pool no. 2 between 18 and 20 meters. *Chaetomorpha linum* was distributed between 27th and 29th meters and from 37th meter to 40th meter, mostly on the slope of the rocky surface of the shore. *Dictyota divaricata* appeared from 42 to 47 meters and again in 50th meter.

Stoechospermum marginatum was abundantly seen from 42 to 50 meters. *Gracilaria corticata* was found at 45th and 46th meters. *Grateloupia filicina* was present at 39th meter, on the slop of the shore in association with *Chaetomorpha*. Rare occurrence of *Champia compressa* was noted at 46th and 50th meters. *Gelidium pusillum* was present at 27th and 28th meters, and constantly present beyond 30 to 50 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 4.8 to 5.4 meters.
2. *Chaetomorpha linum* : 1.2 to 3.2 meters.
3. *Dictyota divaricata* : 0.9 to 1.2 meters.

4. *Stoechospermum marginatum* : 0.9 to 1.2 meters.
5. *Gracilaria corticata* : 0.9 to 1.0 meters.
6. *Grateloupia filicina* : 1.4 meter.
7. *Champia compressa* : 0.9 to 1.1 meters.
8. *Gelidium pusillum* : 0.9 to 3.2 meters.

Site – I (Hedavi)

Date of Observation: 3rd November 2009.

	Time	Height
Tide: Low Tide:	04:45 hrs.	0.90 m.
	16:55 hrs.	0.13 m.
High Tide:	10:30 hrs.	2.65 m.
	23:25 hrs.	2.67 m.

This month the site showed variety of algae growing along the line transact. There was no growth of algae up to 31, however from 32nd meter onwards, the line transact showed variety of algae.

Gelidium pusillum was present from 32 to 50 meter. *Chaetomorpha linum* was present between 36 and 39 meters. *Ulva lactuca* was growing (in initial stage of growth) between 36 and 40 meters and also in 43rd and 44th meters.

Dictyota dichotoma was found between 41 and 50 meters. *Gracilaria corticata* a red alga was present from 45 to 50 meters. Another red alga named *Centroceras clavulatum* was present in 41st and 42nd meters along the line transact. *Dictyota divaricata* was observed in 43rd and 44th meters. *Grateloupia filicina* a red algae was present in 45th and 46th meters.

Padina tetrastromatica a brown alga was observed from 45 to 50 meters with thick population. *Stoechospermum marginatum* another brown alga inhabited densely from 44 to 50 meters along the line transact. The patch between 43 and 50 meters was compactly covered by *Sargassum cinereum*. *Hypnea valentiae* was observed only in 49th and 50th meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 1.4 to 2.9 meters.
2. *Ulva lactuca* : 1.2 to 2.9 meters.
3. *Dictyota dichotoma* : 0.9 to 1.2 meters.
4. *Padina tetrastromatica* : 0.9 to 1.2 meters.
5. *Stoechospermum marginatum* : 0.9 to 1.2 meters.
6. *Sargassum cinereum* : 0.9 to 1.2 meters.
7. *Gracilaria corticata* : 0.9 to 1.2 meters.
8. *Centroceras clavulatum* : 1.1 meter.
9. *Grateloupia filicina* : 0.9 to 1.0 meters.
10. *Hypnea valentiae* : 1.1 meter.
11. *Gelidium pusillum* : 0.9 to 2.9 meters.

Site – I (Hedavi)

Date of Observation: 2nd December 2009.

	Time	Height
Tide: Low Tide:	04:25 hrs.	1.03 m.
	16:30 hrs.	0.09 m.
High Tide:	10:00 hrs.	2.50 m.
	23:20 hrs.	2.78 m.

The author was able to record observation up to 50 meters in this month; he found maximum number of species during field work. The line transact up to 19 meters did not show any algae.

The rock pool at 20th and 21st meters showed presence of algae such as, *Jania rubens*, *Spongomorpha indica*, and *Padina tetrastromatica*. Whereas, from 22 to 24 meters all algae mentioned above were present along with *Enteromorpha flexuosa*. From 25 to 28 meters no algal species were recorded.

The algal species like, *Gelidium pusillum*, *Sphacelaria furcigera*, *Chaetomorpha linum*, *Ulva lactuca*, *Padina tetrastromatica*, and *Sargassum cinereum* were observed from 29 to 50 meters.

Stoechospermum marginatum was present from 31 to 36 meters and again at 38th and 42nd meter. *Centroceras clavulatum* was found in 35th and 50th meter. From 36 to 50 meters *Laurencia obtusa* was present. *Catenella rapens* was found from 40 to 42 meters. *Champia compressa* was present from 40 to 42 meters and also appeared in 50th meter.

The growth and numbers of algal species occurring during winter season was very high.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 3.6 to 3.7 meters.
2. *Chaetomorpha linum* : 0.9 to 2.9 meters.
3. *Ulva lactuca* : 0.9 to 2.9 meters.
4. *Padina tetrastrumatica* : 0.9 to 2.6 meters.
5. *Sargassum cinereum* : 0.9 to 2.6 meters.
6. *Stoechospermum marginatum* : 1.1 to 2.6 meters.
7. *Sphacelaria furcigera* : 0.9 to 2.6 meters.
8. *Centroceras clavulatum* : 0.9 to 2.6 meters.
9. *Laurencia obtusa* : 0.9 to 2.6 meters.
10. *Catenella rapens* : 1.1 to 1.2 meters.
11. *Champia compressa* : 1.1 to 1.2 meters.
12. *Gelidium pusillum* : 0.9 to 3.0 meters.

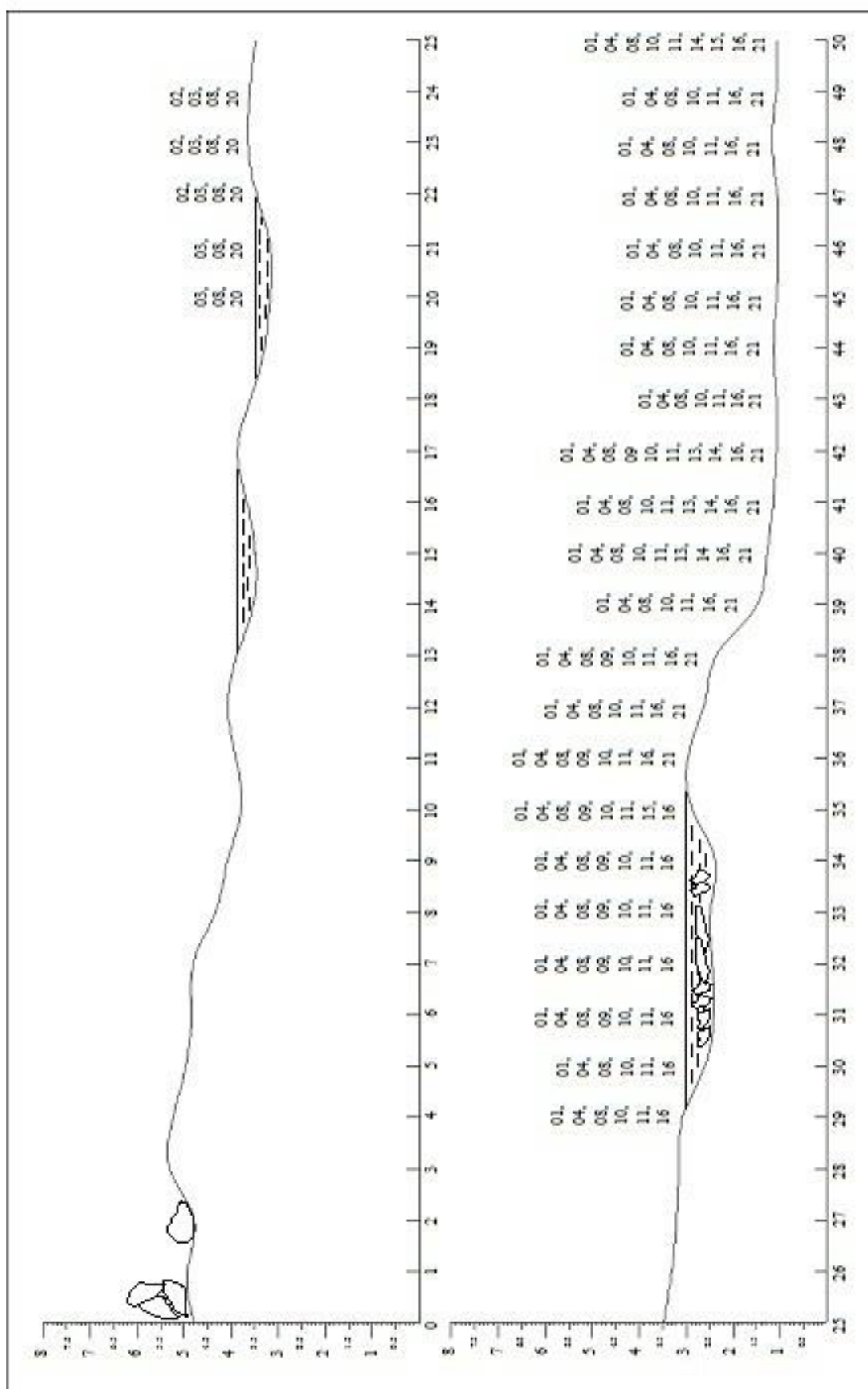


Figure No. 2 Profile of the Shore of Hedavi indicating meter wise distribution of algal species – Month: December 2009

Figure No. A.c.6: Vertical Distribution of Algae at Site – 1: December 2009

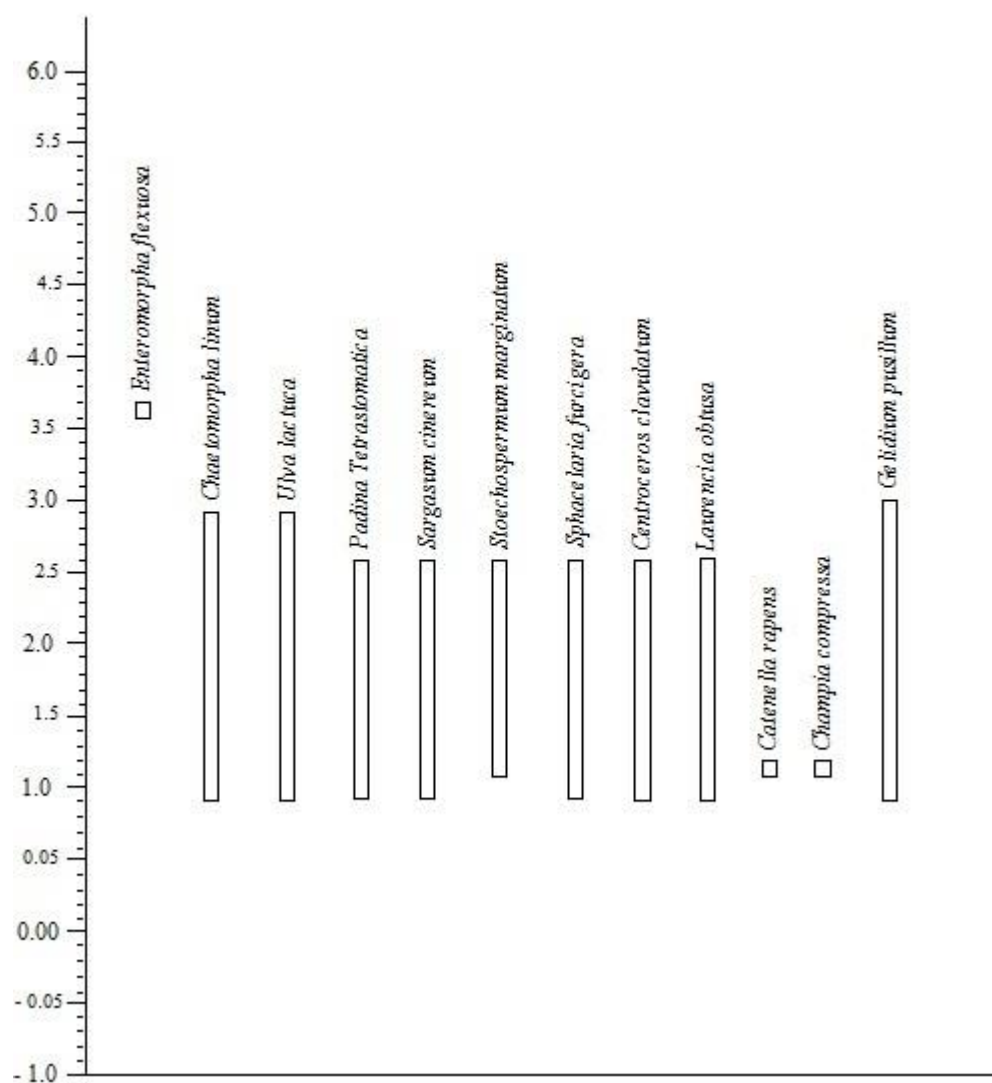
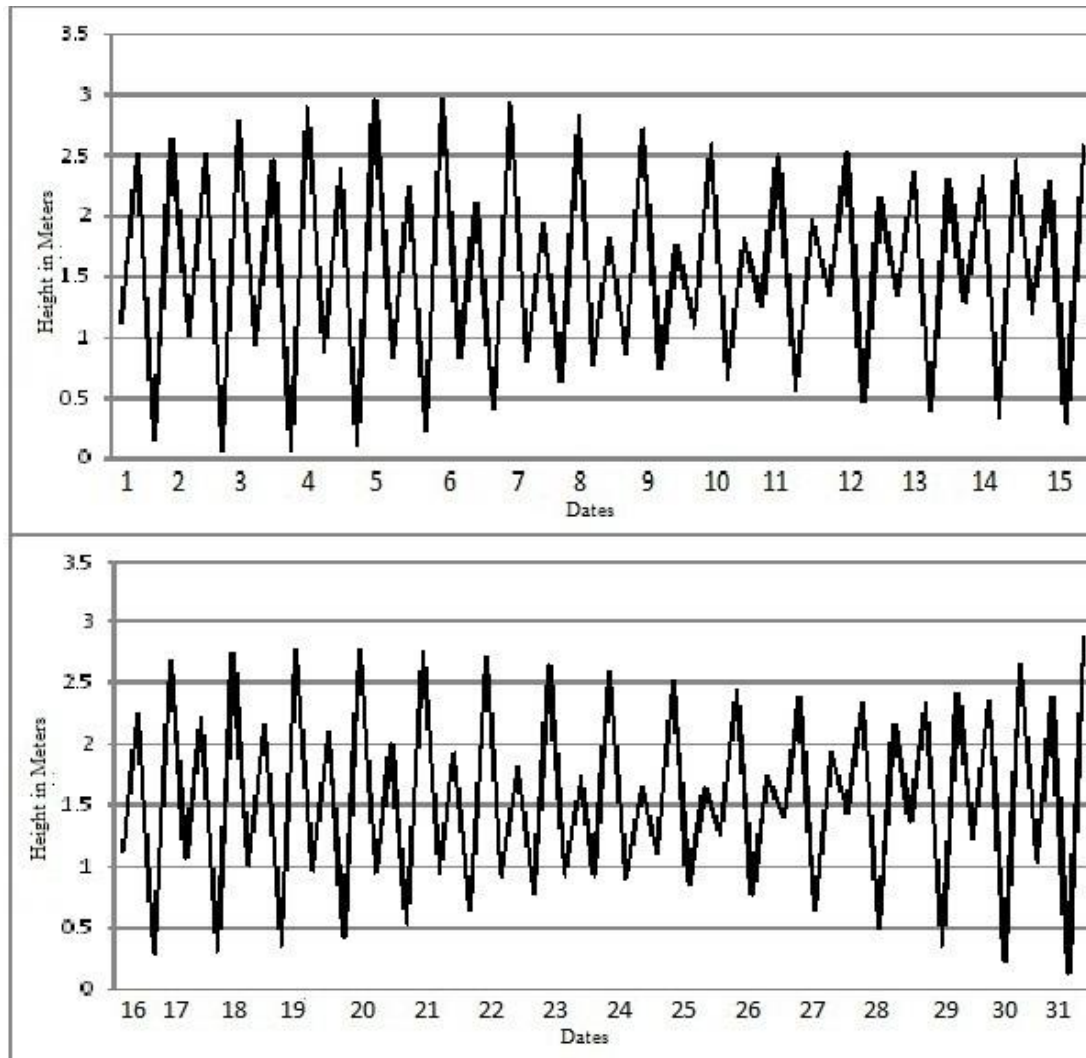


Fig . No. 22. Marigram at Site - 1: December 2009.



Site – I (Hedavi)

Date of Observation: 2nd January 2010.

	Time	Height
Tide: Low Tide:	06:10 hrs.	0.74 m.
	17:45 hrs.	0.12 m.
High Tide:	11:40 hrs.	2.35 m.

Up to 19 meters, no algal species were seen during this month's reading. The rock pool between 20 and 22 meters showed the presence of algae like, *Enteromorpha flexuosa*, *Jania rubens*, *Spongomorpha indica*, and *Cladophora fascicularis*.

No algal growth was found between 23rd and 24th meters. In 25th and 26th meters *Sphacelaria furcigera*, *Chaetomorpha linum* were present with moderate density. A dense population of *Gelidium pusillum* was present from 25 to 50 meters. *Ulva lactuca* was recorded from 27 to 36 meters.

Between 31 and 34 meters, *Sargassum cinereum*, *Spatoglossum asperum*, *Stoechospermum marginatum*, *Gracilaria corticata*, *Padina tetrastromatica* were present with dense population.

Between 35 and 38 meters only *Gelidium pusillum* was present. *Dictyota dichotoma*, *Gracilaria corticata*, *Padina Tetrastromatica*, *Sargassum cinereum*, and *Spatoglossum asperum* are present from 39 to 50 meters with abundance.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 3.3 to 3.5 meters.
2. *Sargassum cinereum* : 0.9 to 1.4 meters.
3. *Spatoglossum asperum* : 0.9 to 1.4 meters.
4. *Stoechospermum marginatum* : 0.9 to 1.4 meters.
5. *Sphacelaria furcigera* : 3.3 to 3.5 meters.

- | | |
|----------------------------------|----------------------|
| 6. <i>Padina tetrastromatica</i> | : 0.9 to 1.4 meters. |
| 7. <i>Dictyota dichotoma</i> | : 0.9 to 1.4 meters. |
| 8. <i>Gracilaria corticata</i> | : 0.9 to 1.4 meters. |
| 9. <i>Gelidium pusillum</i> | : 0.9 to 3.5 meters. |

Site – I (Hedavi)

Date of Observation: 3rd February 2010.

	Time	Height
Tide: Low Tide:	08:00 hrs.	0.38 m.
	19:35 hrs.	0.59 m.
High Tide:	01:20 hrs.	3.07 m.
	13:50 hrs.	2.29 m.

In this month of winter season, author was able to note the observation up to 50 meters. In this month, along the line up to 22 meters no algal growth was found. From 23 to 28 meters, *Cladophora fascicularis* and *Ulva lactuca* were found growing with moderate density. *Gelidium pusillum* was found growing along the line from 36 meters to 50 meters.

Ulva lactuca was again found growing from 39 to 43 meters. *Padina tetrastromatica*, *Stoechospermum marginatum*, *Sargassum cinereum*, and *Spatoglossum asperum* were found growing luxuriantly from 39 to 50 meters. *Champia compressa* was observed at 49th and 50th meter.

Vertical distribution of some major algae was as follows, (except in tide pools)

- | | |
|-----------------------------------|----------------------|
| 1. <i>Cladophora fascicularis</i> | : 3.1 to 3.7 meters. |
| 2. <i>Ulva lactuca</i> | : 1.1 to 3.7 meters. |
| 3. <i>Padina tetrastromatica</i> | : 0.9 to 1.4 meters. |

4. *Stoechospermum marginatum* : 0.9 to 1.4 meters.
5. *Sargassum cinereum* : 0.9 to 1.4 meters.
6. *Spatoglossum asperum* : 0.9 to 1.4 meters.
7. *Champia compressa* : 1.1 meter.
8. *Gelidium pusillum* : 0.9 to 2.9 meters.

Site – I (Hedavi)

Date of Observation: 3rd March 2010.

	Time	Height
Tide: Low Tide:	06:35 hrs.	0.19 m.
	18:40 hrs.	0.51 m.
High Tide:	00:20 hrs.	3.07 m.
	12:50 hrs.	2.56 m.

For this month algal growth was found between 22 and 28 meters and algal species like, *Cladophora fascicularis*, *Ulva lactuca* were found growing.

Gracilaria corticata was found growing from 47 to 50 meters. *Spatoglossum asperum* was found on the slop between 36 and 38 meters. *Padina tetrastrumatica*, *Sargassum cinereum*, and *Stoechospermum marginatum* were found growing from 42 to 50 meters.

Gelidium pusillum was found growing from 36 to 50 meters. *Ulva lactuca* a green alga was found growing from 39 to 44 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Cladophora fascicularis* : 3.1 to 3.7 meters.
2. *Ulva lactuca* : 1.1 to 3.7 meters.
3. *Spatoglossum asperum* : 2.3 to 2.9 meters.
4. *Padina tetrastrumatica* : 0.9 to 1.2 meters.

5. *Sargassum cinereum* : 0.9 to 1.2 meters.
6. *Stoechospermum marginatum* : 0.9 to 1.2 meters.
7. *Gracilaria corticata* : 1.1 to 1.2 meters.
8. *Gelidium pusillum* : 0.9 to 2.9 meters.

Site – I (Hedavi)

Date of Observation: 1st April 2010.

	Time	Height
Tide: Low Tide:	06:20 hrs.	0.12 m.
	18:20 hrs.	0.70 m.
High Tide:	12:30 hrs.	2.68 m.

During the summer season the algae appeared to be shifted to the intertidal zone. The line transact showed occurrence of macroalgae from 23rd meter, and up to this meter no algal growth was found.

Enteromorpha flexuosa, *Jania rubens*, *Padina tetrastrumatica* and *Ulva lactuca* were found from 19 to 22 meters. *Gelidium pusillum* was observed from 32 and 50 meters. The line from 29 to 32 meters was devoid of algal growth. *Ulva lactuca*, *Padina tetrastrumatica*, *Dictyota dichotoma*, *Gracilaria corticata* and *Sargassum cinereum* were present from 37 to 50 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Ulva lactuca* : 0.9 to 3.7 meters.
2. *Dictyota dichotoma* : 0.9 to 2.6 meters.
3. *Padina tetrastrumatica* : 0.9 to 2.6 meters.
4. *Sargassum cinereum* : 0.9 to 2.6 meters.
5. *Gracilaria corticata* : 0.9 to 2.6 meters.

6. *Gelidium pusillum* : 0.9 to 2.9 meters.

Site – I (Hedavi)

Date of Observation: 17th May 2010.

	Time	Height
Tide: Low Tide:	06:40 hrs.	0.27 m.
	19:35 hrs.	0.96 m.
High Tide:	00:10 hrs.	2.31 m.
	13:20 hrs.	2.77 m.

The reading was taken on a very sunny day of the month. The line transact up to 21 meters lack algal growth. *Cladophora fascicularis*, *Enteromorpha flexuosa*, and *Jania rubens* were observed in the rock pool with a lush growth from 18 to 22 meters.

The line between 23 and 30 meters did not show presence of any algal species. *Gelidium pusillum* was grown from 31 to 34 meters and again from 37 meters to 50 meters. *Chaetomorpha linum* was observed growing luxuriantly from 37 to 46 meters. *Ulva lactuca*, *Padina tetrastrumatica*, *Stoechospermum marginatum*, and *Sargassum cinereum* were found growing from 43 to 50 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.9 to 2.6 meters.
2. *Ulva lactuca* : 0.9 to 1.2 meters.
3. *Padina tetrastrumatica* : 0.9 to 1.2 meters.
4. *Stoechospermum marginatum* : 0.9 to 1.2 meters.
5. *Sargassum cinereum* : 0.9 to 1.2 meters.
6. *Gelidium pusillum* : 0.9 to 2.9 meters.

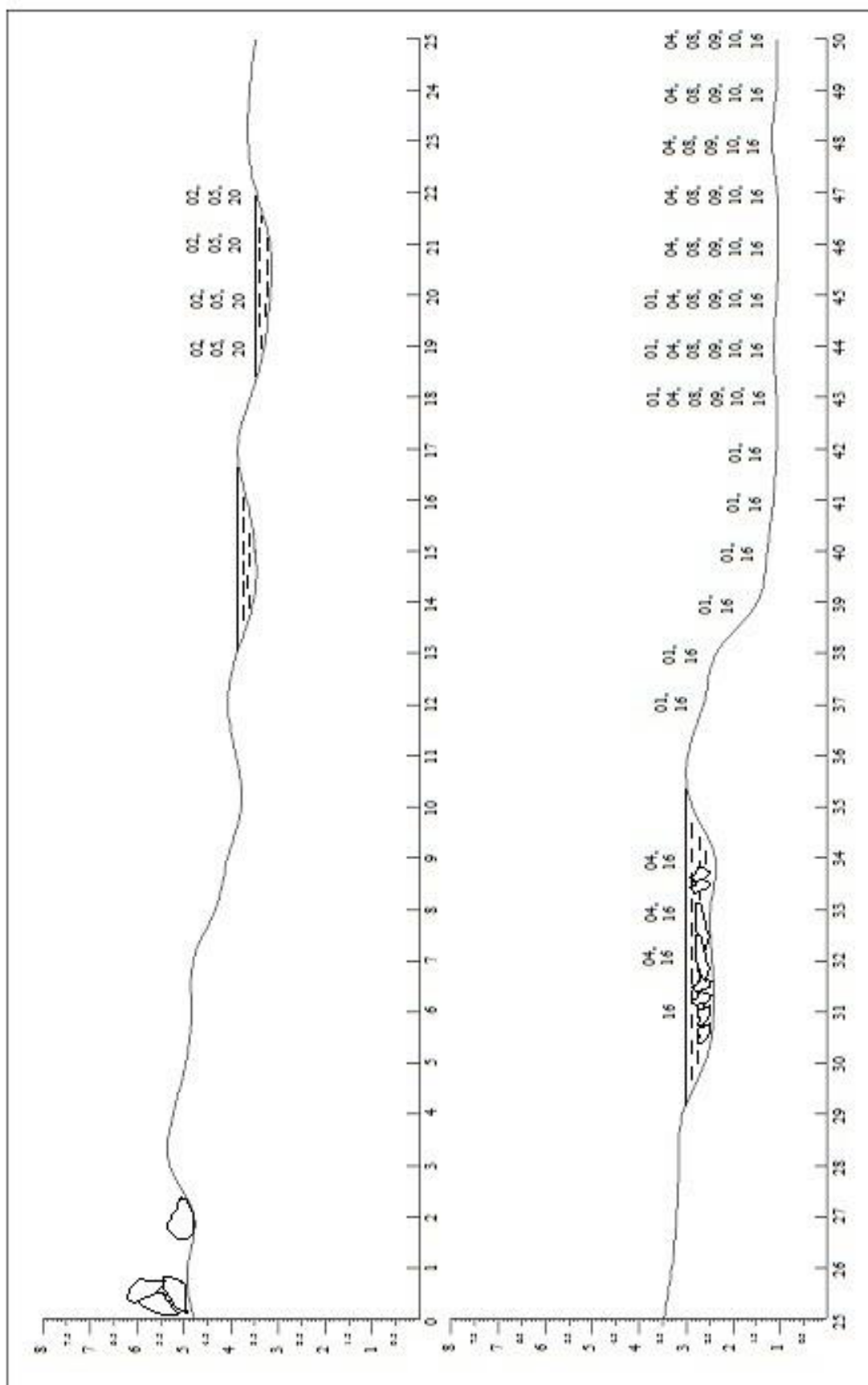


Figure No. 3: Profile of the Shore of Hedavi indicating meter wise distribution of algal species – Month: May 2010

Figure No. A.c.11: Vertical Distribution of Algae at Site – 1: May 2010

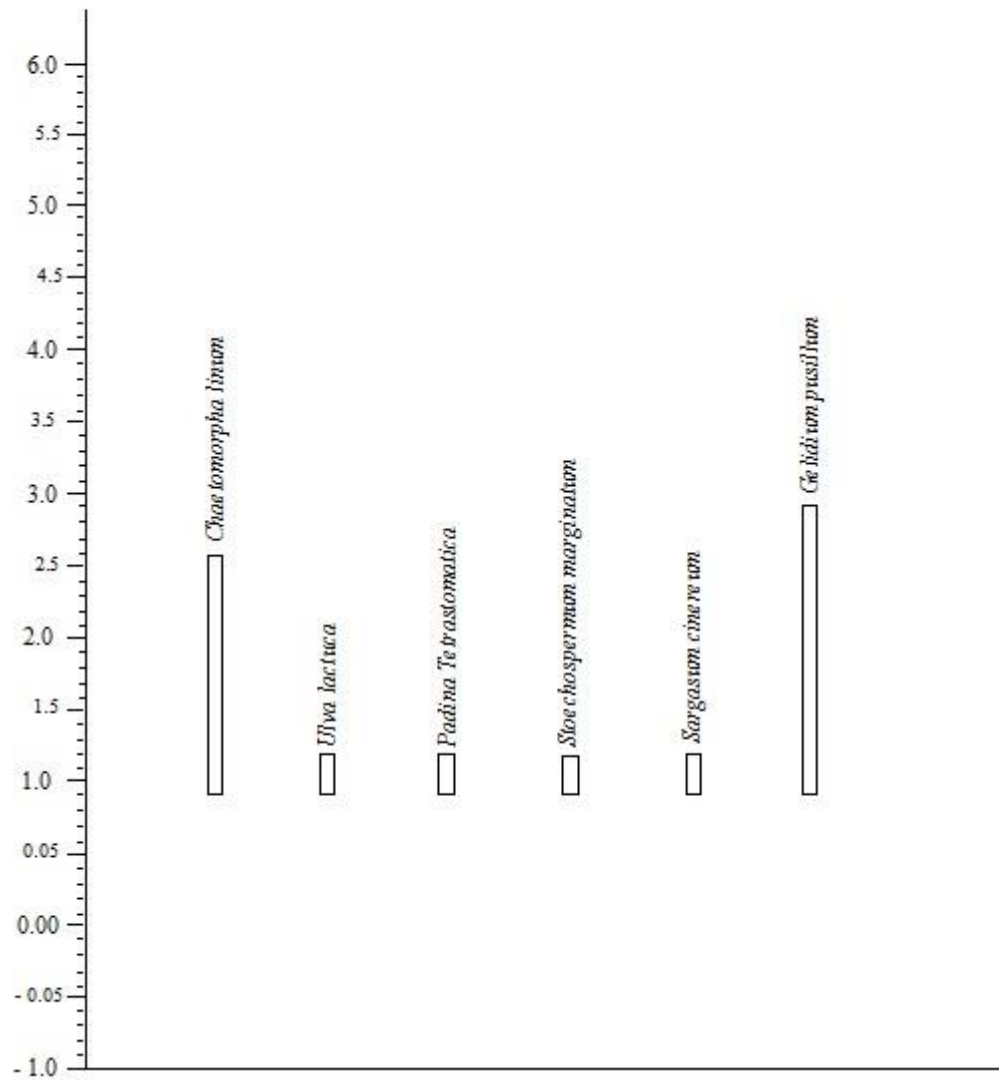
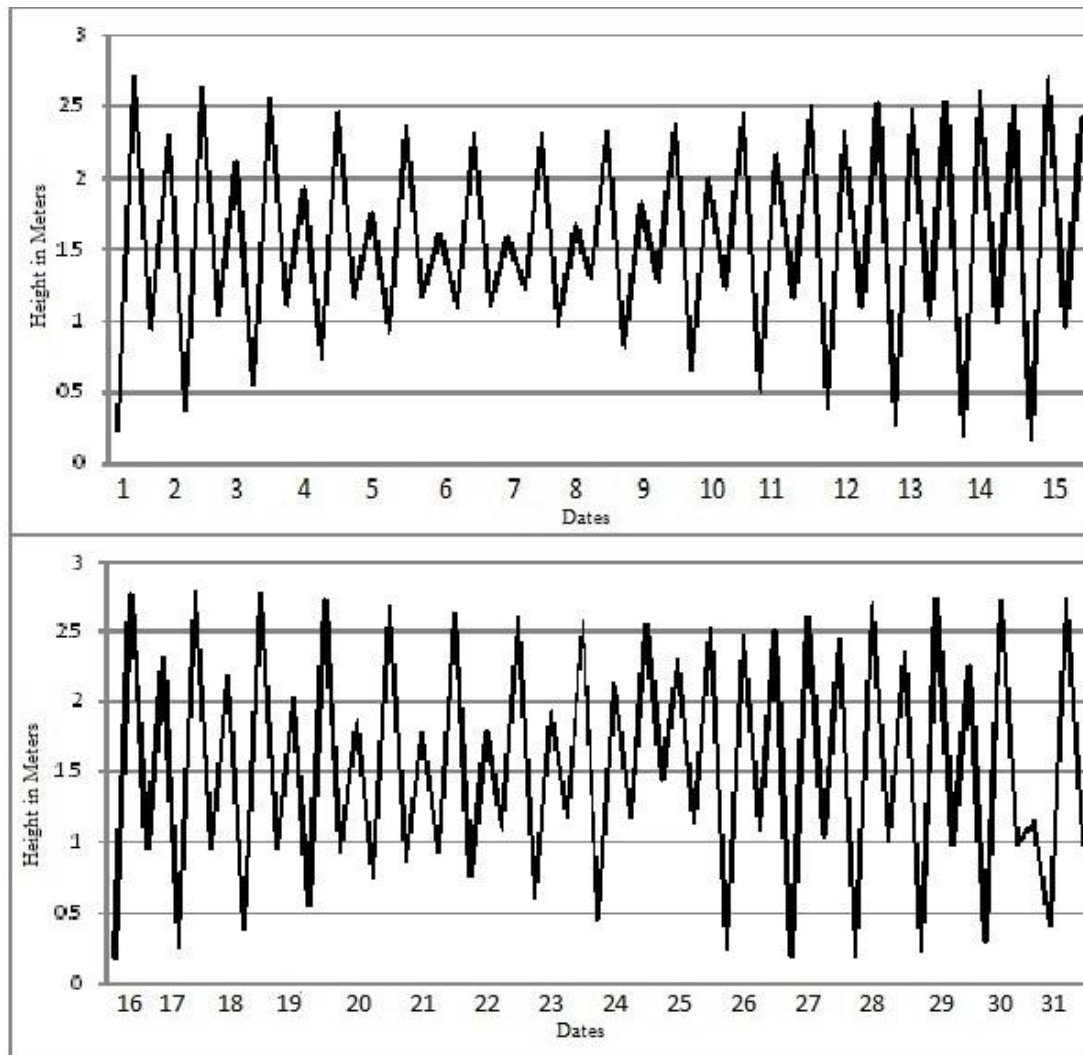


Fig No. 23. Marigram at Site - 1: May 2010.



Site – I (Hedavi)

Date of Observation: 15th June 2010.

	Time	Height
Tide: Low Tide:	06:20 hrs.	0.24 m.
	19:30 hrs.	0.79 m.
High Tide:	00:10 hrs.	2.26 m.
	13:00 hrs.	2.96 m.

As soon as the rainy season started, inconsistencies in distribution of algal species were observed. The author could take reading up to 50 meters along the line transect. The line transect up to 21 meters does not show growth of algal species. In the rock pool from 18 to 22 meters *Jania rubens* and *Enteromorpha flexuosa* were observed, whereas *Cladophora fascicularis* was present in 25th meter. 26 to 30 meters of line does not show any algal species.

Gelidium pusillum was growing from 31 to 34 meters and, from 37 to 50 meters. *Chaetomorpha linum* was observed from 31 to 34 meters and, from 37 to 50 meters. *Gracilaria corticata* was present from 31 to 34 meters. *Ulva lactuca* was observed from 42 to 50 meters. *Champia compressa* was occurring from 48 to 50 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.9 to 2.9 meters.
2. *Ulva lactuca* : 0.9 to 1.2 meters.
3. *Cladophora fascicularis* : 3.5 meter.
4. *Champia compressa* : 1.1 to 1.2 meters.
5. *Gelidium pusillum* : 0.9 to 2.6 meters.

Site – I (Hedavi)

Date of Observation: 14th July 2010.

	Time	Height
Tide: Low Tide:	06:10 hrs.	0.23 m.
	19:20 hrs.	0.55 m.
High Tide:	12:40 hrs.	3.10 m.

Due to strong winds and heavy rains, author was able to take reading upto 47 meters only. In the rainy season algal growth was scanty because of the heavy raining and strong winds.

Porphyra vietnamensis started growing on the edges of the rocks along the line from 15 to 19 meters. In the rock pool from 19 to 22 meters *Jania rubens* was observed growing densely. *Gelidium pusillum* was observed from 30 to 34 meters and from 37 meters to 47 meters. *Chaetomorpha linum* was growing in 34th meter and also in 37th and 38th meter.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 2.3 to 2.6 meters.
2. *Porphyra vietnamensis* : 3.6 to 3.9 meters.
3. *Gelidium pusillum* : 0.9 to 2.6 meters.

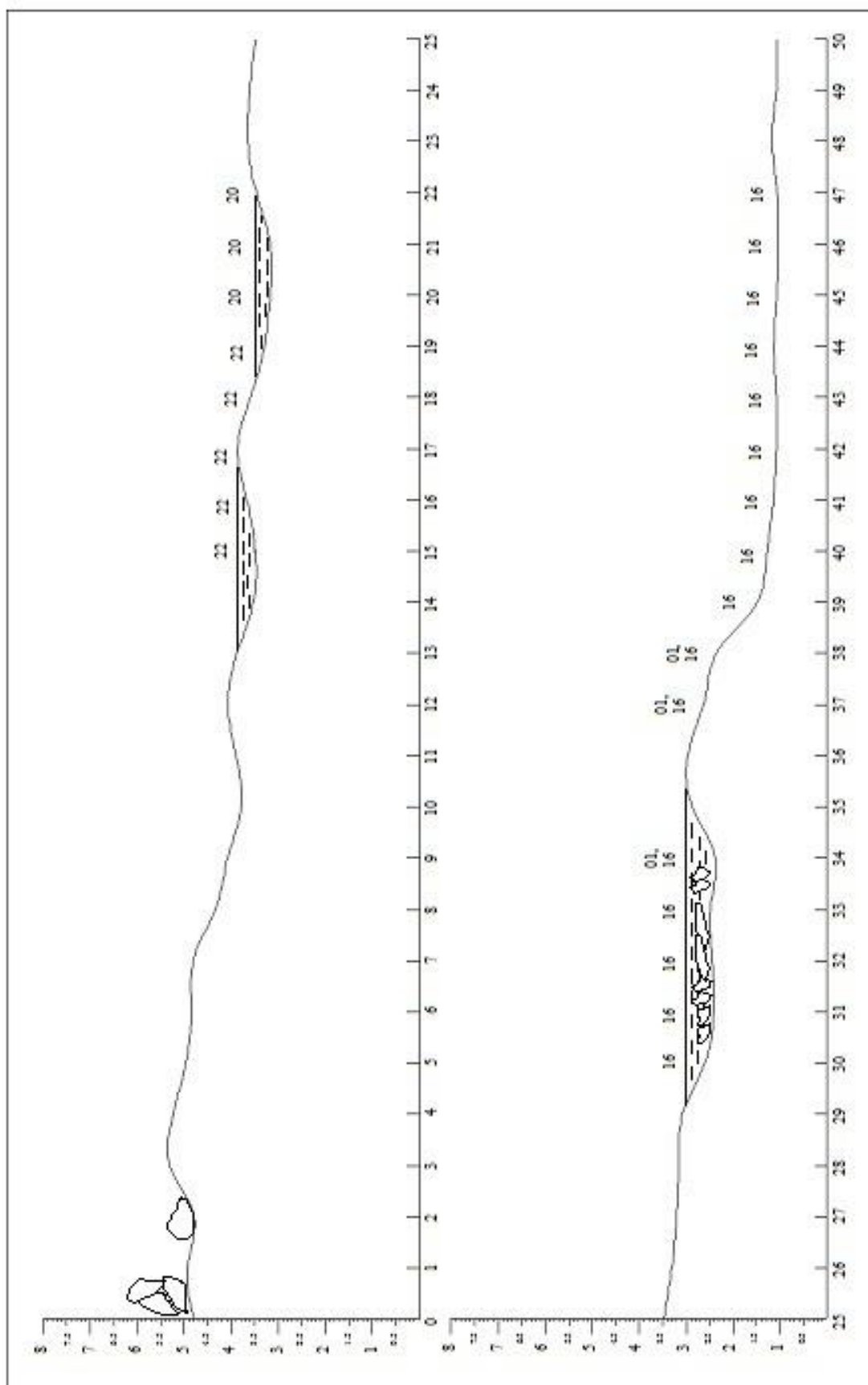


Figure No. 4 : Profile of the Shore of Hedavi indicating meter wise distribution of algal species – Month: July 2010

Figure No. A.c.13: Vertical Distribution of Algae at Site – 1: July 2010

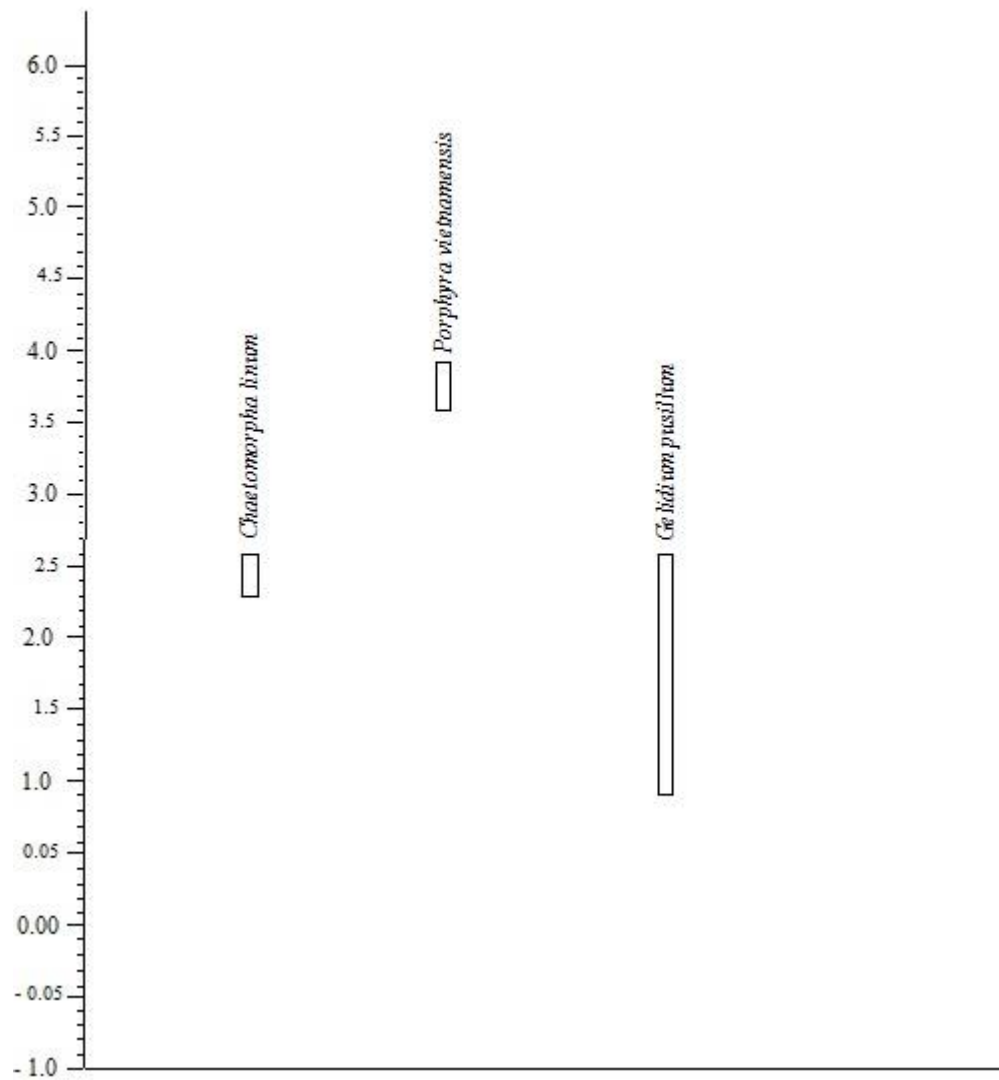
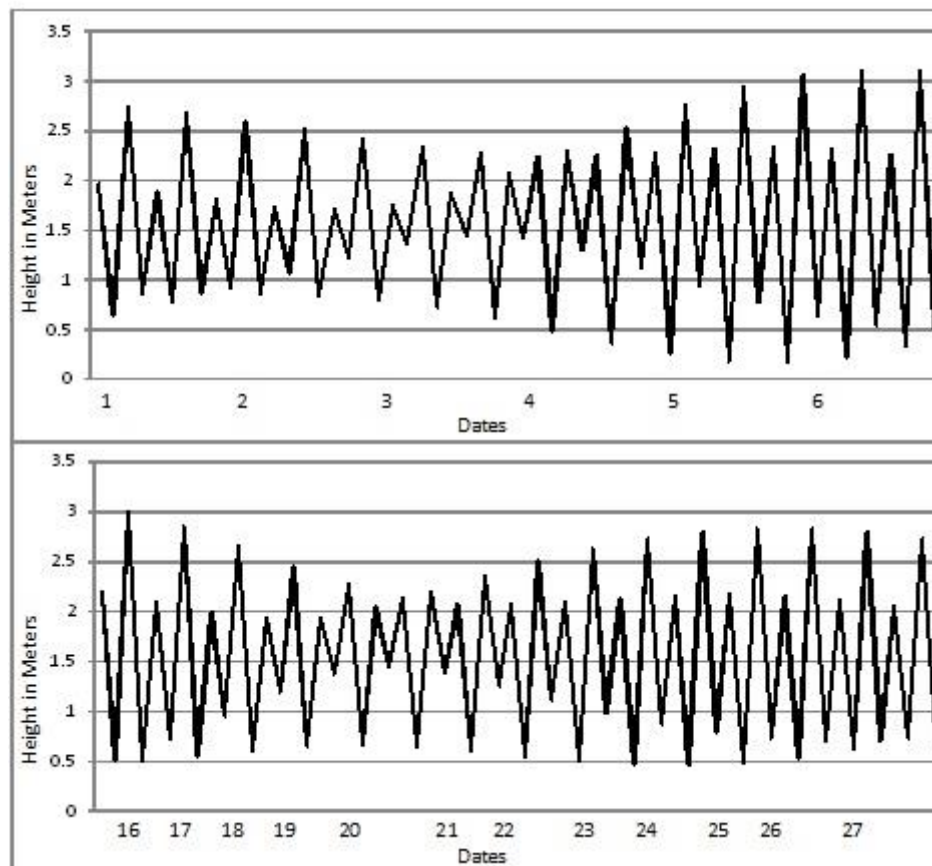


Fig . No. 24. Marigram at Site - 1: July 2010.



Site – I (Hedavi)

Date of Observation: 13th August 2010.

	Time	Height
Tide: Low Tide:	06:40 hrs.	0.38 m.
	19:25 hrs.	0.32 m.
High Tide:	00:40 hrs.	2.45 m.
	13:00 hrs.	3.09 m.

Since it was raining heavily during this visit, author could take reading up to 46 meters. *Enteromorpha flexuosa* was observed with its initial stage of growth from 1 to 2 meters. No algal species was found between 3 to 5 meters along the line. *Porphyra vietnamensis* was found growing luxuriantly and densely from 6 to 39 meters.

Gracilaria corticata was found growing between 35 and 37 meters. *Gelidium pusillum* was observed growing from 40 to 46 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 4.8 to 5.0 meters.
2. *Gracilaria corticata* : 2.6 to 2.9 meters.
3. *Porphyra vietnamensis* : 1.4 to 4.8 meters.
4. *Gelidium pusillum* : 0.9 to 1.2 meters.

Site – I (Hedavi)

Date of Observation: 10th September 2010.

	Time	Height
Tide: Low Tide:	05:30 hrs.	0.40 m.
	18:20 hrs.	0.14 m.

High Tide: 11:50 hrs. 3.07 m.

In this month, the line showed quite variation in occurrence of algal species. It was raining moderately on the seashore, thus author was in a position to take reading up to 46 meters.

Enteromorpha flexuosa was observed from 1 to 3 meter along line transact. *Porphyra vietnamensis* was growing profusely and very densely from 6 to 36 meters. *Chaetomorpha linum* was abundant in 35th, 36th, 38th and 39th meters. *Gelidium pusillum* was found growing from 36 to 43 meters and in 45th and 46th meters. *Sphacelaria furcigera* was observed from 35 to 37 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 4.8 to 5.4 meters.
2. *Chaetomorpha linum* : 1.4 to 2.9 meters.
3. *Sphacelaria furcigera* : 2.6 to 2.9 meters.
4. *Porphyra vietnamensis* : 2.9 to 4.8 meters.
5. *Gelidium pusillum* : 0.9 to 2.9 meters.

Site – I (Hedavi)

Date of Observation: 8th October 2010.

	Time	Height
Tide: Low Tide:	04:30 hrs.	0.59 m.
	17:10 hrs.	0.05 m.
High Tide:	10:40 hrs.	2.93 m.
	23:30 hrs.	2.73 m.

With the start of the winter season, variation in species of algae was found during this visit to the site. Also due to optimum climatic condition author was able to take reading up to 50 meters.

Enteromorpha flexuosa was found growing in 2nd and 3rd meters. *Porphyra vietnamensis* was completely disappeared from the shore. Line from 4 to 16 does not show any algal growth. *Cladophora fascicularis* and *Spongomorpha indica* were found with high density in 17th meter and from 19 to 21 meters. *Jania rubens* was observed from 19 to 21 meters.

The line between 22 to 29 meters lacks any algal growth. *Gelidium pusillum* was present from 30 to 50 meters. *Chaetomorpha linum* was occurred from 31 to 38 meters with dense population. *Stoechospermum marginatum* was found with initial stage of growth from 31 to 34 meters and from 39 to 50 meters. *Sphacelaria furcigera* found growing in patches in 36th and 37th meters.

Grateloupia filicina was observed at 39th meter along the line. *Dictyota divaricata* was noted with moderate density in 39th, 40th and 46th meters. *Catenella rapens* was found growing profusely from 41 to 44 meters. *Champia compressa* was observed in 49th and 50th meter. *Sargassum cinereum* was occurred from 48 to 50 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 4.8 to 5.4 meters.
2. *Chaetomorpha linum* : 2.3 to 2.9 meters.
3. *Cladophora fascicularis* : 3.9 meter.
4. *Spongomorpha indica* : 3.9 meter.
5. *Stoechospermum marginatum* : 0.9 to 1.4 meters.
6. *Sphacelaria furcigera* : 2.6 to 2.9 meters.

- | | |
|---------------------------------|----------------------|
| 7. <i>Dictyota divaricata</i> | : 0.9 to 1.4 meters. |
| 8. <i>Sargassum cinereum</i> | : 1.1 to 1.2 meters. |
| 9. <i>Catenella rapens</i> | : 1.1 to 1.2 meters. |
| 10. <i>Grateloupia filicina</i> | : 1.4 meter. |
| 11. <i>Champia compressa</i> | : 1.1 meter. |
| 12. <i>Gelidium pusillum</i> | : 0.9 to 2.9 meters. |

Site – I (Hedavi)

Date of Observation: 6th November 2010.

	Time	Height
Tide: Low Tide:	04:15 hrs.	0.83 m.
	16:40 hrs.	0.04 m.
High Tide:	10:20 hrs.	2.70 m.
	23:10 hrs.	2.77 m.

During this visit, the site had shown, rather fine level, of algal species distributed along line transact. Up to 14 meters no algal growth was found.

Enteromorpha flexuosa was found from 15 to 17 meters. *Sphacelaria furcigera* was observed from 15 to 17 and in the rock pool at 20th, 21st meters and from 30 to 32 meters. *Chaetomorpha linum* was present from 20 to 23 meters and 30 to 32 meters.

Gelidium pusillum observed from 20 to 23 meters and from 30 to 32 meters, and continued from 35 to 50 meters. *Ulva lactuca* was observed at 23rd meter. *Padina tetrastrumatica*, *Stoechospermum marginatum*, *Sargassum cinereum*, and *Spatoglossum asperum* were observed from 35 to 50 meters. *Dictyota dichotoma* was present from 38 to 42 meters.

Catenella rapens and *Champia compressa* were found growing at 49th and 50th meters along the line transact.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 3.7 meter.
2. *Ulva lactuca* : 3.7 meter.
3. *Dictyota dichotoma* : 1.1 to 2.3 meters.
4. *Sphacelaria furcigera* : 3.9 meter.
5. *Padina tetrastrumatica* : 0.9 to 2.9 meters.
6. *Stoechospermum marginatum* : 0.9 to 2.9 meters.
7. *Sargassum cinereum* : 0.9 to 2.9 meters.
8. *Spatoglossum asperum* : 0.9 to 2.9 meters.
9. *Catenella rapens* : 1.1 meter.
10. *Champia compressa* : 1.1 meter.
11. *Gelidium pusillum* : 0.9 to 3.7 meters.

Site – I (Hedavi)

Date of Observation: 6th December 2010.

	Time	Height
Tide: Low Tide:	05:00 hrs.	0.97 m.
	17:00 hrs.	0.17 m.
High Tide:	10:30 hrs.	2.38 m.
	23:40 hrs.	2.82 m.

This was the last reading taken along the line of transact at Site – I (Hedavi). The variation in distribution of algal species along the line was noted down.

The line up to 19 meters does not show any algal growth. *Jania rubens* and *Spongomorpha indica* were observed with dense population in the rock pool from 20 to 24 meters, whereas *Cladophora fascicularis* was present from 22 to 24 meters.

The area between 25 to 28 meters does not show presence of macroalgae. *Gelidium pusillum*, *Chaetomorpha linum*, *Sphacelaria furcigera* and *Ulva lactuca* were observed from 29 to 38 meters. Whereas *Gelidium pusillum* was found to grow from 38 to 50 meters. *Padina tetrastrumatica* and *Sargassum cinereum* were observed from 39 to 50 meters. *Spatoglossum asperum* was found growing from 41 to 50 meters. *Stoechospermum marginatum* was observed from 45 to 50 meters.

Centroceras clavulatum was present at 43rd and 50th meters. *Laurencia obtusa* was found growing from 46 to 49 meters. *Champia compressa* was observed at 50th meter.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 2.3 to 2.9 meters.
2. *Ulva lactuca* : 2.3 to 2.9 meters.
3. *Sphacelaria furcigera* : 2.3 to 2.9 meters.
4. *Padina tetrastrumatica* : 0.9 to 1.4 meters.
5. *Sargassum cinereum* : 0.9 to 1.4 meters.
6. *Stoechospermum marginatum* : 0.9 to 1.2 meters.
7. *Spatoglossum asperum* : 0.9 to 1.2 meters.
8. *Centroceras clavulatum* : 1.1 to 1.2 meters.
9. *Laurencia obtusa* : 0.9 to 1.2 meters.
10. *Champia compressa* : 1.1 meter.
11. *Gelidium pusillum* : 0.9 to 3.5 meters.

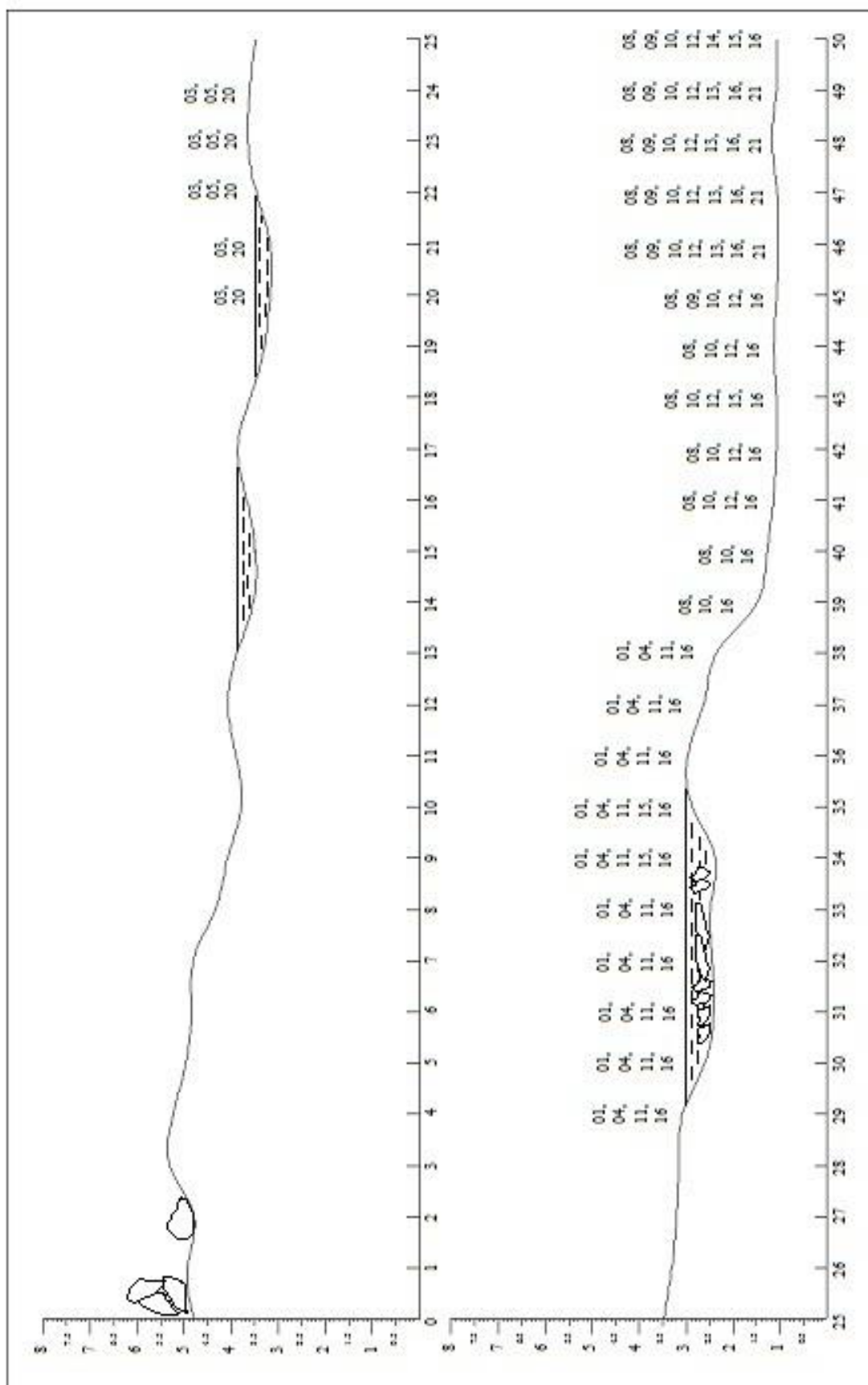


Figure No. 5: Profile of the Shore of Hedavi indicating meter wise distribution of algal species – Month: December 2010

Figure No. A.c.18: Vertical Distribution of Algae at Site – 1: December 2010

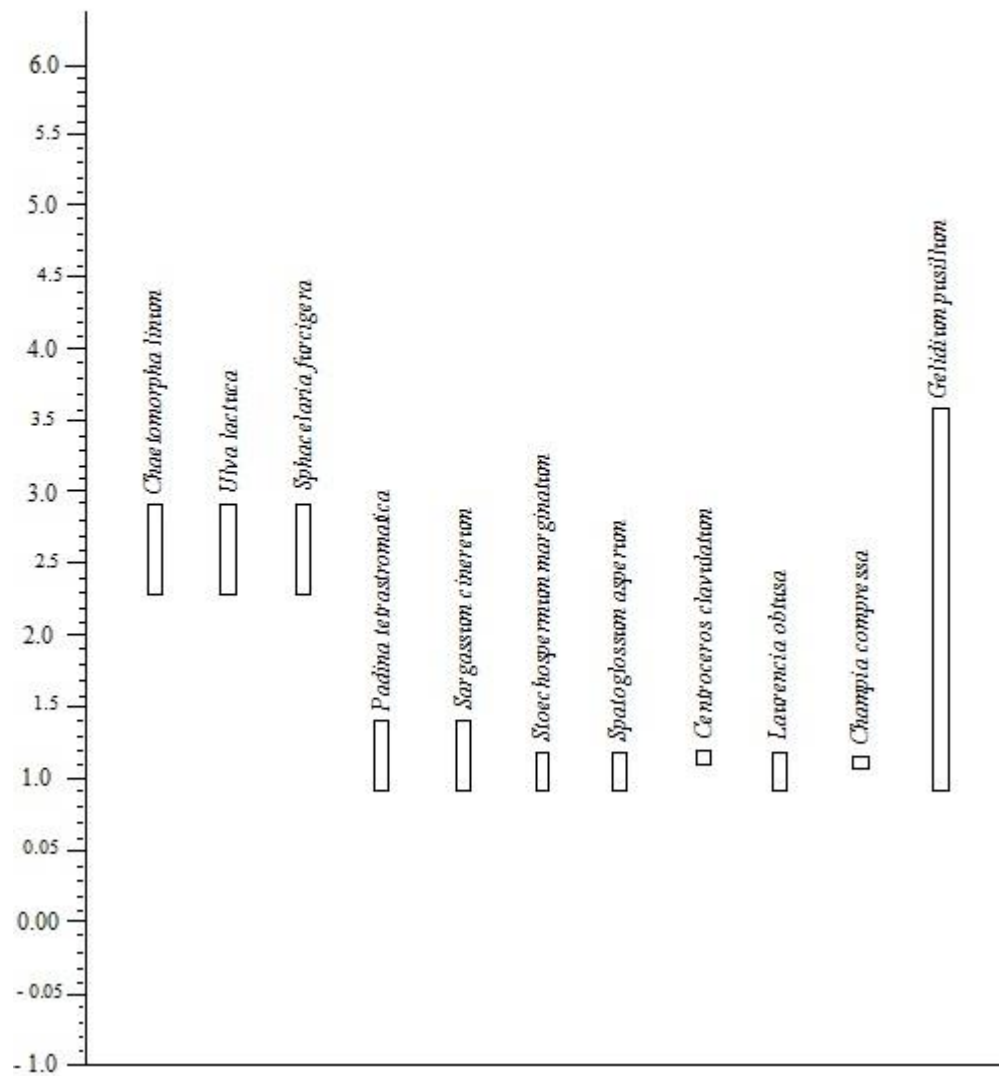
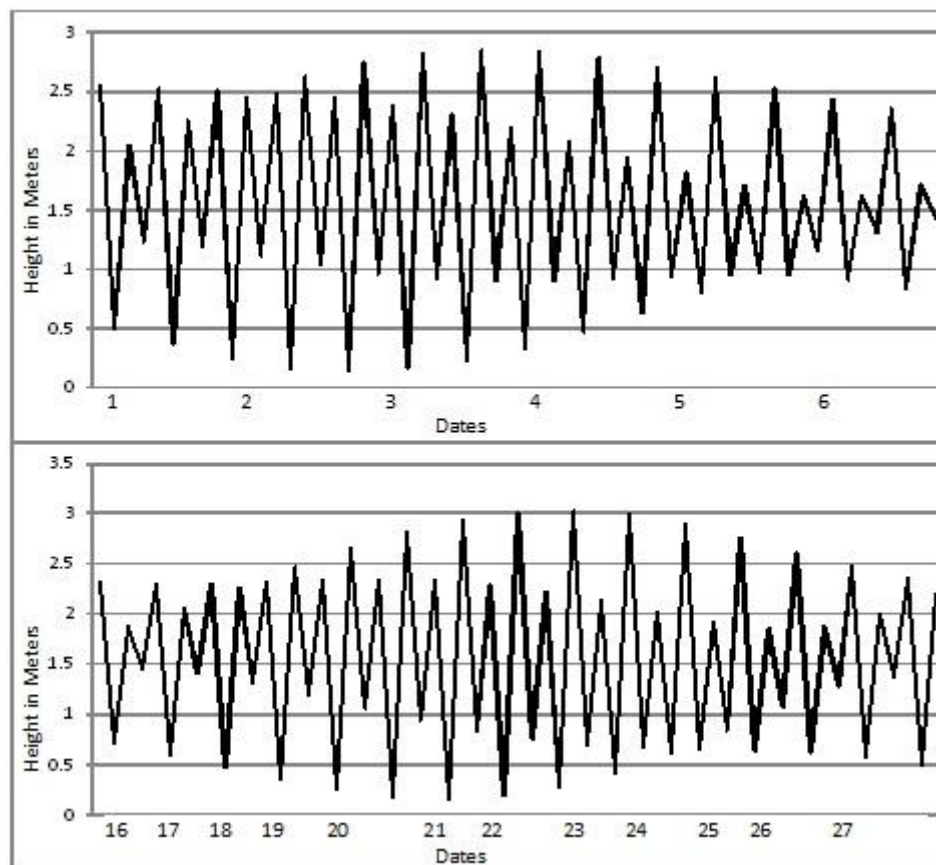


Fig. No. 25. Marigram at Site - 1: December 2010.



Site – 2 (Kolthare).

Date of Observation: 26th July 2009.

	Time	Height
Tide: Low tide:	07:40 hrs.	0.63 m.
	20:30 hrs.	0.53 m.
High tide:	01:50 hrs.	2.59 m.
	14:10 hrs.	2.94 m.

It was also the first visit to Site – II (Kolthare) for the study of distribution of marine algae along the line transact. Today due to absence of strong winds and heavy rains, author could take reading up to 50 meters along line. Up to first 35 meters no algal growth was found in this month.

Only two algal species were reported along the line transact. *Gelidium pusillum* was present between 36 and 50 meters. *Chaetomorpha linum* was found from 45 to 47 meters along with *Gelidium pusillum*.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.9 to 1.1 meters.
2. *Gelidium pusillum* : 0.9 to 2.9 meters.

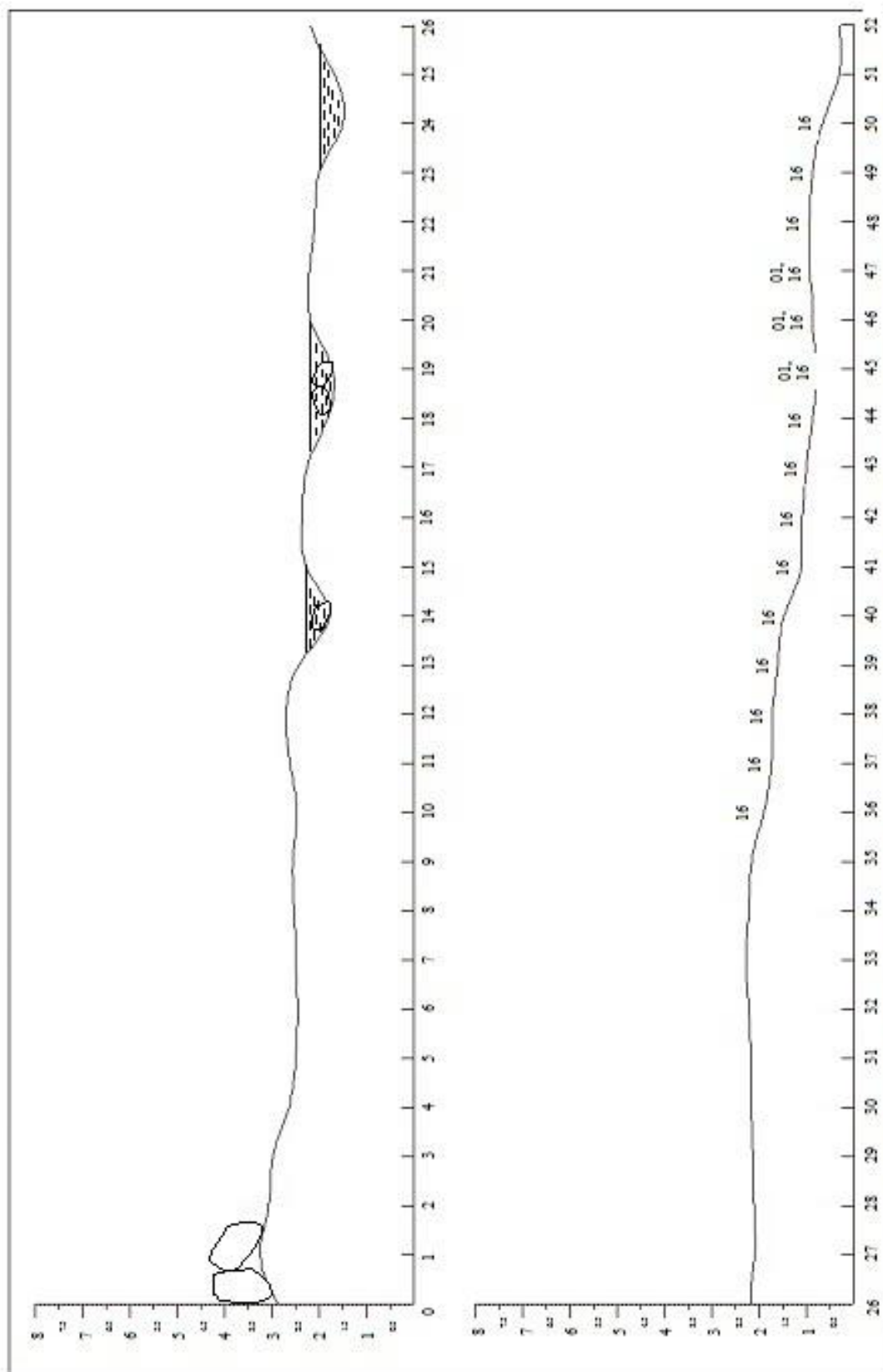


Figure No. 6 : Profile of the Shore of Kolthare indicating meter wise distribution of algal species – Month: July 2009

Figures No. A.c.19: Vertical Distribution of Algae at Site – 2: July 2009

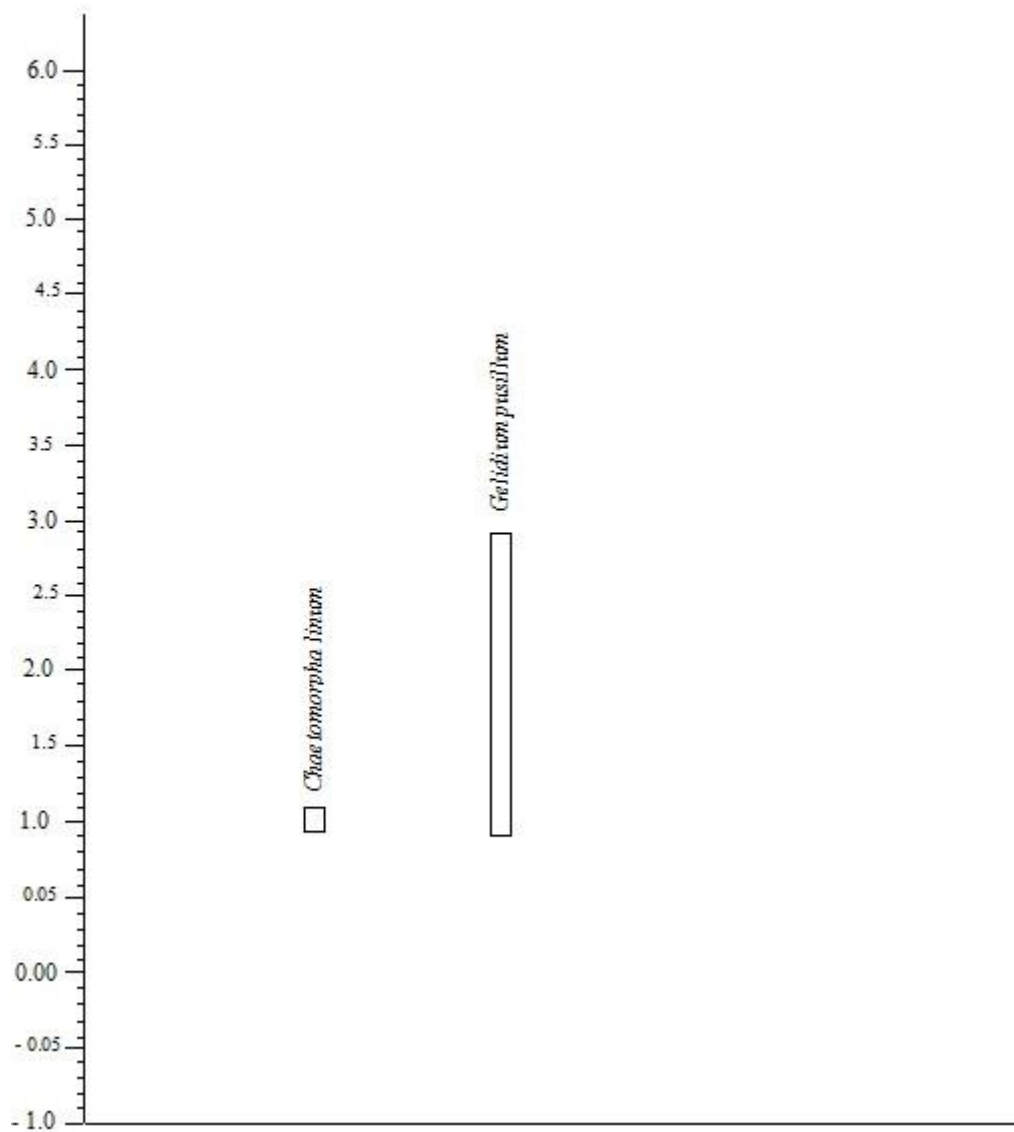
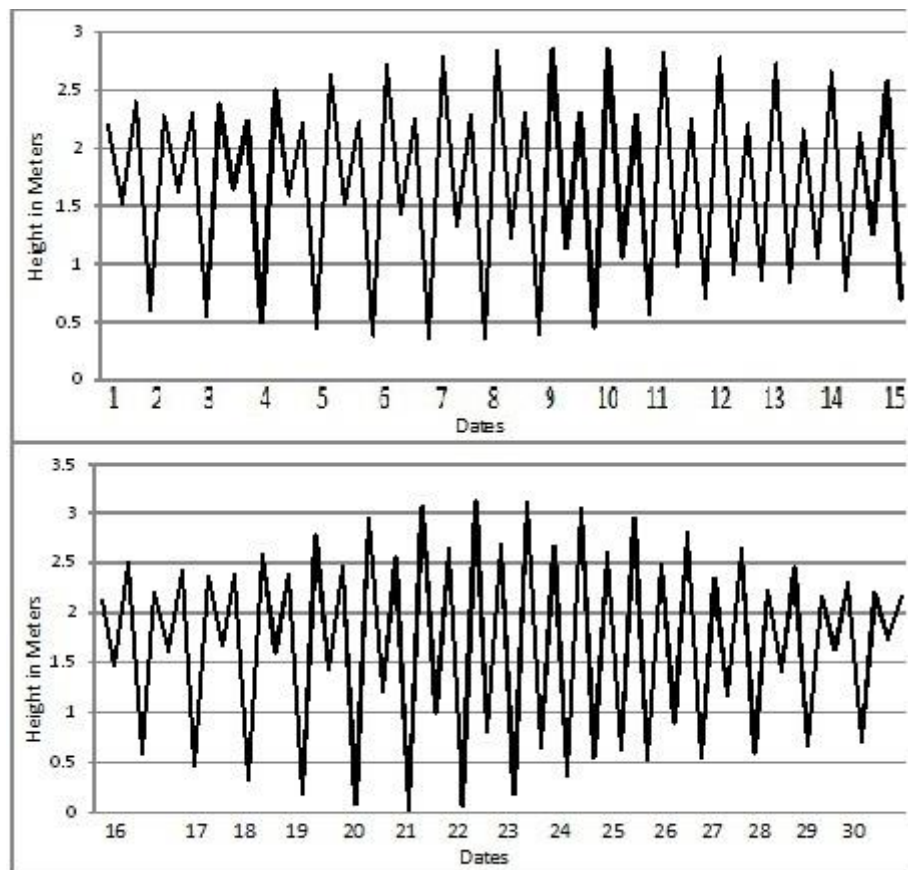


Fig. No. 26. Marigram at Site - 2: July 2009.



Site – 2 (Kolthare).

Date of Observation: 22nd August 2009.

	Time	Height
Tide: Low Tide:	06:00 hrs.	0.39 m.
	18:25 hrs.	0.39 m.
High Tide:	12:20 hrs.	3.04 m.

This was the second visit to the Site – II. It was raining heavily. *Enteromorpha flexuosa* was present in the 1st meter only. The rocky surface between 2 and 14 meters was devoid of algal growth. The area from 15 to 18 meters and from 21 to 26 meters along with the rock pool no. 2 and 3, showed dense occurrence of *Porphyra vietnamensis*.

From 27 to 33 meters no algal species was recorded. *Gelidium pusillum* was present from 34 to 47 meters. *Chaetomorpha linum* was present in patches along the line between 38 and 47 meters. At this site, tide was suitable for taking reading up to 47 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Enteromorpha flexuosa* : 3.2 meter.
2. *Chaetomorpha linum* : 0.7 to 1.6 meters.
3. *Porphyra vietnamensis* : 2.1 to 2.4 meters.
4. *Gelidium pusillum* : 0.7 to 2.2 meters.

Site – 2 (Kolthare).

Date of Observation: 7th September 2009.

	Time	Height
Tide: Low Tide:	06:15 hrs.	0.76 m.
	18:40 hrs.	0.44 m.
High Tide:	00:15 hrs.	2.65 m.
	12:20 hrs.	2.81 m.

Enteromorpha flexuosa was still present in the same area that is in 1st meter. The algal growth between 2 to 13 meters was totally absent. *Gelidium pusillum* was present between 15th and 17th meters, and also along 22nd and 24th meter on the line transect. *Gelidium pusillum* continued its growth from 35 to 52 meter. *Porphyra vietnamensis* was also seen in this month and was present between 15th and 18th meters, and 21st and 31st meters including all three rock pools.

Other red alga named *Catenella rapens* occurred in the rock pool at 24th and 25th meters, and was also recorded in 45th, 46th, 51st and 52nd meters. *Chaetomorpha linum* was present from 42 to 47 meters. The growth of this algal species was luxuriant. *Gracilaria corticata* was growing from 45 to 47 meters, and was very scanty. The beautiful brown alga like *Stoechospermum marginatum* was spotted from 46 to 52 meters with high density. Another brown alga *Sargassum cinereum* was found growing constantly beyond 46 to 52 meters. *Sphacelaria furcigera* was found from 47 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools/rock pools)

1. *Enteromorpha flexuosa* : 3.2 meter.
2. *Chaetomorpha linum* : 0.7 to 1.0 meters.

3. *Stoechospermum marginatum* : 0.3 to 0.9 meters.
4. *Sargassum cinereum* : 0.3 to 0.9 meters.
5. *Sphacelaria furcigera* : 0.3 to 0.9 meters.
6. *Catenella rapens* : 0.3 to 0.8 meters.
7. *Gracilaria corticata* : 0.7 to 0.9 meters.
8. *Porphyra vietnamensis* : 2.1 to 2.4 meters.
9. *Gelidium pusillum* : 0.3 to 2.4 meters.

Site – 2 (Kolthare)

Date of Observation: 5th October 2009.

	Time	Height
Tide: Low Tide:	05:20 hrs.	0.88 m.
	17:45 hrs.	0.25 m.
High Tide:	11:15 hrs.	2.75 m.

At this site also *Porphyra vietnamensis* was moved to the complete submerged area as rainy season ended. Up to 12 meters on the line, the growth of any algal species was not seen.

Padina tetrastromatica was lushly growing in the rock pool no. 1 from 13 to 15 meters, and also in rock pool no. 2 at 18th, 19th meters and in the rock pool no. 3 at 24th and 25th meters. The same alga showed continuous growth on the rock from 47th meters up to 52nd meters.

Gracilaria corticata was found growing in at the three rock pools at 14th, 15th, 18th, 19th, 24th, 25th meters. The same species was growing luxuriantly on the rocky surface from 45 to 52 meters. *Jania rubens* was present in the rock pool no. 1 and no. 2, at 14th and 19th meters.

Dictyota divaricata was found in the rock pool no. 3 at 23rd and 24th meters. *Sargassum cinereum* occurred in the rock pool no. 3 at 23rd and 24th meters and was also present on the rocky surface of the shore from 50 to 52 meters.

Ulva lactuca was found growing densely from 25 to 34 meters. This alga was associated with *Gelidium*. *Gelidium pusillum* was found growing with high density along the line of study. It was present in the rock pools no. 1 and no. 2, from 13th to 15th meters and also from 17th to 19th meters. The same alga occurred from 26 to 52 meters with dense growth.

Luxuriant growth of *Dictyota dichotoma* was observed from 50 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Ulva lactuca* : 2.1 to 2.3 meters.
2. *Padina tetrastrum* : 0.3 to 0.9 meters.
3. *Sargassum cinereum* : 0.3 to 0.6 meters.
4. *Gracilaria corticata* : 0.3 to 0.9 meters.
5. *Dictyota dichotoma* : 0.3 to 0.6 meters.
6. *Gelidium pusillum* : 0.3 to 2.3 meters.

Site – 2 (Kolthare)

Date of Observation : 4th November 2009.

	Time	Height
Tide: Low Tide:	05:50 hrs.	1.14 m.
	17:45 hrs.	- 0.01 m.
High Tide:	11:20 hrs.	2.65 m.

The author was able to take reading up to 47 meters due to low height of water during low tide. The line transact showed no algal growth up to 13 meters. The rock

pool no. 1 between 13 and 15 meters showed the presence of the different algae like *Gracilaria corticata*, *Jania rubens*, *Padina tetrastrumatica*, *Sargassum cinereum* and *Sphacelaria furcigera*. The same algal growth was found in the rock pool no. 2 and 3 except *Sphacelaria furcigera*. *Gelidium pusillum* was found in 20th, 21st, 23rd, and 27th meters, where it was continuously p[resent from 29 meters to 38 meters, and from 41 meters to 47 meters. It was in the form of thick cover on the boulders.

Grateloupia filicina was recorded in 33rd and 34th meters as well as in 45th and 46th meters. Thick patches *Sphacelaria furcigera* were again observed from 41 to 44 meter. *Gracilaria corticata*, *Padina tetrastrumatica* and *Sargassum cinereum* were again present 45 to 47 meters. *Laurencia obtusa* was present in 47th meter.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Padina tetrastrumatica* : 0.7 to 0.9 meters.
2. *Sargassum cinereum* : 0.7 to 0.9 meters.
3. *Sphacelaria furcigera* : 0.8 to 1.1 meters.
4. *Gracilaria corticata* : 0.7 to 0.9 meters.
5. *Grateloupia filicina* : 0.7 to 2.3 meters.
6. *Laurencia obtusa* : 0.9 meter.
7. *Gelidium pusillum* : 0.7 to 2.3 meters.

Site – 2 (Kolthare)

Date of Observation : 3rd December 2009.

	Time	Height
Tide: Low Tide:	05:30 hrs.	1.24 m.
	17:30 hrs.	- 0.08 m.
High Tide:	10:50 hrs.	2.58 m.

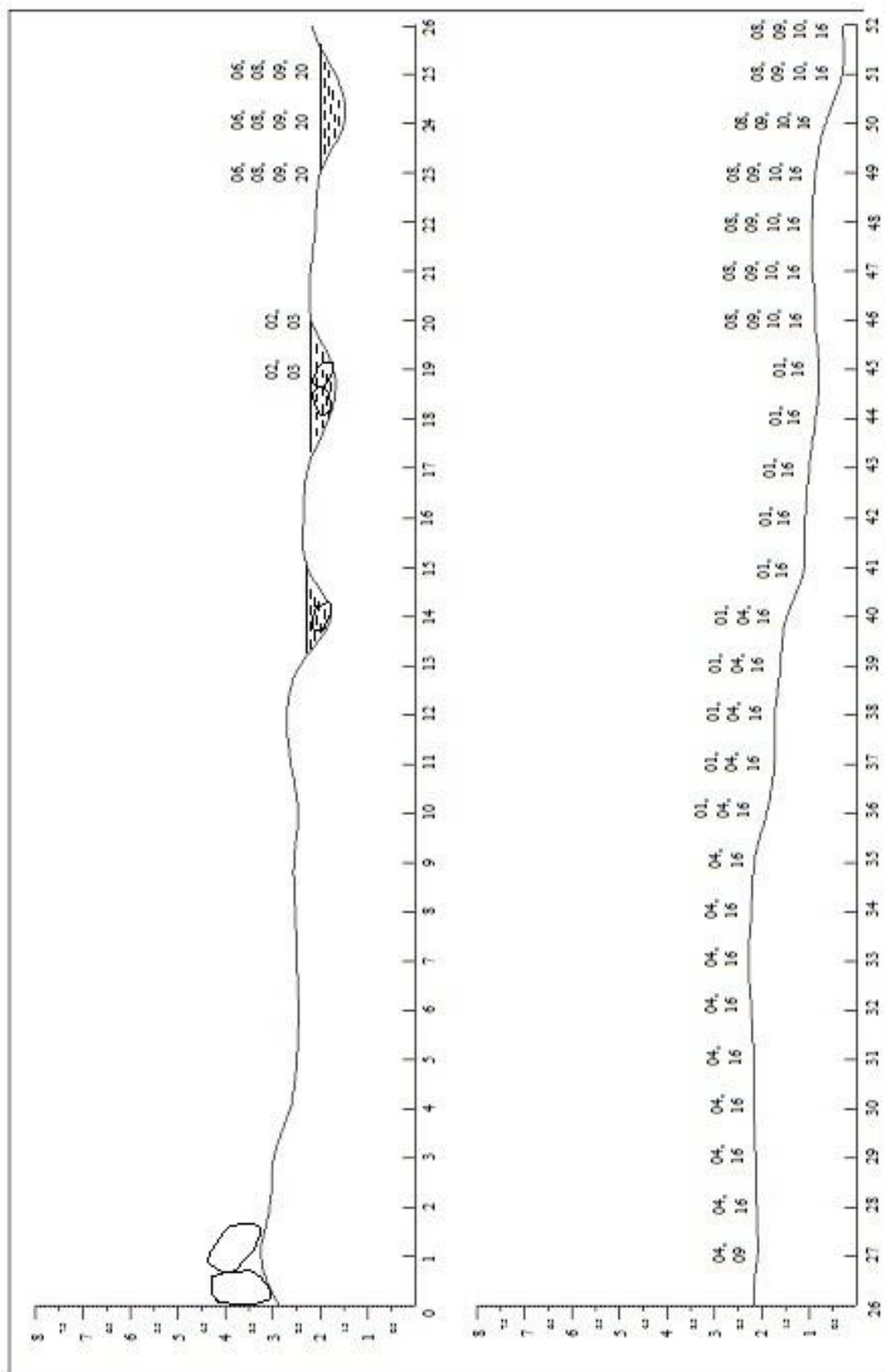
At Kolthare for this month, author had found large numbers of algal species. During the reading the water of the seawater was stable and thus author had taken a reading of algal distribution up to 52 meters.

The line transact up to 18 meters did not show growth of algae. *Spongomorpha indica* and *Enteromorpha flexuosa* were found in the rock pool no. 2 between 19th and 20th meters. In the rock pool no. 3 from 23 to 25 meters algal species found growing luxuriantly were *Dictyota divaricata*, *Jania rubens*, *Padina tetrastrumatica*, *Stoechospermum marginatum*.

Gelidium pusillum was found from 28 to 52 meters. *Ulva lactuca* was present along the line transact between 27 and 40 meters. *Chaetomorpha linum* was present from 36 to 45 meters. *Padina tetrastrumatica*, *Sargassum cinereum*, and *Stoechospermum marginatum* all brown algae were found growing luxuriantly between 46 and 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.8 to 1.8 meters.
2. *Ulva lactuca* : 1.4 to 2.3 meters.
3. *Padina tetrastrumatica* : 0.3 to 0.9 meters.
4. *Stoechospermum marginatum* : 0.3 to 0.9 meters.
5. *Sargassum cinereum* : 0.3 to 0.9 meters.
6. *Gelidium pusillum* : 0.3 to 2.3 meters.



Figures No. A.c.24: Vertical Distribution of Algae at Site – 2: December 2009

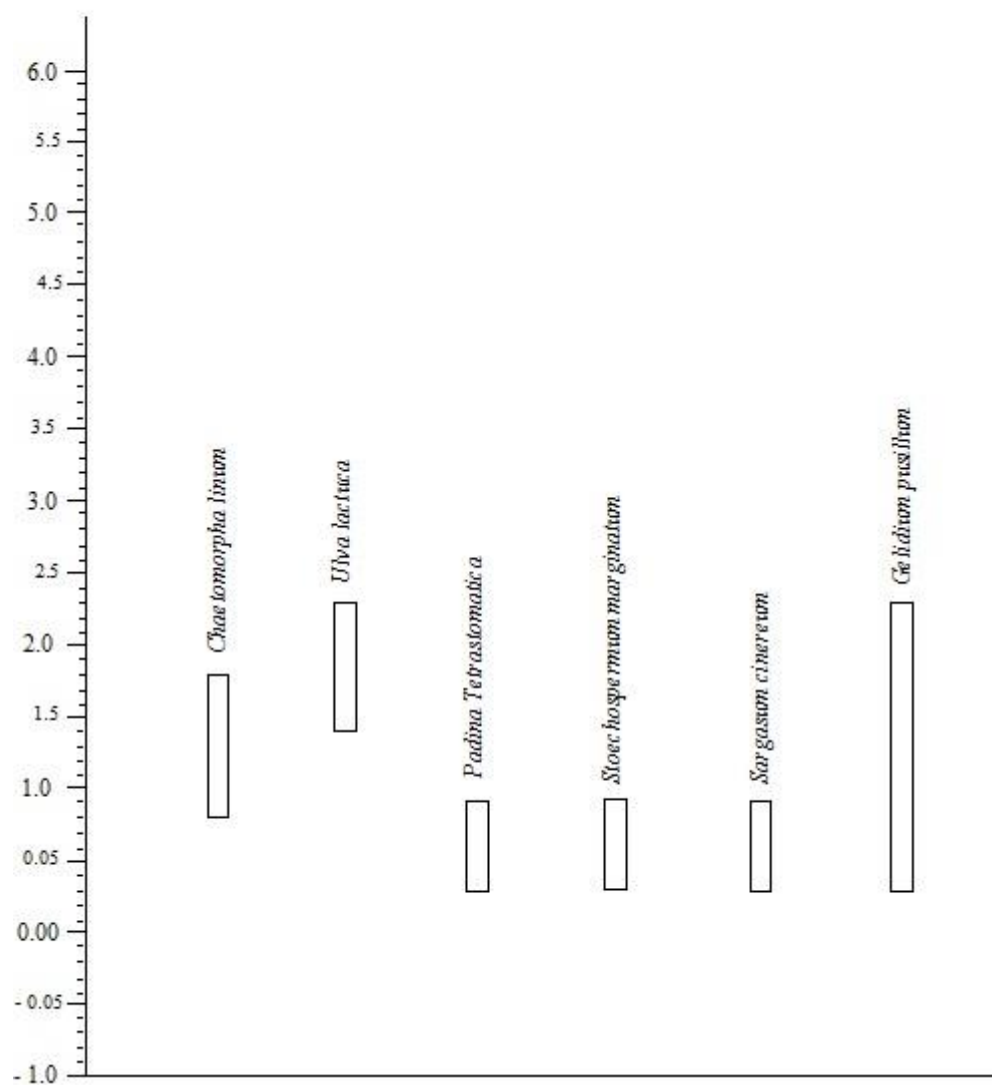
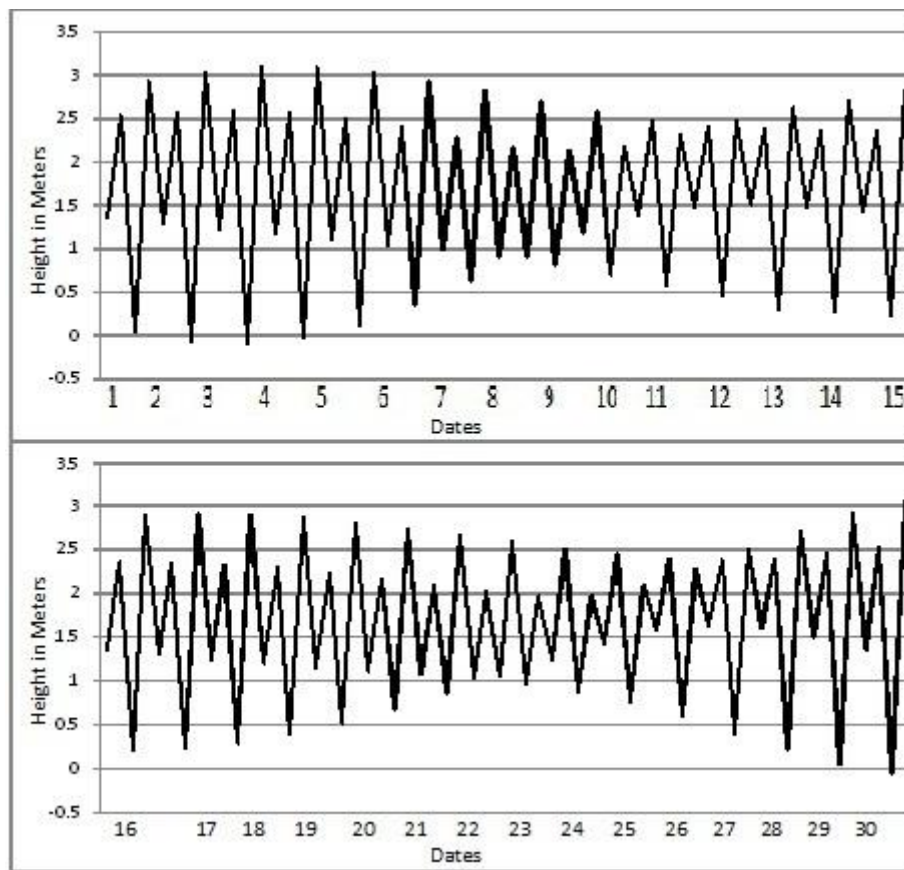


Fig. No. 27. Marigram at Site - 2: December 2009.



Site – 2 (Kolthare)

Date of Observation: 1st January 2010.

	Time	Height
Tide: Low Tide:	05:25 hrs.	1.19 m.
	17:20 hrs.	-0.06 m.
High Tide:	10:50 hrs.	2.59 m.

Along the line, transect up to 17 meters algal growth was not found. In the rock pool number 1 in between 18 and 20 meters, some algae were listed as *Cladophora fascicularis*, *Gelidium pusillum*, and *Gracilaria corticata*. *Cladophora fascicularis*, *Gelidium pusillum* were also found in 21st meter. In the rock pool no. 3 between 23 and 25 meters, *Jania rubens*, *Gracilaria corticata*, *Padina tetrastromatica* were found growing luxuriantly.

25th and 26th meters did not show presence of algae. From 27 to 38 meters onwards *Gelidium pusillum*, *Padina tetrastromatica* and *Ulva lactuca* were seen with moderate density. The line between 39 and 52 meters showed presence of algal species like, *Padina tetrastromatica*, *Gracilaria corticata*, *Sphacelaria furcigera*, *Sargassum cinereum* and showed dense population.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Ulva lactuca* : 1.6 to 2.3 meters.
2. *Cladophora fascicularis* : 2.1 meter.
3. *Padina tetrastromatica* : 0.3 to 2.3 meters.
4. *Sphacelaria furcigera* : 0.3 to 1.5 meters.
5. *Sargassum cinereum* : 0.3 to 1.5 meters.
6. *Gracilaria corticata* : 0.3 to 1.5 meters.
7. *Gelidium pusillum* : 1.6 to 2.3 meters.

Site – 2 (Kolthare)

Date of Observation: 4th February 2010.

	Time	Height
Tide: Low Tide:	08:45 hrs.	0.43 m.
	20:50 hrs.	1.05 m.
High Tide:	02:15 hrs.	2.89 m.
	15:10 hrs.	2.79 m.

Author took the reading up to 52 meters. The first 22 meters did not show algal growth. In the rock pool no. 3 from 23 to 26 meters along line transact *Jania rubens*, *Spongomorpha indica*, and *Gelidium pusillum* were observed.

From 27 to 52 meters algal species like, *Gelidium pusillum*, *Ulva lactuca*, and *Chaetomorpha linum* were seen whereas *Padina tetrastrumatica*, *Sargassum cinereum*, and *Stoechospermum marginatum*, were found growing from 41 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.3 to 2.3 meters.
2. *Ulva lactuca* : 0.3 to 2.3 meters.
3. *Padina tetrastrumatica* : 0.3 to 1.1 meters.
4. *Sargassum cinereum* : 0.3 to 1.1 meters.
5. *Stoechospermum marginatum* : 0.3 to 1.1 meters.
6. *Gelidium pusillum* : 0.3 to 2.3 meters.

Site – 2 (Kolthare)

Date of Observation: 4th March 2010.

	Time	Height
Tide: Low Tide:	07:30 hrs.	0.21 m.
	19:45 hrs.	0.91 m.
High Tide:	01:00 hrs.	2.92 m.
	13:55 hrs.	2.79 m.

This month's reading also show variation of algal species occurring along the line transact. The line up to 20 meters lacks algal growth. *Spongomorpha indica* was grown in the rock pool no. 3 between 23 to 25 meters.

The 26th meters did not show any algal growth. *Gelidium pusillum* was present from 27 to 52 meters. *Ulva lactuca* was present between 34 and 40 meters. *Chaetomorpha linum* was occurring from 36 to 42 meters along with *Sargassum cinereum*, where the latter was continued up to 52 meters.

Padina tetrastrumatica was observed between 43 and 46 meters. *Catenella rapens* and *Champia compressa* were found growing from 47 meters to 52 meters, where they were always submerged in sea water.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 1.0 to 1.8 meters.
2. *Ulva lactuca* : 1.4 to 2.2 meters.
3. *Sargassum cinereum* : 0.3 to 1.8 meters.
4. *Padina tetrastrumatica* : 0.7 to 0.9 meters.
5. *Catenella rapens* : 0.3 to 0.9 meters.
6. *Champia compressa* : 0.3 to 0.9 meters.
7. *Gelidium pusillum* : 0.3 to 2.3 meters.

Site – 2 (Kolthare)

Date of Observation: 2nd April 2010.

	Time	Height
Tide: Low Tide:	07:00 hrs.	0.12 m.
	19:30 hrs.	1.08 m.
High Tide:	00:30 hrs.	2.74 m.
	13:30 hrs.	2.88 m.

At Site – II, on the onset of the summer season the variation in distribution of macro algae appeared. Up to 36 meters there was no algal growth along the line transect. *Gelidium pusillum* was observed from 37 to 52 meters. *Gracilaria corticata* was growing luxuriantly from 45 to 49 meter.

The green alga *Chaetomorpha linum* was found growing abundantly from 45 to 52 meters. *Ulva lactuca* was observed from 49 to 52 meters. *Dasaya* was found growing thinly from 50 to 52 meters along the line transect.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.3 to 0.9 meters.
2. *Ulva lactuca* : 0.3 to 0.7 meters.
3. *Gracilaria corticata* : 0.7 to 0.9 meters.
4. *Dasaya spp.* : 0.3 to 0.6 meters.
5. *Gelidium pusillum* : 0.3 to 1.7 meters.

Site – 2 (Kolthare)

Date of Observation: 16th May 2010.

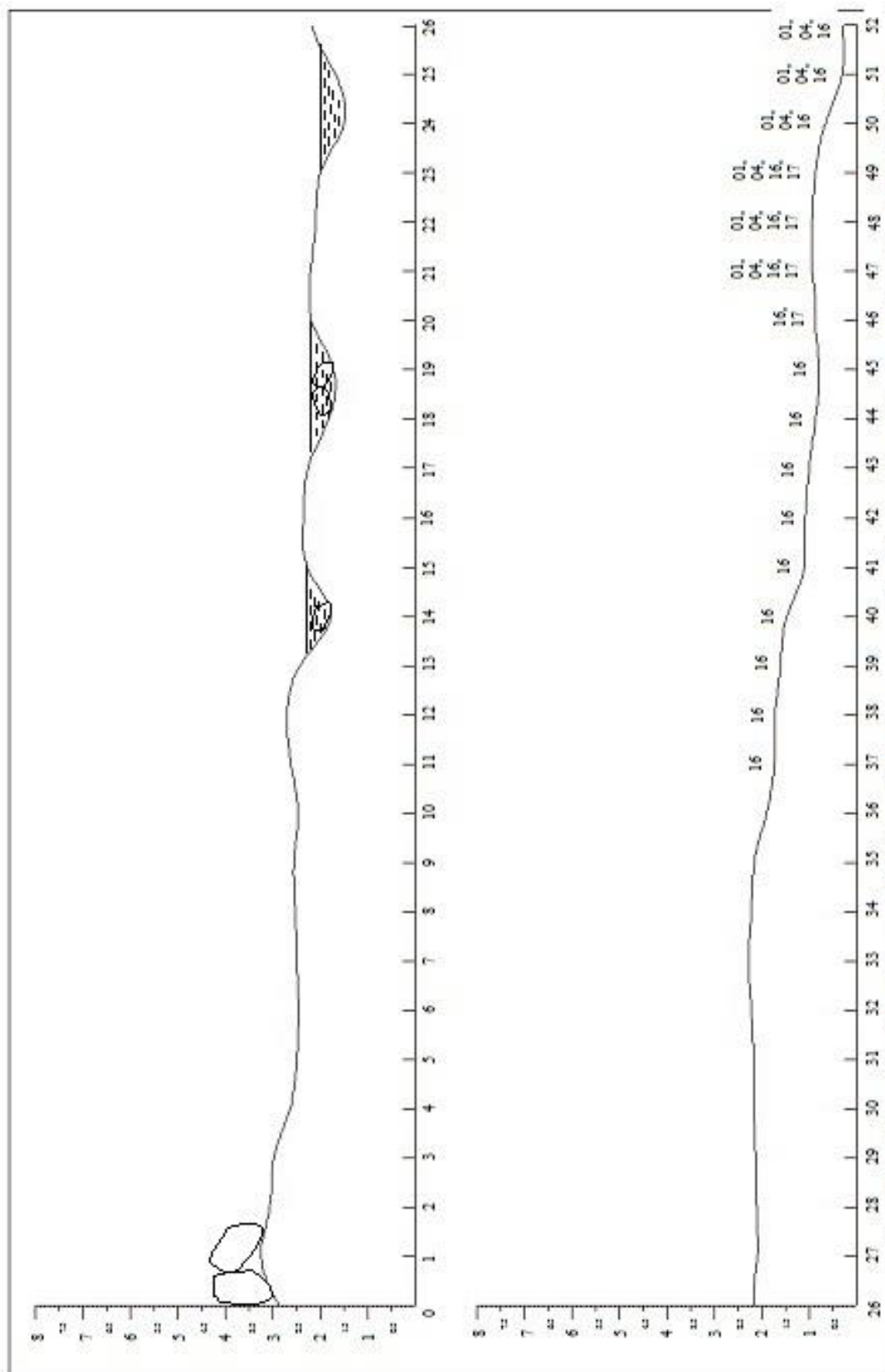
	Time	Height
Tide: Low Tide:	06:00 hrs.	0.07 m.
	18:50 hrs.	1.24 m.
High Tide:	13:00 hrs.	2.95 m.

The line up to 36 meters did not show presence of any algal species. *Gelidium pusillum* was present from 37 to 52 meters. *Gracilaria corticata* was observed from 46 to 49 meters. *Chaetomorpha linum* and *Ulva lactuca* were occurring from 47 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.3 to 0.9 meters.
2. *Ulva lactuca* : 0.3 to 0.9 meters.
3. *Gracilaria corticata* : 0.7 to 0.9 meters.
4. *Gelidium pusillum* : 0.3 to 1.7 meters.

Site – 2 (Kolthare)



Figures No. A.c.29: Vertical Distribution of Algae at Site – 2: May 2010

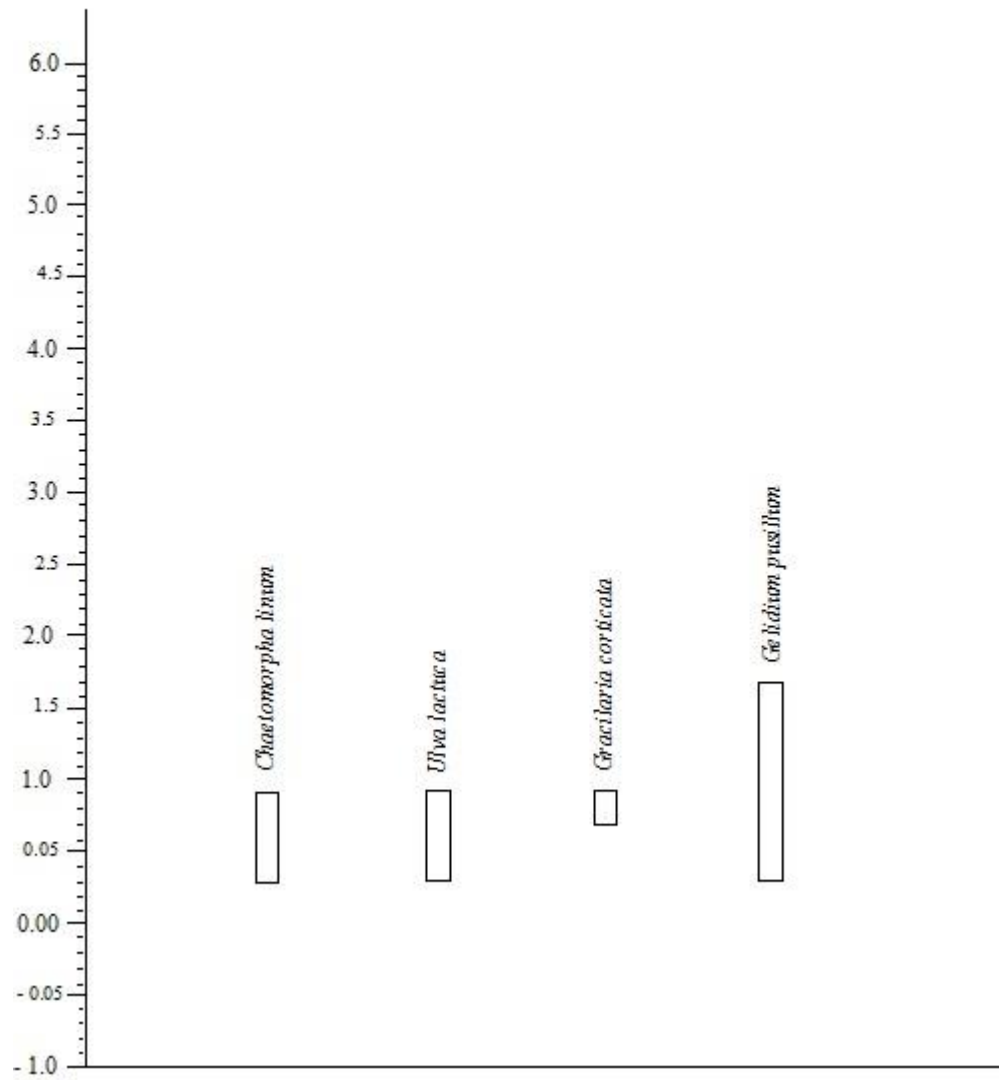
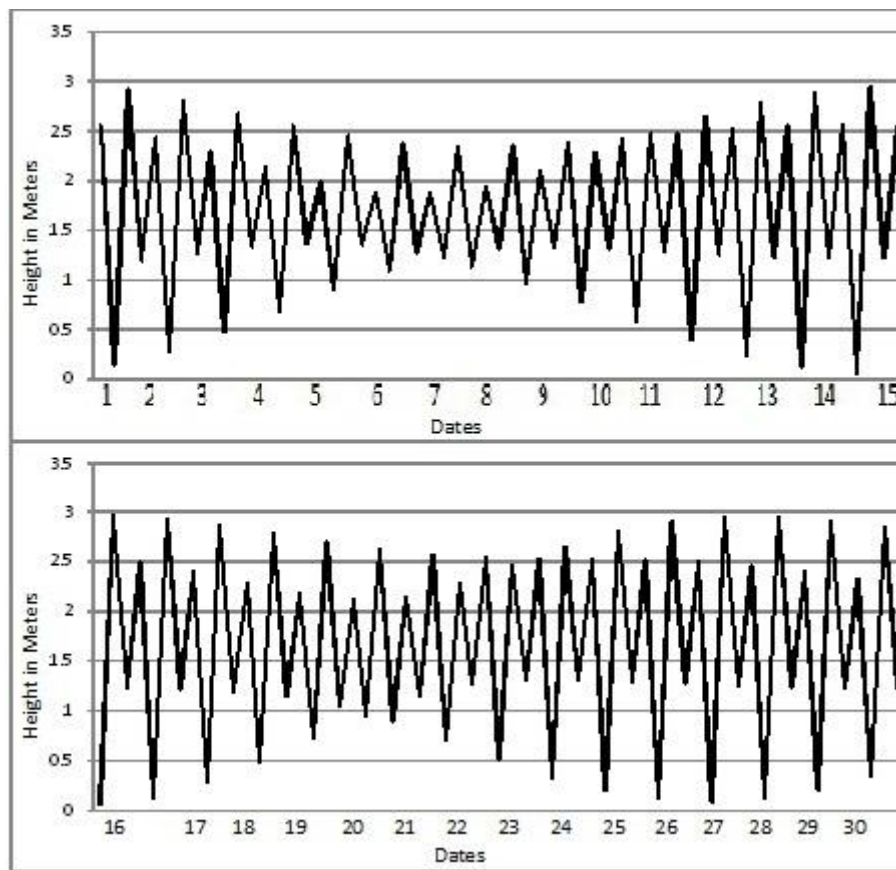


Fig. No. 28. Marigram at Site - 2: May 2010.



Date of Observation: 14th June 2010.

	Time	Height
Tide: Low Tide:	06:00 hrs.	0.04 m.
	18:50 hrs.	1.12 m.
High Tide:	12:50 hrs.	3.04 m.

At Site – II inconsistency in the growth of algal species was found. During this reading the line up to 37 meters did not show any algal growth. *Gelidium pusillum* was present from 38 to 52 meters. *Gracilaria corticata* was observed from 46 to 52 meters. *Chaetomorpha linum* was present from 48 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.3 to 0.8 meters.
2. *Gracilaria corticata* : 0.3 to 0.9 meters.
3. *Gelidium pusillum* : 0.3 to 1.6 meters.

Site – 2 (Kolthare)

Date of Observation: 15th July 2010.

	Time	Height
Tide: Low Tide:	07:20 hrs.	0.36 m.
	20:10 hrs.	0.61 m.
High Tide:	01:10 hrs.	2.62 m.
	13:50 hrs.	3.05 m.

At Site – II due to strong winds and heavy rains author could take reading up to 49 meters. Along the line transact up to 37 meters no algal growth was found. *Gelidium pusillum* was observed from 38 to 49 meters and *Gracilaria corticata* was found growing from 46 to 49 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Gracilaria corticata* : 0.7 to 0.9 meters.
2. *Gelidium pusillum* : 0.7 to 1.6 meters.

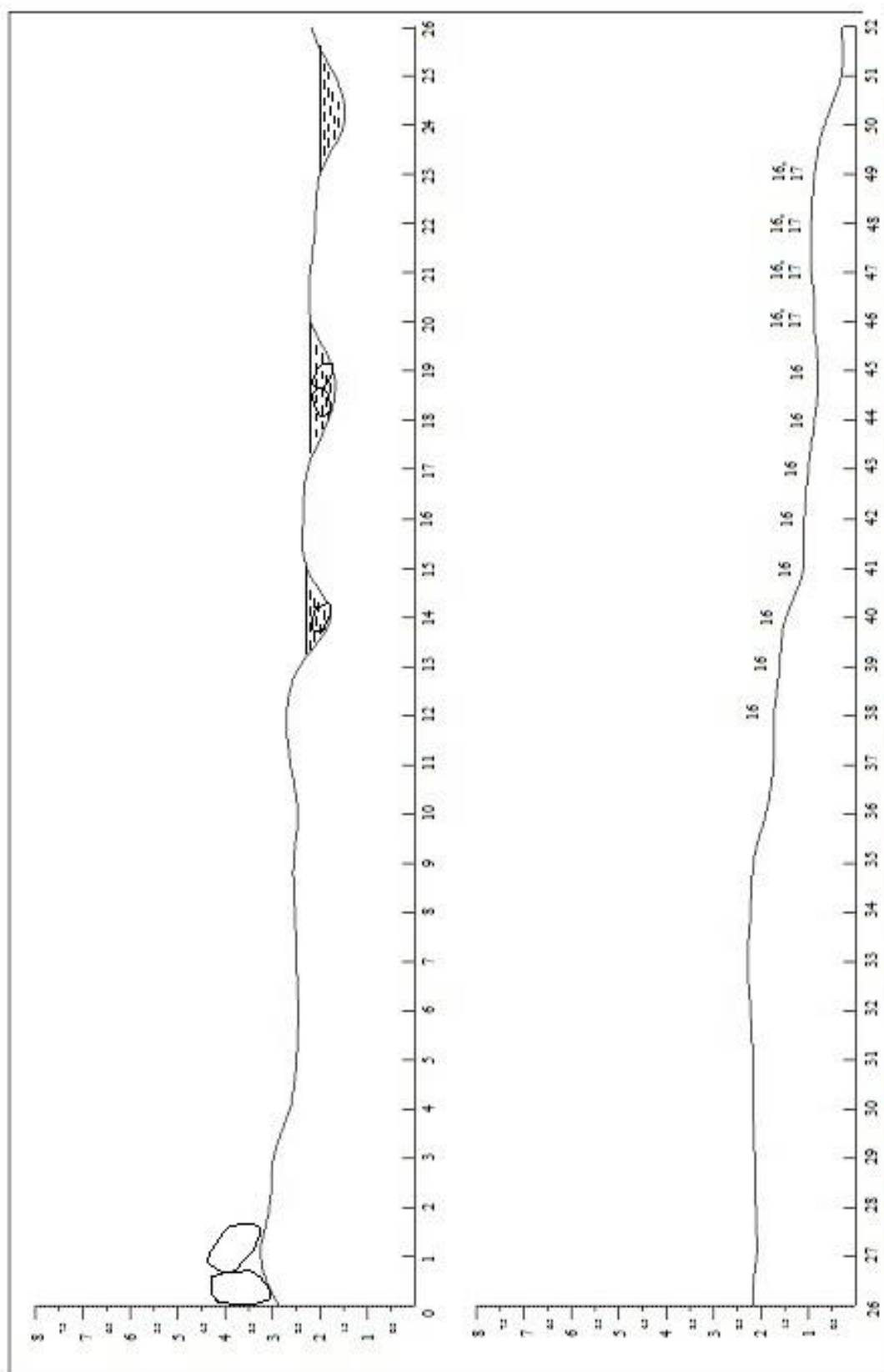


Figure No. 9: Profile of the Shore of Kolthare indicating meter wise distribution of algal species – Month: July 2010

Figures No. A.c.31: Vertical Distribution of Algae at Site – 2: July 2010

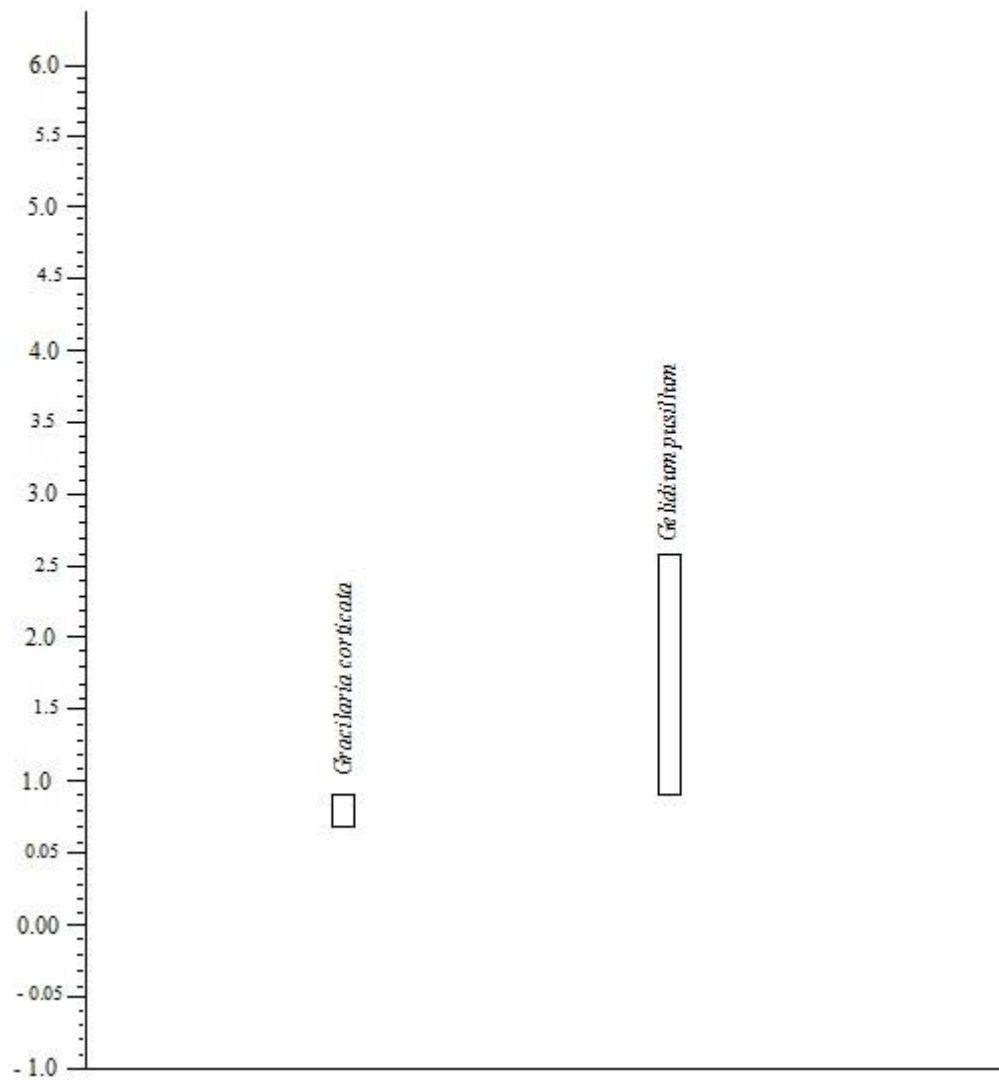
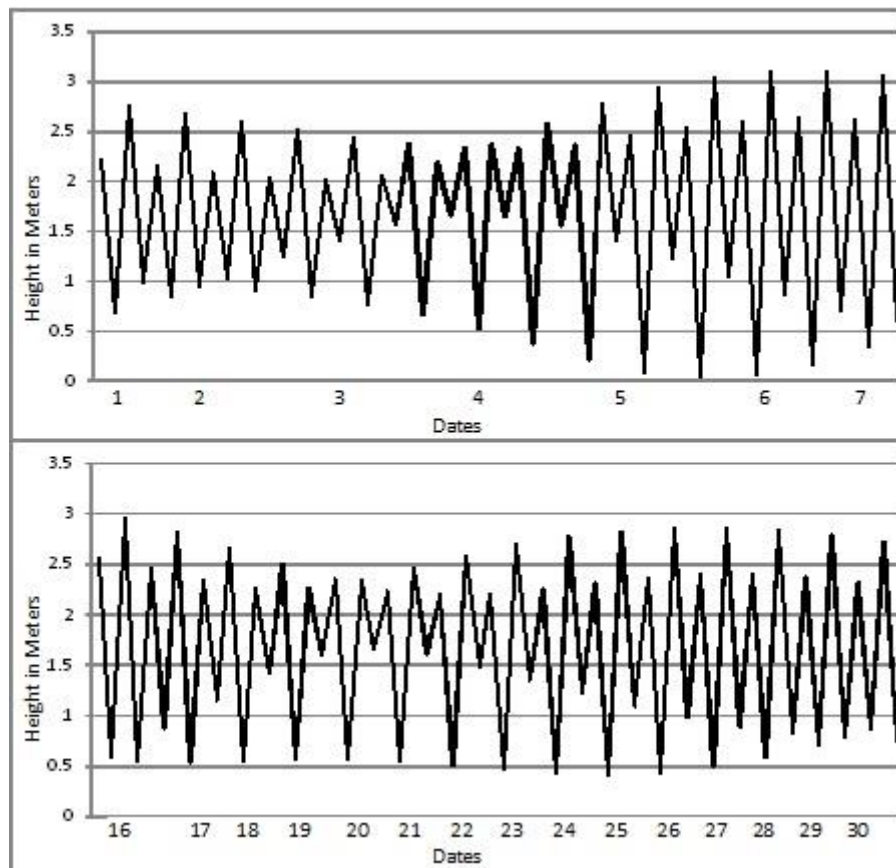


Fig. No. 29. Marigram at Site - 2: July 2010.



Site – 2 (Kolthare)

Date of Observation: 12th August 2010.

	Time	Height
Tide: Low Tide:	06:20 hrs.	0.31 m.
	18:55 hrs.	0.40 m.
High Tide:	00:10 hrs.	2.82 m.
	12:40 hrs.	3.10 m.

In this month author was able to take reading up to 49 meters. *Porphyra vietnamensis* was found growing profusely and densely between 15th and 18th meters and from 21 to 26 meters. *Gelidium pusillum* was observed from 34 to 49 meters. *Chaetomorpha linum* was present from 38 to 47 meters. *Gracilaria corticata* was observed at 48th and 49th meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.7 to 1.6 meters.
2. *Porphyra vietnamensis* : 2.1 to 2.4 meters.
3. *Gracilaria corticata* : 0.7 to 0.8 meters.
4. *Gelidium pusillum* : 0.7 to 2.2 meters.

Site – 2 (Kolthare)

Date of Observation: 9th September 2010.

	Time	Height
Tide: Low Tide:	05:20 hrs.	0.42 m.
	17:45 hrs.	0.24 m.
High Tide:	11:30 hrs.	3.02 m.
	23:55 hrs.	2.99 m.

Despite moderate raining, at Site – 2 author was able to take reading up to 52 meters. *Porphyra vietnamensis* was growing profusely and very densely from 15 to 18 meter, and again from 21 to 34 meters. *Gelidium pusillum* was growing from 39 to 52 meters. *Chaetomorpha linum* was observed growing profusely in 42nd, 43rd, 45th and 47th meters along the line. *Gracilaria corticata* was observed from 44 to 46 meters.

Stoechospermum marginatum, *Sargassum cinereum* and *Sphacelaria furcigera* were found growing from 46 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Chaetomorpha linum* : 0.8 to 1.0 meters.
2. *Stoechospermum marginatum* : 0.3 to 0.9 meters.
3. *Sargassum cinereum* : 0.3 to 0.9 meters.
4. *Sphacelaria furcigera* : 0.3 to 0.9 meters.
5. *Gracilaria corticata* : 0.7 to 0.8 meters.
6. *Porphyra vietnamensis* : 2.1 to 2.4 meters.
7. *Gelidium pusillum* : 0.3 to 1.5 meters.

Site – 2 (Kolthare)

Date of Observation: 9th October 2010.

	Time	Height
Tide: Low Tide:	05:40 hrs.	0.80 m.
	17:55 hrs.	-0.02 m.
High Tide:	11:30 hrs.	2.86 m.

At this site also as the winter season starts, variations in algal species were observed. Due to absence of the heavy rains author could take reading along the line transact up to 52nd meter.

Gelidium pusillum was present in the rock pool from 13 to 15 meters and another rock pool from 17 to 20 meters and again on the rocky shore from 23 to 52 meters. *Jania rubens* was observed in rock pool no. 1 and 2, at 15th, 19th and 20th meters. *Padina tetrastromatica* was observed in the rock pool no. 1 and 2, at 13th, 14th, 17th, 18th meters and in the rock pool no. 3 at 20th, 23rd, 24th meters and from 39 to 52 meters. *Gracilaria corticata* was found growing in all three rock pools at 14th, 15th, 18th, 19th, 20th, 23rd, 24th meters and on the rocky shore from 45 to 52 meters.

Sargassum cinereum was found growing in the rock pool at 23rd and 24th meter and on the rocky shore from 39 to 52 meters. *Ulva lactuca* was found at 27th and 28th meters along the line. Dense population of *Sphacelaria furcigera* was observed from 39 to 46 meters. *Dictyota divaricata* was occurred from 43rd to 50th meters with high density.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Ulva lactuca* : 2.1 meter.
2. *Padina tetrastromatica* : 0.3 to 1.5 meters.
3. *Gracilaria corticata* : 0.3 to 0.9 meters.
4. *Sargassum cinereum* : 0.3 to 1.5 meters.
5. *Sphacelaria furcigera* : 0.7 to 1.5 meters.
6. *Dictyota divaricata* : 0.6 to 0.9 meters.
7. *Gelidium pusillum* : 0.3 to 2.4 meters.

Site – 2 (Kolthare)

Date of Observation: 7th November 2010.

	Time	Height
Tide: Low Tide:	05:35 hrs.	1.05 m.

17:25 hrs. -0.04 m.

High Tide: 11:00 hrs. 2.67 m.

This reading at the site showed a varied algal species. Due to unwavering seawater author could take reading up to 52 meters. The line transact up to 12 meters no algal growth were recorded. In the rock pool no. 1 at 13 to 15 meters and rock pool no. 2 at 18th and 19th meters also, algal species were observed such as, *Jania rubens*, *Gracilaria corticata*, and *Padina tetrastromatica*. *Sargassum cinereum* was also observed in the rock pools at 14th and 18th meters.

Sphacelaria furcigera was observed from 19 to 23 meters. *Ulva lactuca* was present at 24th, 25th meters and from 38 to 40 meters. *Gelidium pusillum* was observed from 20 to 52 meters. *Chaetomorpha linum* was found growing luxuriantly from 35 to 43 meters. *Gracilaria corticata* was seen from 47 to 52 meters along the line.

Padina tetrastromatica and *Sargassum cinereum* were observed growing profusely from 45 to 52 meters along the line transact. *Dasya spp.* was observed at 51st and 52nd meters. *Catenella rapens* was also found from 50 to 52 meters.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Ulva lactuca* : 1.4 to 1.6 meters.
2. *Chaetomorpha linum* : 0.9 to 2.1 meters.
3. *Padina tetrastromatica* : 0.3 to 0.9 meters.
4. *Sargassum cinereum* : 0.3 to 0.9 meters.
5. *Sphacelaria furcigera* : 2.1 meter.
6. *Gracilaria corticata* : 0.3 to 0.9 meters.
7. *Dasaya spp.* : 0.3 meter.
8. *Catenella rapens* : 0.3 to 0.6 meters.
9. *Gelidium pusillum* : 0.3 to 2.3 meters.

Site – 2 (Kolthare)

Date of Observation: 5th December 2010.

	Time	Height
Tide: Low Tide:	04:45 hrs.	1.27 m.
	16:30 hrs.	0.04 m.
High Tide:	09:50 hrs.	2.51 m.
	23:15 hrs.	2.99 m.

This was the last reading taken along the line of transact at Site – 2 (Kolthare). The variation in distribution of algal species along the line was noted down.

The line up to 17 meters does not show any algal growth. *Dictyota divaricata*, *Jania rubens*, *Padina tetrastrumatica*, *Stoechospermum marginatum*, *Enteromorpha flexuosa*, and *Spongomorpha indica* were present in the rock pool along the line at 18th and 19th meters. Whereas, *Jania rubens*, *Stoechospermum marginatum*, and *Padina tetrastrumatica* was continued to grow in another rock pool at 24th and 25th meters.

Gelidium pusillum was observed from 27 to 52 meters. *Ulva lactuca* a green alga was present from 34 to 37 meters. *Chaetomorpha linum* was profusely growing from 36 to 42 meters. *Sargassum cinereum* was growing with high density from 40 to 52 meters. *Padina tetrastrumatica* was growing luxuriantly from 43 to 52 meters. *Sphacelaria furcigera* was observed at 47th and 48th meters.

Catenella rapens was noted from 50 to 52 meters, along with *Centroceras clavulatum* at 49th and 50th meters. *Dasaya spp.* was observed 50th and 51st meters. *Champia compressa* was present at 52nd meter.

Vertical distribution of some major algae was as follows, (except in tide pools)

1. *Ulva lactuca* : 1.7 to 2.2 meters.
2. *Chaetomorpha linum* : 1.0 to 1.8 meters.
3. *Sphacelaria furcigera* : 0.8 to 0.9 meters.
4. *Sargassum cinereum* : 0.3 to 1.4 meters.
5. *Padina tetrastromatica* : 0.3 to 0.9 meters.
6. *Catenella rapens* : 0.3 to 0.6 meters.
7. *Centroceras clavulatum* : 0.6 to 0.7 metres.
8. *Champia compressa* : 0.3 meter.
9. *Dasaya spp.* : 0.3 to 0.6 meters.
10. *Gelidium pusillum* : 0.3 to 2.3 meters.

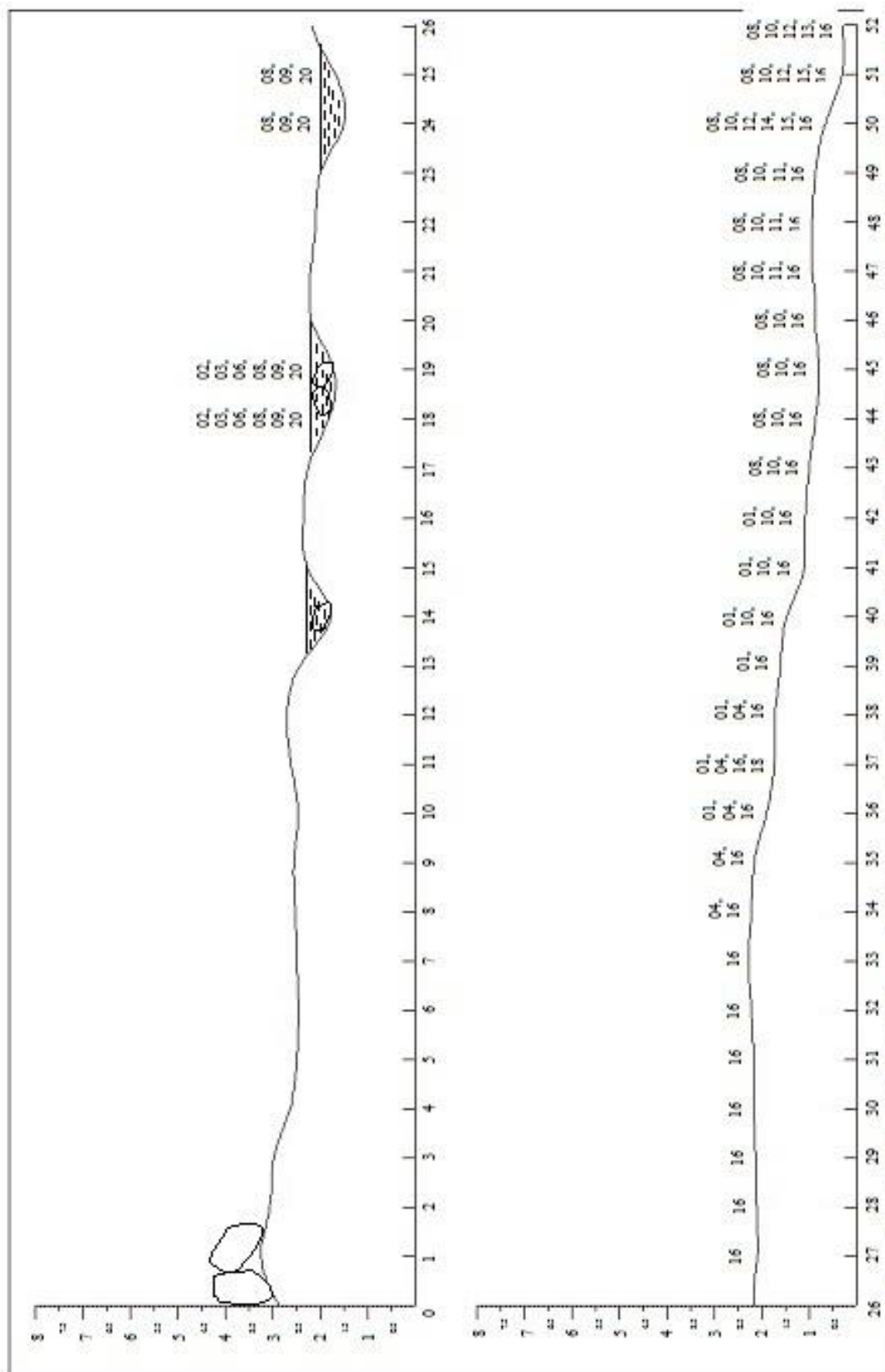


Figure No.10 : Profile of the Shore of Kolthare indicating meter wise distribution of algal species – Month: December 2010

Figures No. A.c.36: Vertical Distribution of Algae at Site – 2: December 2010

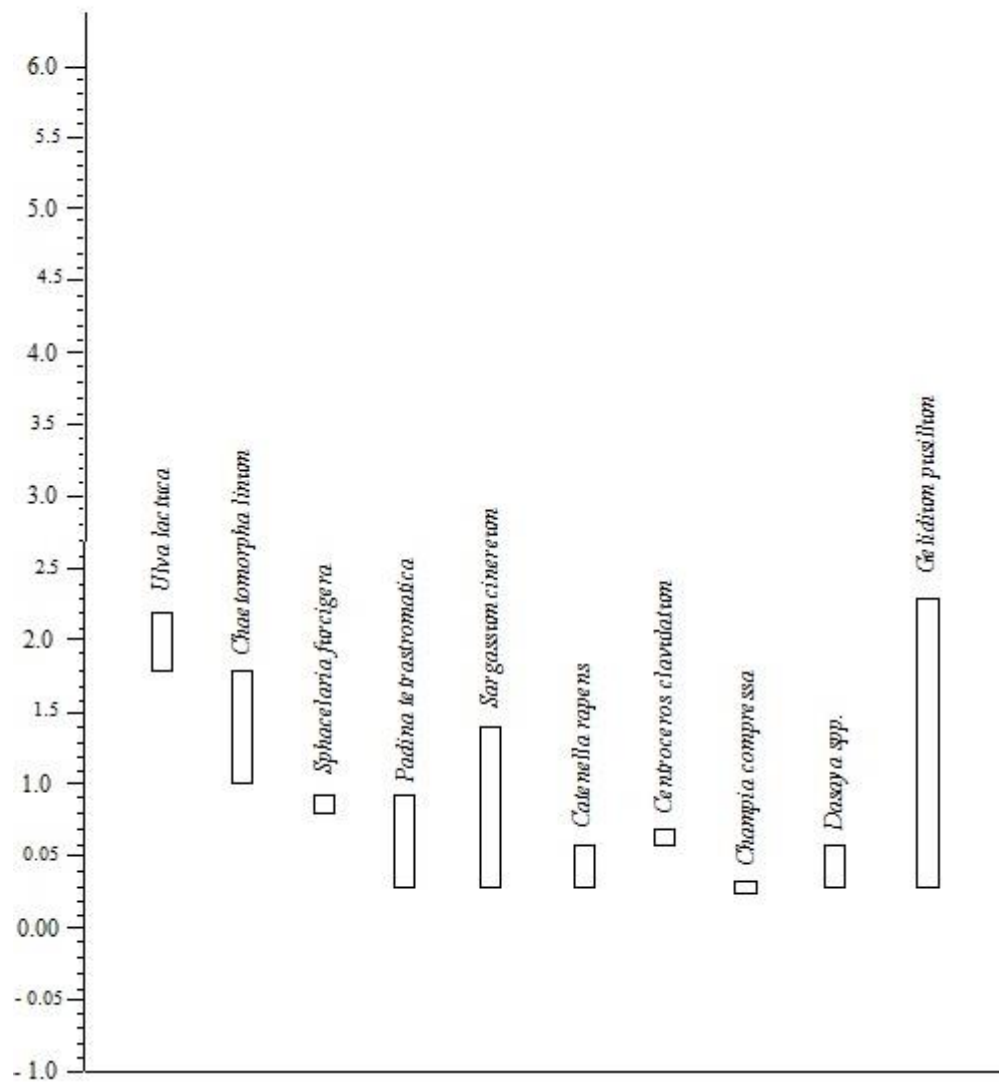
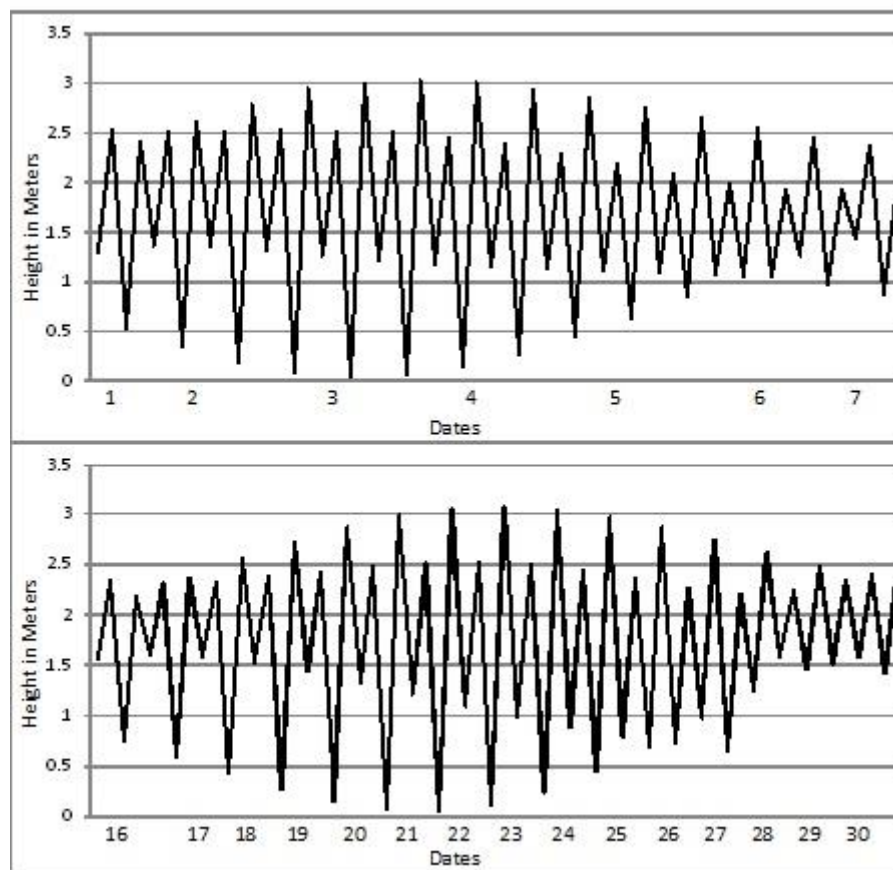


Fig. No. 30. Marigram at Site - 2: December 2010.



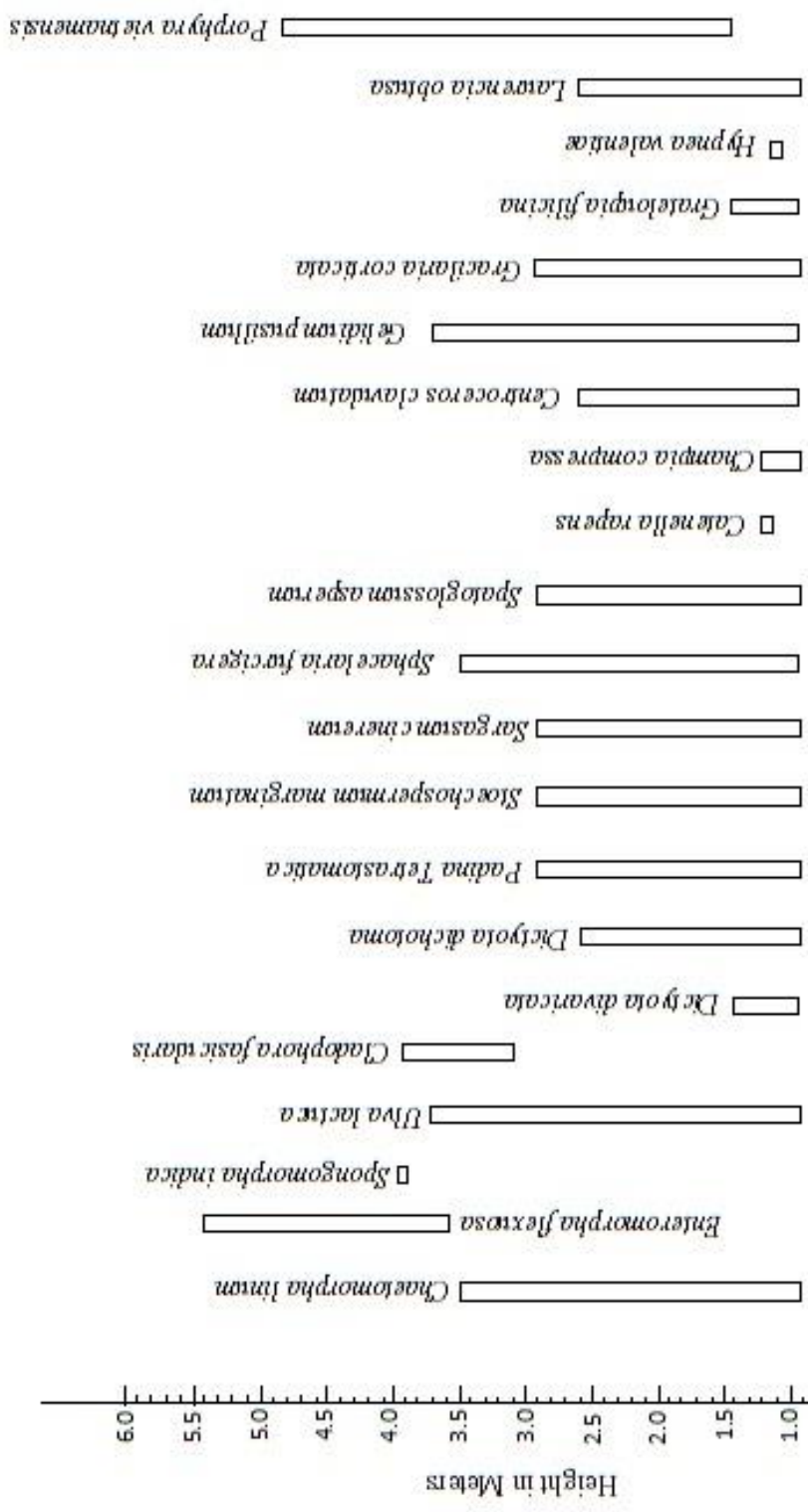


Figure No. A.d: Vertical Distribution of Algae at Site - 1 for 18 Months

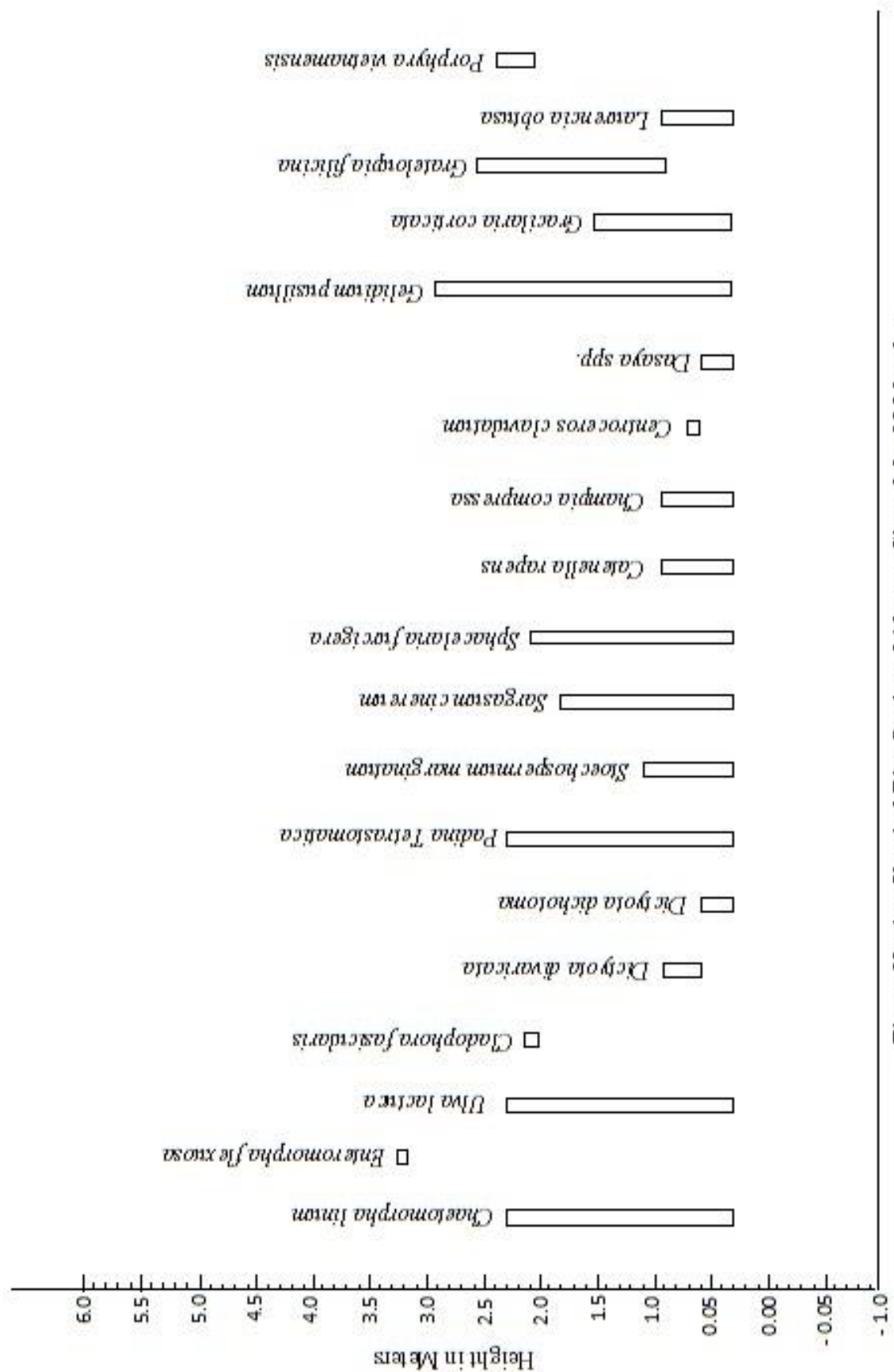


Plate No. 3



Arial View Of The Site - 1



Arial View Of The Site - 1 (Hedavi) During Rainy



Exposed Rocky Surface Of The Site - 1 (Hedavi) Showing Rock Pools



Exposed Rocky Surface Of The Site - 1 (Hedavi)

Plate No. 5



Rock pool with Algal Growth



Boulders with Algal Growth

Plate No. 6



Exposed Rocky shore Showing various zones



Exposed Rocky Shore Showing Growth of Barnacles

Plate No. 7



Fornt View of the Site - 2



**Rocky Surface at Site - 2 (Kolthare)
Showing Lush Growth of Barnacles**



Rocky Surface at Site - 2 (Kolthare)



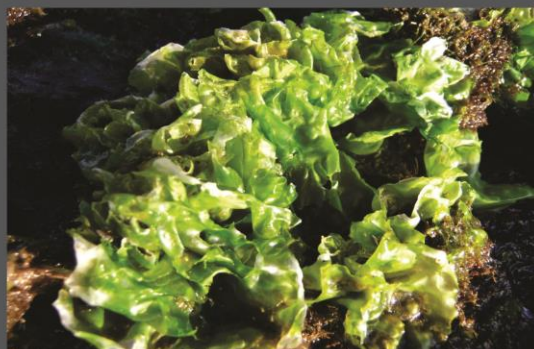
**Rocky Surface at Site - 2 (Kolthare)
with Line Transact**

Plate No. 11
Photographs of Green Algae

Chaetomorpha linum (Muell.) Kuetz



Ulva lactuca Linn.



Ulva lactuca in Initial stage of growth



Abundance of *Chaetomorpha linum*



Abundant growth of Marine Algae



Chaetomorpha linum
(Muell.) Kuetz



Plate No. 12
Photographs of Brown Algae

Dictyota divaricata Lamouroux



Padina tetrastratica Hauck.



Spatoglossum asperum



Stoechospermum marginatum (C. Ag.)
Kutez



Sargassum cinereum J. Ag.



Stoechospermum marginatum showing
sori at margin



Sphacelaria furcigera Kutez.



Plate No. 13
Photographs of Red Algae

Champia compressa Harvey.



Gracilaria corticata J. Ag.



Jania rubens Lamour



Porphyra vietnamensis Tanaka et Ho
with Lush growth on Rocky Surface



Porphyra vietnamensis
Tanaka et Ho



Grateloupia filicina
Wulf G. Ag.



Laurencia obtusa
(Hudson) Lamouroux



Plate No. 14
Photographs Showing Algal Association

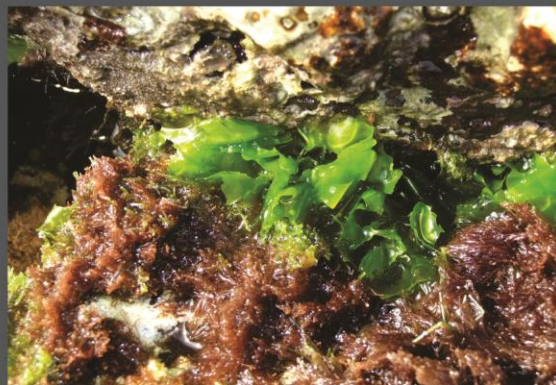
**Association of
Algae**



**Association of
Algae**



**Association of
Algae *Ulva* with**



DISCUSSION:

Vertical distribution of marine algae and their zonation pattern has been described by various scientists in the past. Both Sites – 1 and 2, on the West coast of Ratnagiri district exhibit good diversity in the macro algal species. The shore type at both sites is rocky and is similar to that of other Indian rocky shores. The rocky shore at Site – 1 and Site – 2, shows gradual slope towards sea. The region between extreme high water spring and extreme low water spring is well-exposed area consisting of rocky boulders, stones pebbles, gullies and small rock pools. Rocky surfaces are bare and sometimes covered with fine silt. The rock pools with rocky substratum shows presence of scattered stones. Thus there are ‘open shore’ and ‘close shore’ habitats at both the Sites – 1 and 2.

It was necessary to undertake the present research work as baseline data, as new developmental projects including nuclear and thermal power plants are proposed on the Ratnagiri coast, The present studies were carried out for 18 months from July 2009 to December 2010, and distribution of marine algae on the seashore along the line transact was recorded.

The area at both Site – 1 and 2 were studied using line transact of 50 and 52 meters respectively, extending from the shoreline to low water level. The vertical emersion is 5.4 meters at Site – 1 above the Chart Datum (CD) and at Site – 2 is 3.2 meters above the Chart Datum (CD).

Stephenson T.A. and Stephenson A. (1949) in their universal scheme of zonation patterns, for rocky shores, proposed five different zones. In their scheme they recognized –

1. Supralittoral zone – the maritime belt lying near the sea, above the tide marks or the upper limit of Littorinoids, and includes majorly the finely divided spray in rough weather.
2. Supralittoral fringe – from the upper limit of barnacles to the lower limit of the Littorinoids and lying mostly above the level of extreme high water of Spring tides.
3. Mid littoral zone – from the upper limit of barnacles down to the upper limit of zone below and extending down to the mean low water level of Neap tides. This zone tends to be exposed and unexposed every day.
4. Infralittoral fringe - lying between mean low water of Neap and extreme low water of Spring tides. This zone uncovers only at the major tides and sometimes only in calm weather.
5. Infralittoral zone – from extreme low water of springs to a depth to the lower limit of seaweeds, which are never exposed.

The above mentioned type of zonation pattern at the present study area has been compared and found the subsequent result.

Supralittoral zone at Site – 1 was found near the shore line at the height of 4.9 to 5.4 meters from CD, while at Site – 2 it was found at the height of 2.4 to 3.2 meters from CD.

Supralittoral fringe at Site – 1 was found at the height of 3.1 to 4.9 meters from the CD, whereas the Site – 2 showed the height of this belt at 1.5 to 2.4 meters from CD.

Midlittoral zone found at Site – 1 was at the height of 3.1 to 3.9 meters from CD and at Site – 2 it was at the height of 1.5 to 2.3 meters from CD.

Infralittoral fringe was observed at Site – 1 was at height of 0.9 to 3.1 meters above CD, while the Site – 2 showed the height of this belt at 0.3 to 1.7 meters above CD.

Infralittoral zone was found bellow the 0.9 meters from CD at Site – 1, and at Site – 2 it was observed the height bellow 0.3 meters from CD.

The present study indicates that, majority of algal species occur in the intertidal region. During late monsoon time *Enteromorpha flexuosa* is the only member that can be collected in the supralittoral zone, the region above high water mark, which is a spray zone.

On The rocky surface in the supralittoral fringe zone various algal members like *Porphyra vietnamensis*, *Chaetomorpha linum* and *Ulva lactuca* are found.

At both Sites – 1 and 2, in the supra-littoral fringe and mid-littoral region, on the rocky surfaces, are present many algal species like *Gelidium pusillum*, *Spongomorpha indica*, *Cladophora* and *Padina tetrastrumatica*. Whereas, *Sargassum cinereum*, *Dictyota*, *Stoechospermum marginatum*, *Gracilaria corticata*, *Hypnea valentiae*, *Jania rubens* etc. are seen growing in the rock pools of this region. Such rock pools are never exposed to atmosphere.

At Site – 1 and Site – 2, near the extreme low water spring zone or in the infralittoral fringe large number of algal species grow. Most of the species in this region are either exposed for very short period or always submerged. This area is characterized by *Padina tetrastrumatica*, *Sargassum cinereum*, *Spatoglossum asperum*, *Stoechospermum marginatum*, *Gracilaria corticata*, *Champia compressa*, *Laurencia obtusa*, *Dasaya spp.*, *Catenella rapens*, etc.

All these species also extend down in the infralittoral zone, which is always covered with seawater and never exposed. Along with algae Littorinoids, Belenoids,

and Barnacles are some of the animals that shows characteristics belts in different zones.

Thus, it is possible to recognize a pattern of zonation of the algal species at Site – 1 and Site – 2 as postulated by Stephenson T.A. and Stephenson A. (1949).

Above the upper limit of *Littorina* is a supralittoral zone. At Site – 1 and 2, the supralittoral zone is present on the rocks near the shoreline. This zone can be recognized by the presence of snails like *Littorina*. During late monsoon period, the algae like *Enteromorpha flexuosa* grows on the rock surface. The upper limit of this zone at Site – 1 and Site – 2 corresponds with the extreme high water of spring (EHWS) and lie at 5.4 and 3.3 meters level respectively, and thus matches with that of the Stephenson's scheme. There some boulders are placed in front of shoreline at both sites. This area near the shoreline shows rapid aridness and thus keeps the shoreline rarely wet. However, in the remaining period of the year, no organism could be seen in the supralittoral zone and thus, *Enteromorpha flexuosa* and other organisms migrate to the next zone.

In the Stephenson's scheme, lower limit of supralittoral fringe corresponds to the upper limit of Barnacles. At Hedavi this limit is located at 3.6 meters and at Kolthare it is located at 2.3 meters level above Chart Datum. In this zone some algae have been recorded, of which green algae like *Chaetomorpha linum*, *Spongomorpha indica*, *Ulva lactuca* and red algae like *Gelidium pusillum*, *Jania rubens* (in rock pool) etc. are found most of the time. However, some of these algae are not restricted to this zone but extended far below into the Midlittoral zone.

The Midlittoral zone of Stephenson's universal scheme is a zone between the lower limit of supralittoral fringe, which is the upper limit of Barnacles and the level

of mean low water of neap tides (MLWN), which is upper Limit of laminarians. The corresponding zone exists at both sites Hedavi and Kolthare.

The upper limit of Barnacles is at 3.5 meters at Site – 1 and at 2.2 meters at Site – 2 above the Chart Datum, and the level of mean low water of neap tides is at 0.99 meters at Site – 1 and 1.08 meters at Site – 2 above Chart Datum. Thus, the width of Midlittoral zone at Site – 1 is 2.51 meters and at Site – 2 it is 1.12 meters. This zone is distinctly formed by the belt of Barnacles. Algal species restricted to this zone are *Chaetomorpha linum*, *Spongomorpha indica*, *Gelidium pusillum*, *Cladophora*, *Padina tetrastomatica*, *Porphyra vietnamensis* which are growing on the rock surface of this zone. Whereas *Chaetomorpha linum*, *Ulva lactuca* extend from supralittoral fringe down to the lower limit of this zone. Also *Sargasum cinereum*, *Dictyota*, *Stoechospermum marginatum*, *Gracilaria corticata*, *Hypnea valentiae*, etc. are seen growing in the rock pools of this region.

Infralittoral fringe is a next zone in Stephenson's scheme. There is a break between Midlittoral zone and infralittoral fringe. The upper limit of this zone in the scheme of Stephenson's corresponds to the upper limit of Laminarians, while lower limit corresponds to the extreme low water of spring tides (ELWS). The Indian coasts do not show presence of Laminariales.

At Hedavi the mean level of low water of Neap (MLWN) tides is located at 0.99 meters above C.D. and at Kolthare it is 1.08 meters above C.D. The extreme low water of spring (ELWS) at Hedavi is at 0.04 meters below C.D. and at Kolthare it is – 0.06 meters below the C.D. Thus the vertical width of this zone at Hedavi is 0.95 meters and at Kolthare it is 1.14 meters. A prominent animal in this zone is an edible Oyster, which extends downwards into infralittoral zone. Algae that are restricted to upper region of this zone are green algae like *Ulva lactuca*, brown algae like *Padina*

tetrastromatica, *Stoechospermum marginatum*, *Sargassum cinereum*, *Sphacelaria furcigera*, *Spatoglossum asperum*, and red algae like *Gracilaria corticata*, *Centroceras clavulatum*, *Hypnea valentiae*, *Gelidium pusillum* are present. While algal species like *Sargassum cinereum*, *Spatoglossum asperum*, *Gracilaria corticata*, *Gelidium pusillum*, *Laurencia obtusa*, *Champia compressa*, *Catenella rapens* occupy the lower part of this zone and, also extend into the infralittoral zone.

The fifth zone – infralittoral zone of Stephenson's zonation pattern extends below extreme low water of spring (ELWS) to a depth which has yet to be settled. This zone at Hedavi and Kolthare is characterized by the growth of *Sargassum cinereum*, *Laurencia obtusa*, *Champia compressa*, *Dasaya spp.* and *Catenella rapens*, which are restricted only to this zone and are seen in this infralittoral zone as well as in infralittoral fringe.

Thus, a close evaluation of zonation pattern at Site – 1 and Site – 2 with the Stephenson's universal pattern of zonation clearly indicates a close similarity with difference of being the species composition.

Earlier scientists like, Misra J.N. (1960), Umamaheshwar Rao M. and Sreeramulu T. (1963) and Umamaheshwar Rao M. (1972) has carried extensive studies on Indian coasts indicating Stephenson's universal pattern of zonation.

Misra J.N. (1960) has major contribution to the ecology of West coast of India. He has studied ecology, distribution and seasonal succession of the littoral algae along the intertidal regions. Misra J.N. recognized four major zones composed of five belts.

Misra J.N. has described several algae occurring in the supralittoral zone, whereas except *Enteromorpha* there is no algal growth in the supralittoral zone of Site – 1 and Site – 2. Misra J.N. has not mentioned about the supralittoral fringe. In upper

Midlittoral zone, he recorded algae like *Ulva*, *Enteromorpha* etc. while *Gelidium*, and *Polysiphonia* etc. were reported extending down, well up to the extreme low water mark region. At both sites in the present study, algae like *Ulva* and *Gelidium* are found growing in the infralittoral fringe which is the lower limit of the intertidal zone.

In the infralittoral zone, Misra J.N. recorded algae like *Champia*, *Sargassum*, *Grateloupia*, *Gracilaria*, etc. Most of these algae are also found in infralittoral zone of Site – 1 and Site – 2.

The pattern of zonation has no similarity with that of the four zones described by Srinivasan K.S. (1946) for marine algae at Mahabalipuram.

Umamaheshwar Rao M. and Sreeramulu T. (1963) observed three distinct zones on the Vishakhapatnam coast, corresponding well with the three basic zones in the universal scheme of zonation proposed by Stephenson T.A. (1949). In their study, they have not mentioned any algal growth in the supralittoral fringe. The Midlittoral zone was well defined and showed a precise rip in the vegetation at the lower limit of this midlittoral zone. Umamaheshwar Rao M. and Sreeramulu T. have mentioned major algal species like *Ulva*, *Chaetomorpha*, *Enteromorpha*, and *Porphyra*. These algae formed a cluster which occupied the entire Midlittoral zone. In the lower part of Midlittoral zone, *Chaetomorpha* and *Ligora* formed regular clusters. Of the above listed algae only *Chaetomorpha* and *Porphyra* are found in the Midlittoral zone of Site – 1 and Site – 2 shores.

In the infralittoral fringe, they recorded *Caulerpa*, *Padina*, *Grateloupia*, *Centroceras*, *Hypnea*, *Dictyota* and *Jania* and formed regular clusters. Of the above listed algae *Dictyota*, *Padina*, *Centroceras* and *Hypnea* are found in the infralittoral fringe at Site – 1 (Hedavi) and Site – 2 (Kolthare).

Umamaheshwar Rao M. (1972), while studying the intertidal algae of Mandapam has reported scanty algal growth in Midlittoral zone and no algal growth in the supralittoral fringe. He found algae in the Midlittoral zone of Mandapam were *Enteromorpha*, *Chaetomorpha*, *Ulva*, *Bachelotia*, and *Brachitrichea*. *Chaetomorpha* and *Ulva* are the only algal species common in the Midlittoral zone of Mandapam and Site – 1 and Site – 2.

At Mandapam a diverse high density of algae found in the infralittoral fringe and *Sargassum* and *Gracilaria* were the dominated this zone. Other algal species found of this zone were *Caulerpa*, *Padina*, *Hypnea*, *Centroceras*, and *Gracilaria*. The author in the infralittoral fringe also observed algae like *Enteromorpha*, *Ulva*, and *Chaetomorpha* that are the Midlittoral members.

At Mandapam *Ulva lactuca* has been reported as the member of Midlittoral zone, and at Site – 1 and Site – 2 this alga also found in the infralittoral fringe.

For the Infralittoral zone algal species like *Padina*, *Hypnea*, *Gracilaria*, *Dictyota*, *Stoechospermum*, and *Champia* are common for both coasts of Mandapam and Hedavi and Kolthare.

Balasundaram A. (1981), studied marine algal vegetation at Thiruchendur, Gulf of Mannar, in South India. The results of his study showed close conformity with the universal scheme of zonation given by Stephenson T.A. (1949).

The species like *Enteromorpha*, *Centroceras* and *Oscillatoria* were occurred in the supralittoral zone and in the infralittoral zone algae like, *Gracilaria* and *Hypnea* were observed. A diverse number of algal species with transient associations occupy the area between these two on the intertidal zone. This zone with of mixed type of algal populations was termed as ‘Algal mosaic’ by the Author. This mosaic zone showed vertical migration of algal species in different months of the year.

At Hedavi and Kolthare, comparable type of 'mosaic zone' could be seen in the infralittoral fringe particularly below the level of mean low water of spring tides (MLWS). The entire vertical range of the intertidal algal zone is 2.61 meters at Site – 1 and with a gentle slope extending to a horizontal distance of 50 meters. While at Site – 2 vertical range of the intertidal algal zone is 2.26 meters with a gentle slope extending to a horizontal distance of 52 meters. The mosaic zone at both sites is a narrow zone as both sites are attributed by the wide range of vertical emergence and tides.

Along with the zonation pattern, factors controlling zonation have also been taken into consideration. Factors like critical tide levels and percentage exposure have been studied. For both sites seven critical tide levels are calculated as; Extreme High Water Springs (EHWS), Mean High Water Springs (MHWS), Mean High Water Neaps (MHWN), Mean Tide Level (MTL), Mean Low Water Neaps (MLWN), Mean Low Water Springs (MLWS) and Extreme Low Water Springs (ELWS).

Doty M.S. (1946), proposed the 'tide factor hypothesis', in which he correlated the changing tide factor with the patterns of zonation. According to him the intertidal flora and fauna are broken into series of zones whose limits are correlated with the levels of certain critical tide levels and the vertical breadth of the intertidal zone is directly correlated with the tide range. He described eight critical tide factors as follows;

HHHW – Highest Higher High Water, LHHW – Lowest Higher High Water, HLHW – Highest Lower High Water, LLHW – Lowest Lower High Water, HHLW – Highest Higher Low Water, LHLW – Lowest Higher Low Water, HLLW – Highest Lower Low Water, LLLW – Lowest Lower Low Water. With this at Site – I and Site

– If the zonation pattern marine algae can be recognized as postulated by Doty M.S. (1946).

At Site – 1 and Site – 2, the upper and lower limit of *Enteromorpha flexuosa*, *Ulva lactuca*, and *Spongomorpha indica* are HHHW and LHHW, whereas *Chaetomorpha linum*, *Ulva lactuca*, and *Gelidium pusillum* extends from the LHHW to HLHW and restricted to LLHW. *Padina tetrastrum*, *Stoechospermum marginatum*, *Dictyota* and *Gelidium pusillum* are extended between LHLW and HLLW, while *Sargassum*, *Champia*, *Spatoglossum*, etc. Occur below HLLW and some are found in LLLW.

Evans R.G. (1947) evaluated the relation of the distribution of algal species with changes in exposure to air. Table No. 3.A and Table No 4.A illustrates the vertical distribution of algal species in relation with the percentage of exposure to the air at Site – 1 and Site – 2 respectively. Figure No. A.f and A.g demonstrates the diagrammatic representation of vertical distribution of algal species in relation with the percentage of exposure to the air at Site – 1 and Site – 2 respectively.

Table No. 3.A

Distribution of algal species with percent exposure to air at Site – 1

Name of Organisms	Percentage Exposure
<i>Enteromorpha flexuosa</i>	100 %
<i>Chaetomorpha linum</i> , <i>Ulva lactuca</i>	18 – 100 %
<i>Porphyra vietnamensis</i>	35 – 100 %
<i>Gelidium pusillum</i>	18 – 100 %
<i>Dictyota dichotoma</i>	18 – 85 %
<i>Padina tetrastrum</i> , <i>Stoechospermum marginatum</i> , <i>Sargassum cinereum</i>	18 - 100 %
<i>Sphacelaria furcigera</i>	18 – 100 %
<i>Gracilaria corticata</i>	18 – 100 %
<i>Champia compressa</i>	18 – 28 %
<i>Jania rubens</i>	0 %

Table No. 4.A

Distribution of algal species with percent exposure to air at Site – 2

Name of Organisms	Percentage Exposure
<i>Enteromorpha flexuosa</i>	100 %
<i>Chaetomorpha linum, Ulva lactuca</i>	5 – 62 %
<i>Porphyra vietnamensis</i>	55 – 70 %
<i>Gelidium pusillum</i>	5 – 95 %
<i>Dictyota dichotoma</i>	5 – 10 %
<i>Padina tetrastrum</i>	5 – 65 %
<i>Stoechospermum marginatum</i>	5 – 22 %
<i>Sphacelaria furcigera</i>	5 – 58 %
<i>Sargassum cinereum</i>	5 – 50 %
<i>Gracilaria corticata</i>	5 – 38 %
<i>Laurencia obtusa</i>	0 – 18 %
<i>Jania rubens</i>	0 %

Figure No. A.f

Vertical distribution of algae in terms of exposure to air at Site – 1

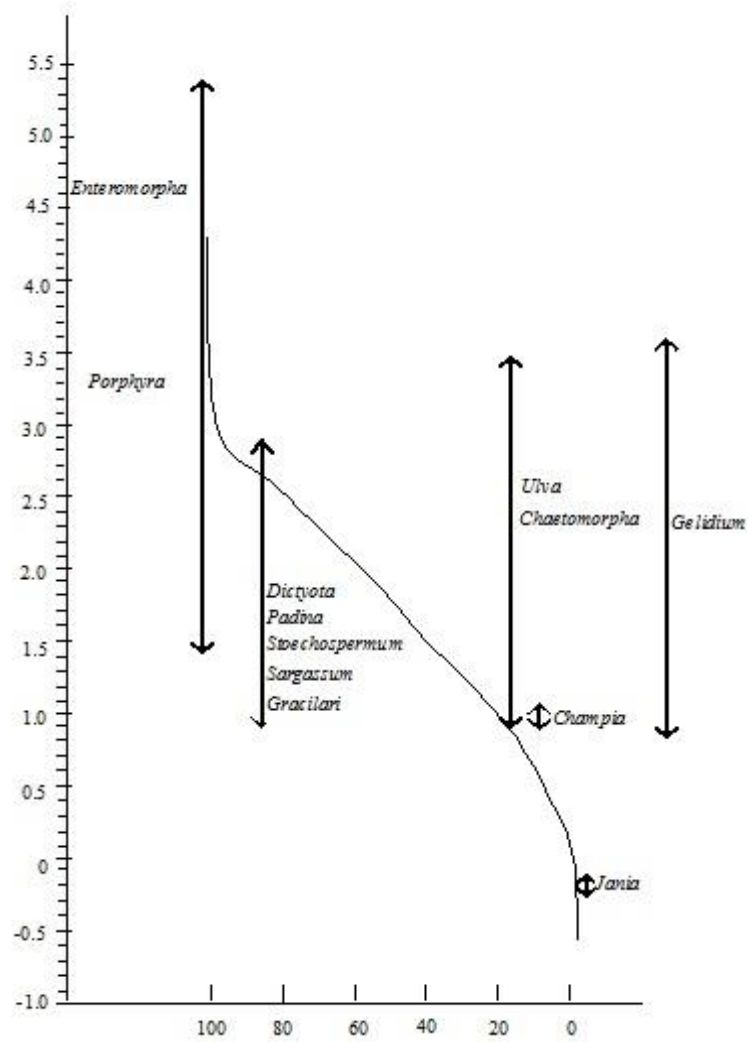
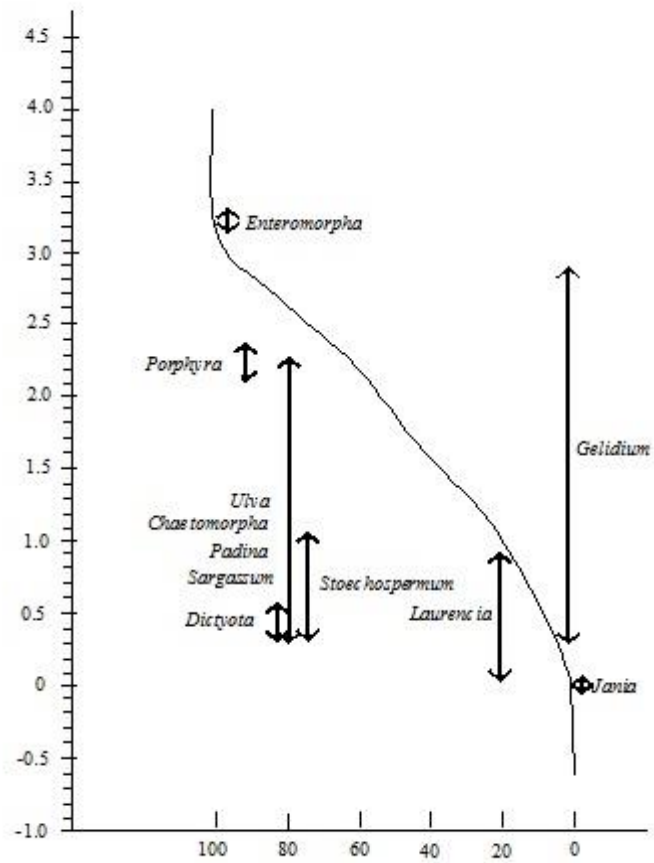


Figure No. A.g

Vertical distribution of algae in terms of exposure to air at Site – 2



CONCLUSION:

The study of vertical distribution of the marine algae at Hedavi and Kolthare, along the North Ratnagiri district has been carried out. The line transects at Site – 1 and Site – 2 were measured about 50 and 52 meters respectively, extending from the shoreline to low water level. The height at each meter along the transect has been calculated with the help of Emery profile method. The vertical emersion at Site – 1 was found to be 5.4 meters while at Site – 2 it was found to be 3.2 meters above the Chart Datum.

The zonation pattern of the marine algae at Hedavi and Kolthare shows close conformity with the universal scheme of zonation pattern for rocky coasts as suggested by Stephenson and Stephenson (1949). The five different zones at Hedavi and Kolthare have been recognized as follows,

1. Supralittoral Zone: This zone existed in the monsoon period i.e. from July to August. *Enteromorpha flexuosa* was the only alga found in this zone throughout the study period.
2. Supralittoral fringe: This zone was characterized by *Chaetomorpha linum*, *Spongomorpha indica*, and *Ulva lactuca* and some red algae like *Gelidium pusillum* and *Jania rubens* (in rock pool). The upper limit of this zone at both sites coincided with the lower limit of the supralittoral zone. The alga *Ulva lactuca* sometimes was seen migrated to upper zone.
3. Midlittoral zone: The algal species of this zone were *Padina tetrastrum*, *Porphyra vietnamensis* and *Gelidium pusillum*. Whereas *Chaetomorpha linum*, *Ulva lactuca* extended from supralittoral fringe down to the lower limit of this zone. *Sargassum*

cinereum, *Dictyota*, *Stoechospermum marginatum*, *Gracilaria corticata*, *Hypnea valentiae*, etc. were seen growing in the rock pools of this region.

4. Infralittoral fringe: In this zone brown algae like *Padina tetrastrum*, *Stoechospermum marginatum*, *Sargassum cinereum*, *Sphacelaria furcigera*, *Spatoglossum asperum*, and red algae like *Gracilaria corticata*, *Centroceras clavulatum*, *Hypnea valentiae*, and *Gelidium pusillum* were present. While some algal species like *Sargassum cinereum*, *Spatoglossum asperum*, *Gracilaria corticata*, *Gelidium pusillum*, *Laurencia obtusa*, *Champia compressa*, and *Catenella rapens* occupied the lower part of this zone and, also extend into the infralittoral zone.
5. Infralittoral zone: This zone was characterized by the growth of *Sargassum cinereum*, *Laurencia obtusa*, *Champia compressa*, and *Catenella rapens*, which were restricted only to this zone and were seen in the infralittoral zone as well as in the infralittoral fringe.

Thus five characteristic zones existed along the coast of Hedavi and Kolthare, but it was observed that, most of the algal species were found in the infralittoral region and infralittoral zone.

Along with the zonation pattern, factors like critical level of tides and percentage exposure has been studied following the method described by Doty (1946) and Evans (1947). But it has been found that, the critical tide and percentage exposure to air were not the sole factors responsible for zonation, but some other factors like temperature and insolation were equally responsible.

Some algal communities were found in the rock pools at both sites. These algal species mainly comprised of the members of the infralittoral fringe and infralittoral zone. But such members of these rock pools never got exposed to air.

At Hedavi and Kolthare, mixed type of algal populations was observed and termed as algal mosaics. This mosaic zone showed vertical migration of algal species in different months of the year.

The seasonal variation has shown relation with the zonation pattern of algal community, as during the monsoon period the algal flora was very poor. The algal community has shown more density during the post monsoon period in the month of November to January. The density again was found to be gradually reduced during the summer season till the monsoon period and during the monsoon season majority of the algal members got vanished. Thus, the mode of seasonal succession is markedly different from the one described by Srinivasan K.S. (1946), Umamaheshwar Rao M. and Sreeramulu T. (1964) and Umamaheshwar Rao M. (1972).

REFERENCES:

- ❖ Allender, B. M., Effects of emersion and temperature upon growth of the tropical brown alga *Padina japonica* using a tide-simulation apparatus, *Marine Biology*, 40: 95 – 99, 1977.
- ❖ Anand, P. L., Marine algae from Karachi, Pt 1, Chlorophyceae, Punjab Univ. bot. publ., Lahore., 1 – 52, 1940.
- ❖ Anand, P. L., Marine algae from Karachi, Pt 2, Rhodophyceae, Punjab Univ. bot. publ., Lahore., 1 – 76, 1945.
- ❖ Balkrishnan, M. S., and Kinkar, V. N., A taxonomic account of Indian Ectocarpales and Ralfsiales, *Seaweed Res. Utiln.*, 4 (2): 1 – 57, 1981.
- ❖ Balasundaram, A., Studies on the intertidal ecology of rocky shores at Thiruchendur, Ph.D. Thesis, Univ. of Madras, Madras, 1981.
- ❖ Biswas, K., A general review of the marine algae of the West coast of India, *J. Bom. Nat. Hist. Soc.*, 45 (5): 237 – 241, 1945.
- ❖ Boergesen, F., Some Indian green and brown algae, especially from the shores of the Presidency of Bombay – I, *J. Indian bot. Soc.*, 9: 151 – 174, 1930.
- ❖ Chaugule, B. B. and Gunale, V. R., Marine algae of Konkan (Maharashtra), *M.V.M. Patrika*, 16 (1-2): 5 – 14, 1981.
- ❖ Chaugule, B. B. and Deodhar, H. D., Notes on Konkan algae III, *Champia compressa* Harvey, *Seaweed Res. Utiln.*, 7 (2): 63 – 64, 1985.
- ❖ Chauhan, V. D., Report on the survey of marine algal resources of Maharashtra coast, *Salt. Res. Ind. (CSMCRI, Bhavnagar, India)*, 14: 10, 1979.
- ❖ Daisuke, F. *et al*, Vertical distribution and zonation of marine algae in *Sargassum* forests at Abugashima Island in Western Toyama Bay, *Japanese Journal of Phycology*, **Volume 52, No.3**: 149 – 155, 2004.

- ❖ Dawes, C. J., Marine Botany, A Wiley Interscience publication, New York, USA, 1981.
- ❖ Deodhar, H. D., The biology of marine algae of Bombay, Ph.D. thesis, University of Pune, 1987.
- ❖ Dhargalkar, V. K., Untwale, A. G. and Jagtap, T. G., Marine Macroalgal diversity along Maharashtra coast: past and present status, Ind. J. Mar. Sci., Volume 30: 18 – 24, 2001.
- ❖ Desai V., Geomorphology, and climatology of Mumbai coast, Ph.D. Thesis, University of Mumbai, 2002.
- ❖ Dixit, S. C., Species list of Indian marine algae I, J. Univ. Bombay, 32 (2-5):1 – 23, 1964.
- ❖ Dixit, S. C., Species list of Indian marine algae II, J. Univ. Bombay, 36 (3-5): 9 – 24, 1968.
- ❖ Dixit, S. C., Species list of Indian marine algae III, J. Univ. Bombay, 34 (66): 99 – 130, 1970.
- ❖ Dixit, S. C., Species list of Indian marine algae IV, J. Univ. Bombay, XLVIII – XLVIX (75-76): 56 – 80, 1973.
- ❖ Dooty, M. S., Critical tide factors that are correlated with the vertical distribution of marine algae and organisms along the Pacific coast, Ecology, 27: 313 – 328, 1946.
- ❖ Druehl, L. D. and Green, J. M., Vertical distribution of intertidal seaweeds as related to patterns of submergence and emergence, Mar. Ecol. Pro. Ser. 9 (2): 163 – 170, 1982.

- ❖ Duggins, D. O., Simenstad, C. A., and Estes, J. A., Magnification of secondary production by kelp detritus in coastal marine ecosystems, *Science*, 245: 170 – 173, 1989.
- ❖ Ellis, D. V., Rocky shore intertidal zonation as a means of monitoring and assessing shoreline biodiversity recovery., *Marine Pollution Bulletin* 46: 305–307, 2003.
- ❖ Evans, R. G., The intertidal ecology of Cardigan Bay, *J. Ecol.*, 34: 273 – 309, 1947a.
- ❖ Feldmann, J., Recherché sur la vegetation marine de la mediterranee lo cote des Alberes, *Rev. Algol.*, 10: 1-339, 1937.
- ❖ Feldmann, J., L'ordre des scytosiphonales, *Trav. bot. ded. ar, Maire Alger*. pp. 103-115, 1949.
- ❖ Feldmann, J., Ecology of marine algae in manual of phycology, *An introduction to the algae and their biology*, (ed. Smith G.M.) *Chronica Botanica*, Waltham, Massachusetts, pp. 313-334, 1951.
- ❖ Iyengar, M. O. P., Krusadai island flora, *Bull. Madras Govt. Museum N. S. Nat. Hist. Sn. Vol. I. Appendix II*. 185-188, 1927.
- ❖ Kadam, S. S., and Tiwari, L. R., Ecological study of phytoplankton from Dahanu creek – west coast of India, *Ind. J. Mar. Sci.*, Vol. 40, No. 4: 593 – 597, 2011.
- ❖ Kirtikar, K. R., A new species of alga *Conferva thermalis* Birdwood, *J. Bomb. Nat. Hist. Soc.*, 1: 135 – 138, 1887.
- ❖ Krishnamurthy, V. and Subbaramiah, K., The importance of shore types in intertidal ecology of Indian marine algae, *Proc. Ind. Nat. Sci. Acad.* 38 (B) (3 & 4): 259 – 266, 1972.

- ❖ Krishnamurthy, V., Ecology and seasonal succession of marine algal flora of salt marsh at Madras, J. Madras Univ., B 24(2): 161-178, 1954.
- ❖ Misra, J. N., The ecology, distribution and seasonal succession of the littoral algae on the West coast of India, Proc. Symp. Algology, Indian Coun. Agri. Res., New Delhi 1959: 187-203, 1960.
- ❖ Murthy, M. S., Bhattacharya, M., and Radia, P., Ecological studies of the intertidal algae of Okha (India), Botanica Marina, Vol. XXI: 381 – 386, 1978.
- ❖ Murthy, S. B. K., and Umamaheswara Rao, M., Effect of industrial wastes on the growth and reproductive stages of macroalgae of Visakhapatnam coastline, east coast of India, Ind. J. Mar. Sci., Vol. 32 (1): 57 – 66, 2003.
- ❖ Odum, E. P., “Fundamentals of Ecology”, published by W. B. Saunders Co., Philadelphia and London, 1971.
- ❖ Parija, P. and Parija, B., Algal succession on a rocky island named Charaiguha in the Chilka Lake, J. I. B. S., M.O.P. Iyengar Commom. Vol. (Ed. By B. Sahni): 378 – 379, 1946.
- ❖ Phanse, S. S., The Biology of marine algae of Konkan, M.Sc. (Research) thesis, University of Mumbai, 2000.
- ❖ Ramalakshmi, Y., Chauhan, V. D., Ecological study of *Sargassum swartzii* (Turn). C. Ag. on the coast of Port Okha, Gujrat, J. Environ. Bio., 13 (2): 135 – 144, 1992.
- ❖ Srinivasan, K.S., Ecology and Seasonal succession of marine algae at Mahabalipurum (Seven Pagodas) near Madras, J. I. B. S., M.O.P. Iyengar Commom. Vol. (Ed. By B. Sahni), pp. 267 – 278, 1946.
- ❖ Stephenson, T.A. and Stephenson, A., The universal features of zonation between tidemarks on rocky coasts, J. Ecol., 37: 289 – 305, 1949.

- ❖ Svedelius, N., Über die algenvegetation eines ceylonischen korallenriffes mit besondererrucksicht auf ihre periodizitat, Bot. Stud. Till. Kjellmann: 184 – 220, 1906a.
- ❖ Svedelius, N., Ecological and systematic studies on the Ceylon species of *Caulerpa*, Ceylon Mar. Boil. Reports, No. 4: 81 – 144, 1906b.
- ❖ Umamaheshwar Rao, M. and Sreeramulu, T., Vertical zonation and seasonal variation in the growth of *Porphyra* on Vishakhapatnam coast, Current Science, 32: 173 – 174, 1963.
- ❖ Umamaheshwar Rao, M. and Sreeramulu, T., Ecological studies on some intertidal algae of the Vishakhapatnam coast, Journal of Ecology, 52: 595 – 616, 1964.
- ❖ Umamaheshwar Rao, M., Ecological observations of some intertidal algae of Mandapam coast, Proci. Indian Nat. Sci. Acad. 38 B (3 & 4): 298 – 307, 1972.
- ❖ Venkataraman, K. and Wafar, M., Coastal and marine biodiversity of India, Ind. J. Mar. Sci., Vol. 34 (1): 76 – 87, 2005.
- ❖ Wahlenberg, G. E., Flora laponica, exhibens plantas geographice et botanicae in lapponii's succicis, Berlin, Reimer, lxvi: 550, 1812.