International Journal of Agricultural Sciences
Volume 19 | Issue 1 | January, 2023 | 185-192 ■ ISSN : 0973-130X
DOI:10.15740/HAS/IJAS/19.1/185-192
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RESEARCH PAPER

Seasonal distribution of phytoplankton in river Gauthami-Godavari, Andhra Pradesh

N. Prasanthi[1], A.V.V.S. Swamy* **and** K.N. Murty[2]
Department of Environmental Studies, Acharya Nagarjuna University, Guntur (A.P.) India

Abstract : The present study was investigated to evaluate the seasonal variability of phytoplankton species at the places Vruddha and Bhairavapalem along the stretch of river Godavari in Konaseema region, Andhra Pradesh. A total of 123 phytoplankton species were identified during the study period (2015-2017) in which diatoms contributes 91, dinoflagellates -26, Blue Green Algae-1 chlorphyceae-4. Dissimilarity in phytoplankton species composition was noticed in all seasons. Diatoms found as the dominant prevailing phytoplankton group in all seasons in terms of number of species and abundance. Diatom species *viz., Coscinodiscus* sp., *Thalassiothrix* sp., *Skeletonema costatus* were ubiquitous off Godavari estuary throughout the year. Diatoms are the most abundant group dominated in late winter and early spring bloom whereas dinoflagellates, dominate during the late spring blooms.

Key Words : Phytoplankton, Nutrients, Godavari river

View Point Article : Prasanthi, N., Swamy, A.V.V.S. and Murty, K.N. (2023). Seasonal distribution of phytoplankton in river Gauthami-Godavari, Andhra Pradesh. *Internat. J. agric. Sci.*, **19** (1) : 185-192, **DOI:10.15740/HAS/IJAS/19.1/185-192.** Copyright@2023: Hind Agri-Horticultural Society.

Article History : Received : 18.09.2022**; Revised :** 04.11.2022**; Accepted :** 05.12.2022

INTRODUCTION

The phytoplankton community is very vital in the food web dynamics of sea. About 90% of the total production in aquatic ecosystem is contributed by the phytoplankters. Phytoplanktons are primary producers from the base of food webs that supports commercial fisheries, in the marine environment (Sridhar *et al.,* 2006, Mathivanan *et al.,* 2007 and Saravanakumar *et al.*, 2008). Diatoms and other dominating phytoplankton constitute a fundamental link in aquatic food web and contribute significantly to the biogeochemical fluxes and cycle within the ecosystem (Lalli *et al.*, 1997 and Miller, 2004). As a result, phytoplankton, especially diatoms, remains as subject of increased interest with respect to global warming and effects of carbon dioxide (CO_2) emissions in the atmosphere (Miller, 2004). Two significant ecological factors are familiar as controlling community structure of phytoplankton. The first is related to physical processes, such as mixing of water masses, light, temperature, salinity, and the second is associated with chemical aspects *i.e.* nutrients (Reynolds, 1984).

MATERIAL AND METHODS

The Gautami-Godavari estuary is one of the largest

***Author for correspondence:**
[1]Department of Environmental Studies, Pragati Engineering College (Autonomous), Surampalem (A.P.) India
[2]Department of Fisheries, Ideal College of Arts and Sciences (Autonomous) Kakinada (A.P.) India

estuaries on the east coast of India. The Godavari estuarine system is located at ~ 16º 42' 34" N and 82º 19' 09" E and covers an area of 15 km². Surface water samples were collected at monthly intervals from March 2015 to February 2017 (21 months). During navigation, GPS (Global Positioning System), GARMIN was used. The sampling stations (Gautami Godavari River) are at a distance of 0 to 15 km from Vruddha to Bhairavapalem (Fig.A). In the laboratory, the samples were concentrated by sedimentation (UNESCO, 1978) by allowing them to stand for 48 hrs before the supernatant was siphoned off; leaving a final volume of 100ml. Out of this, 1ml of the concentrated sample was taken for counting with a Sedgwick Rafter Counting chamber. A minimum of three replicates were counted for each sample. Identification and enumeration of samples were performed using (Labomed, Germany) research microscope (Lx400). Abundance of each species was expressed as nos^{-ml}. Nomenclature and classification adopted for taxonomic identification of phytoplankton was according to Tomas (1997). Species identification was carried out according to Subrahmanyan (1946), Desikachary (1986-89) and Tomas (1997) for Bacillariophyta; Subrahmanyan (1959), Desikachary (1959).

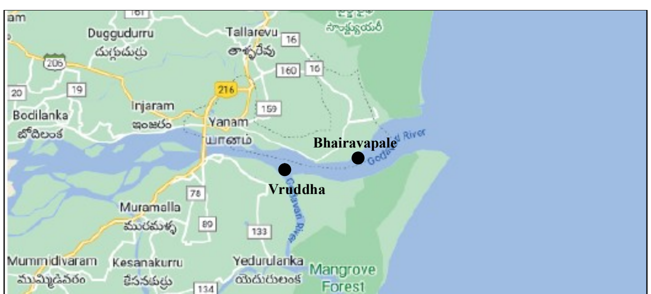

Fig. A : Study area (Vruddha and Bhairavapalem)

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Vruddha :

In the Vruddha region 88 species were identified with 65 Bacillariophyceans, 17 dinophyceans, 2 cyanophyceans,4 Chlorophyceans and Euglenophyceans. There was prevalence of *Chaetoceros* sp. *Coscinodiscus eccentricus, Coscinodiscus* sp., *Skeletonema coastatum,* Gyrosigma sp. *Navicula* sp. *Nitzschia* sp., *Thalassionema nitzschiodes, Thalassionema* sp., *Thalassiothrix longissima, Thalassiothrix* sp., Dinoflagellates were *Prorocentrum micans* and Cyanophyceans *Trichodesmium erythraeum* (Table 1). The composition of dominant species has changed from the year 2015-2016 to 2016-2017. It is observed that the diatoms number has decreased during monsoon season and increased during pre monsoon and post monsoon seasons. Dinoflagellates number has decreased in all the seasons (Table 2). Cyanophyceae and Chlorophyceae number has increased in year 2016-2017 compared to the past year (Fig. 1).

Table 1: Overall Distribution of phytoplankton at Vruddha and Bhairavapalem (Gautami-Godavari River) March 2015 to February 2017

Phytoplankton groups	(Vruddha) Cells. ml⁻	(Bhairavapalem) Cells. ml⁻
Diatoms	65	69
Dinoflagellates	17	21
Cyanophyceae	2	2
Chlorophyceae	4	3
Euglenophyceae	-	-
Total	88	95

Table 2 : Seasonal distribution of phytoplankton at Vruddha (Gautami-Godavari River) March 2015 to February 2017

Groups	2015 to 2016			2016 to 2017		
	Pre.M	M	PoM	Pre.M	M	PoM
Diatoms	24	33	18	27	19	36
Dinoflagellates	8	9	6	5	3	5
Cyanophyceae	0	1	1	1	1	2
Chlorophyceae	0	1	0	2	0	1
	32	44	25	35	23	44

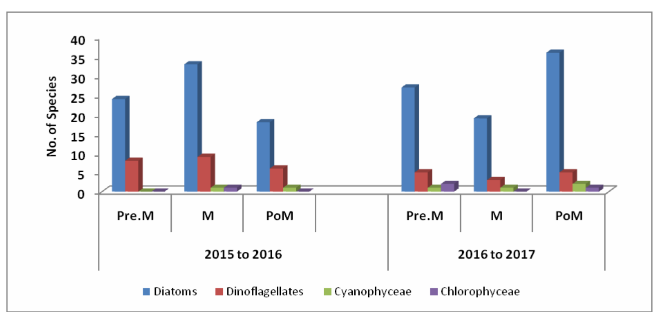

Fig. 1: Graph showing phytoplankton species variation at Vruddha

Bhairavapalem :

In this station 95 species were observed with 69 Bacillariophyceans, 21 dinophyceans, 2 cyanophyceans3 Chlorophyceans and Euglenophyceans. There was preponderance of *Chaetoceros* sp. *Coscinodiscus Coscinodiscus* sp., *Rhizosolenia* sp., *Skeletonema coastatum*, *Navicula* sp.,*Thalassionema nitzschiodes, Thalassionema* sp., *Thalassiothrix longissima, Thalassiothrix* sp., Dinoflagellates were *Ceratium furca, Prorocentrum micans* and Cyanophyceans *Trichodesmium erythraeum*. It is observed that the Dinoflagellates number has increased significantly during pre monsoon season at this station (Table 3) and Diatoms number has decreased during monsoon season and increased during pre monsoon and post monsoon seasons in the year 2016-2017 in contrast to 2015-2016 (Fig. 2).

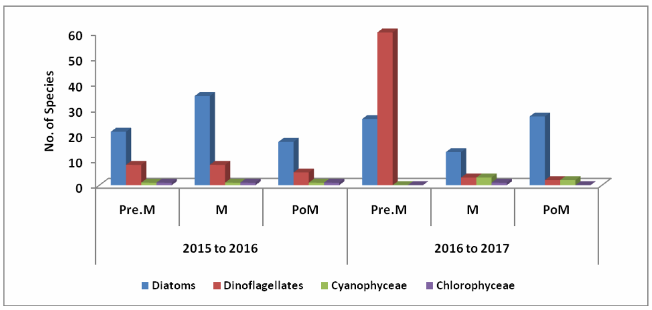

Fig. 3 : Graph showing phytoplankton species variation at Bhairavapalem

Phytoplankton species were commonly station wise observed during the present study (Table 2). According to Raymont, 1981, the diatom species such as *Chaetceros* sp., *Coscinodiscus* sp., *Skeletonema costatum Thalassionema* sp.,*Thalassiothrix* sp. and blue green algae *Trichodesmium erythraeum* followed by dinoflagellates such as *Prorocentrum micans* form typical members of warm water phytoplankton. The phytoplankton taxa encountered during this investigation in general agrees with those reported from the coastal and estuarine waters of Goa (Devaasy and Goes, 1988), Chennai coast (Subramanyan, 1946, 1968, Desikachary, 1987), and Kalpakkam coast (Sahu *et al.*, 2012) Parangipettai coast (Manigandan *et al.*, 2017) Godavari River (Bharathi *et al.*, 2018).

The abundant pennate diatoms *viz., Skeletonema costatum Thalassionema* sp., *Thalassiothrix* sp., usually with high surface to volume ratio might be absorbing nutrients rapidly. But, the highly diverse centric diatoms *viz.,* (Skeletonema, Coscinodiscus, Chaetoceros, etc., with low surface to volume ratio) might begin multiplying after the optimal nutrient concentrations are attained. Mixture of these communities, therefore, may be well suited to inhabit the low nutrient, generally stratified upper water column in the Bay. It is also well known that oligotrophic waters are more diverse compared to mesotrophic and/or eutrophic waters (Raymont, 1980).

Presence of high numbers of *Thalassiothrix* sp. appear to contribute in a large way to the biomass along both transects as well as to the material fluxes. Ramaswamy and Nair (1994) reported the highest particle flux and organic carbon to carbonate carbon ratios in the deep traps being during the summer monsoon. Apparently, oligohaline waters and warm temperatures

Table 3: Seasonal distribution of phytoplankton at Bhairavapalem (Gautami-Godavari River) March 2015 to February 2017

	2015 to 2016			2016 to 2017		
	Pre.M	M	PoM	Pre.M	M	PoM
Diatoms	21	35	17	26	13	27
Dinoflagellates	8	8	5	60	3	2
Cyanophyceae	1	1	1	0	3	2
Chlorophyceae	1	1	1	0	1	0
	31	45	24	86	20	31

Table 4: Overall Seasonal abundance of phytoplankton during 2015 to 2017

Groups	2015 to 2016						2016 to 2017					
	Pre.M	%	M	%	PoM	%	Pre.M	%	M	%	PoM	%
Diatoms	48	68.6	56	68.3	46	69.7	46	76.7	37	74.0	42	75.0
Dinoflagellates	17	24.3	20	24.4	15	22.7	12	20.0	9	18.0	7	12.5
Cyanophyceae	1	1.4	2	2.4	2	3.0	1	1.7	2	4.0	3	5.4
Chlorophyceae	1	1.4	4	4.9	3	4.5	1	1.7	2	4.0	4	7.1
Euglenophyceae	3	4.3	-	-	-	-	-	-	-	-	-	-
Total	70	100.0	82	100.0	66	100.0	60	100.0	50	100.0	56	100.0

Appendix : Phytoplankton composition (Mean, nos.ml^{-1}) in Godavari river during March 2015 – February 2017

Sr. No.	Phylum	Class	Order	Family	Genus	Species	Vruddha	Bhairava-palem
	Protokaryota							
1.	Cyanophyta	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	*Oscillatoria*	*Trichodesmium erythraeum*	3	3
2.					*Richelia*	*Richelia intracellularis*	74	83
3.	Eukaryota							
4.	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Skeletonemaceae	*Skeletonema*	*Skeletonema costatum*	183	229
5.				Thalassiosiraceae	*Thalassiosira*	*Thalassiosira* sp,	33	17
6.					*Lauderia*	*Lauderia* sp.	6	3
7.					*Podosira*	*Podosira* sp.		3
8.					*Cyclotella*	*Cyclotella striata*	3	10
9.					*Planktoniella*	*Planktoniella sol*		3
10.			Melosirales	Melosiraceae	*Melosira*	*Melosira* sp.	13	17
11.					*Stephanopyxis*	*Stephanopyxis turris*	3	0
12.					*Paralia*	*Paralia sulcata*	0	7
13.						*Paralia* sp.	3	0
14.				Leptocylindraceae	*Leptocylindrus*	*Leptocylindrus danicus*	3	0
15.						*Leptocylindrus* sp.	40	17
16.					*Corethron*	*Corethron criophilum*	6	0
17.						*Corethron* sp.	0	3
18.				Coscinodiscaceae	*Coscinodiscus*	*C. radiatus*	23	7
19.						*C. gigas*	3	0
20.						*Coscinodiscus* sp.	169	197
21.					*Hemidiscus*	*Hemidiscus hardmanianus*	3	0
22.						*Hemiaulus hauckii*	0	3
23.						*Hemiidiscus*sp.	3	0
24.				Asteriolampraceae	*Asteromphalus*	*A. arachne*	10	23
25.						*A. cleceanus*	3	3
26.						*A. flabellatus*	3	0
27.						*Asteriomphalus* sp.	13	3
28.			Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia*	*R. pungens*	3	3
29.						*R. cylindrcus*	0	7
30.						*R. cochlea*	23	20
31.						*R. crassispina*	54	47
32.						*R. imbricata*	0	10
33.						*R. setigera*	10	7
34.						*R. striata*	10	3

Appendix : Contd………..

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35.					*Rhizosolenia* sp.	81	60
36.				*Guinardia*	*G. striata*	10	7
37.					*Guinardia* sp.	17	3
38.			Hemiaulaceae	*Hemiaulus*	*Hemiaulus* sp.	3	0
39.				*Eucampia*	*Eucampia* sp.	3	0
40.		Chaetocerotales	Chaetocerotaceae	*Chaetoceros*	*Ch. coarctatus*	10	10
41.					*Ch. curvisetus*	0	7
42.					*Ch. decipiens*	0	3
43.					*Ch. lorenzianus*	37	17
44.					*Chaetoceros* sp.	157	100
45.				*Bacteriastrum*	*B. furcatum*	0	3
46.					*B. heterocera*		
47.					*B. directicum*	0	3
48.			Lithodesmiaceae	*Lithodesmium*	*L. undulatum*	0	3
49.				*Ditylum*	*D. brightwellii*	27	13
50.					*D. sol*	40	13
51.					*Ditylum* sp.	17	0
52.			Eupodiscaceae	*Odontella*	*O. mobiliensis*	20	33
53.					*Odontella* sp.	9	19
54.				*Triceratium*	*Triceratium* sp.	3	0
55.		Bacillariales	Bacillariaceae	*Bacillaria*	*Bacillaria paradoxa*	3	10
56.				*Nitzschia*	*N. longissima*	43	20
57.					*N. sigma*	23	3
58.					*N. seriata*	26	7
59.					*N. pungens*	0	3
60.					*Nitzschia* sp.	60	33
61.				*Pseudo-nitzschia*	*Pseudo-nitzschia australis*	0	3
62.				*Cylindrotheca*	*Cylindrotheca closterium*	7	3
63.				*Climacosphenia*	*Climacosphenia* sp.	0	10
64.				*Licmophora*	*Licmophora* sp.	3	0
65.		Tabellariales	Thalassionemataceae	*Thalassionema*	*T. nitzschioides*	90	100
66.					*T. psedo-nitzschioides*	10	0
67.					*Thalassionema* sp.	220	323
68.					*T. longissima*	67	100
69.					*Thalassiothrix* sp.	117	87
70.			Fragilariaceae	Asterionella	*Asterionella japonica*	10	17
71.					*Asterionella* sp.	53	30
72.				*Frazillaria*	*Frazillaria* sp.	10	0
73.		Naviculales	Naviculaceae	*Navicula*	*N. granii*	3	7
74.					*N. rhombicas*	23	23

Appendix : Contd………..

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75.						*N. vanhoeffeni*	23	7
76.						*Navicula* sp.	90	60
77.						*P. formosum*	20	10
78.						*P. balticum*	3	0
79.						*Pleurosigma* sp.	53	30
80.					*Gyrosigma*	*Gyrosigma* sp.	87	49
81.				Diploneidaceae	*Diploneis*	*D. robusta*	0	3
82.						*D. weissflogi*	0	3
83.						*D. bombus*	3	0
84.						*D. smithii*	0	3
85.						*Diploneis* sp.	0	10
86.			Thalassiophysales	Catenulaceae	*Amphora*	*Amphora sp.*	0	3
87.			Surirellales	Surirellaceae	*Surirella*	*Surirella* sp.	7	0
88.	Dinophyta	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratium*	*C. furca*	47	50
89.						*C. fusus*	10	7
90.						*C. symmetricum*		
91.						*C. trichoceros*		
92.						*C. tripos*	0	10
93.						*Ceratium* sp.	26	12
94.			Peridiniales	Peridiniaceae	*Peridinium*	*Peridinium* sp.	7	3
95.				Protoperidinaceae	*Protoperidinium*	*Protoperidinium conicum*	3	3
96.						*P. pentagonum*	0	7
97.						*P. punctulatum*	0	3
98.						*P. depressum*	0	7
99.						*P. oceanicum*	0	10
100.						*P. parthenopes*	0	10
101.						*P. pallidum*	3	0
102.						*Protoperidinium* sp.	30	13
103.			Prorocentrales	Prorocentraceae	*Prorocentrum*	*P. dentatum*	3	0
104.						*P. gracile*	17	10
105.						*P. micans*	90	57
106.						*P. scutellum*	0	3
107.						*Prorocentrum* sp.	17	23
108.					*Exuviaella*	*Exuviaella compressa*	10	17
109.				Dinophysiaceae	Dinophysis	*Dinophysis cudata*	7	17
110.						*Dinophysis* sp.	7	23
111.				Oxyphysaceae				
112.			Gymnodinials	Gymnodiniaceae		*Gymnodinium* sp.	7	7
113.			Noctilucales	Noctilucaceae	Noctiluca	*Noctiluca* sp.		
114.			Gonyaulacales	Gonyaulacaceae	*Gonyaulax*	*Gonyaulax* sp.	3	0
115.	Euglenophyta	Euglenophyceae	Euglenales	Euglenaceae	*Euglena*	*Euglena* sp.		
116.	Chromophyta	Dictyochophyceae	Dictyochales	Dictyochaceae	*Dictyocha*	*Dictyocha fibula*	3	0
117.						*Dictyocha* sp.	7	7
118.		Prymnesiophyceae	Coccosphaerales	Braarudosphaeraceae	*Coccolithophores*	*Coccolithophores* sp.	10	7
119.			Syracosphaerales	Rhabdosphaeraceae	*Acanthoica*	*Acanthoica aculeata*	0	3
120.						*Acanthoica quattropina*		
121.	Chlorophyta	Chlorophyceae	Chlorococcales		*Dunaliella*	*Dunaliella* sp.	3	0

around 28-30ºC at this location are ideal for *Skeletonema costatum*. Low salinity near-coastal tropical regions are reported to aid the proliferation of this species (Mitbavkar and Anil 2000 and Babu *et al.,* 2001).

Seasonal variations of phytoplankton :

Thalassionema sp. density was observed during pre-monsoon (2015-16) *i.e.* (117 ml^{-1} and 227 ml^{-1}) at Vruddha and Bhairavapalem (Table 4). But more than a few workers reported lower phytoplankton population density in monsoon attributed to high turbidity, reduced salinity, decreased temperature and pH. In this season phytoplankton density showed complete dominance of diatom. Similar observation was also reported by Paul *et al.* (2007). So in this case it can be said that higher abundance in monsoon season compared to post-monsoon might be due to the ecological adaptation by phytoplankton community to utilize the available nutrients. Phytoplankton population density as well as Chl-*a* exhibited positive correlation with all the measured nutrients specifically with NO_2, NO_3 and PO_4. Phytoplankton requires a wide array of nutrients for its growth among which nitrogen and phosphorous are proved to be important.

The phytoplankton dominance recorded in the present study was similar to that of Bay of Bengal studied by (Gouda and Panigrahy, 1996). The distribution of phytoplankton depends on the physico-chemical and nutrient conditions. In Arabian sea Sawant and Madhupratap (1996) reported that the diatoms were the largest group followed by Dinoflaggelates. Radhakrishna *et al.* (1978) reported that the *Cosinodiscus* sp., *Chaetoceros* sp. and *Skeletonema coastatum*, *Thalassionema* sp., were the dominant forms in the parts of Godavari river. In the present study changes in the distribution of phytoplankton may be due to changes in hydrographical conditions and light requirement of the species as reported by (Marshall, 1996).

Conclusion :

The function of phytoplankton is the potential to achieve photosynthesis, namely: a process that can absorb solar energy and form organic compounds from inorganic compounds. These organic compounds are a source of vigor that is required by all living creatures for various activities including moving, growing, and reproducing. Hence, phytoplankton is an important component of all life in the waters, either directly or indirectly, or through the food chain. Based on the present observation it can be concluded that the phytoplankton species vary in their abundance from one station to another in the study area depending on the water quality and seasonal variations.

Acknowledgment :

Authors thank to Department of Environmental Studies for provided Research and Community Service, Acharya Nagarjuna University, Guntur.

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