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Seasonal dynamics of phytoplankton and its relationship with the environmental factors in Meghadrigedda Reservoir of Visakhapatnam, Andhra Pradesh, India

Jyothi Kaparapu and Mohan Narasimha Rao Geddada

Department of Botany, Andhra University, Visakhapatnam–530 003, Andhra Pradesh, India.

Corresponding author: jyothikaparapu@gmail.com

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Abstract:
As understanding the process of phytoplankton variation is useful in water quality improvement and management decisions, the present investigation was carried out to know the limnobiotic status of Meghadrigedda Reservoir of Visakhapatnam district of Andhra Pradesh, India, over a period of April 2012 to March 2013. In this study, the phytoplankton composition, abundance, seasonal variations were studied based on a monthly sampling campaign from five sampling stations. A total of 40 genera, and 63 species, which belong to Chlorophyta (19 genus, 35 species), Bacillariophyta (8 genus, 13 species), Cyanophyta (11 genus, 12 species), Euglenophyta (2 genus, 3 species) were identified. Phytoplankton community structure and water quality variables changed substantially over the survey period. Plankton population size was correlated with biotic and abiotic parameters (pH, alkalinity, temperature, dissolved oxygen, biological oxygen demand, total dissolved solids, Total solids, Sulphates, transparency, phosphate, chloride, and nitrate). Pearson correlations analysis as an integrated approach was applied to analyze the relationships among them. Temperature, Total phosphorus and nitrate played governing roles in the phytoplankton dynamics of reservoir during all periods investigated.

Introduction:

The benefit of freshwater natural reservoirs, which can be used to the potential benefit of mankind, cannot be overemphasized (Thakur *et al.*,2013; Mahapatra *et al.*, 2012; Monjerezi and Ngongondo, 2012). The composition and biomass of phytoplankton species in reservoirs depends on a complex combination of factors, such as temperature, light, availability of nutrients (Enio *et al*., 2012). Reynolds *et al*., 2002, used these factors for the establishment of a functional classification of algae capable of reflecting the ecology of the species. Seasonal replacements of phytoplankton assemblages are related closely to seasonal changes in temperature, external hydraulic and nutrient loads and light availability. Depending on their intensity and on their frequency, these may drive non-equilibrium dynamics and enhance the species diversity of the ecosystem (Margalef, 1958; Connell, 1978). Changes in the aquatic environment accompanying anthropogenic pollution are a cause of growing concern and require monitoring of the surface waters and the organisms inhabiting them (Vandysh, 2004). The trophic state of a reservoir is typically assessed by regularly monitoring a variety of physical and chemical indicators.

This paper concentrates on the monthly monitoring data of physico-chemical variables and phytoplankton community of Meghadrigedda Reservoir from April 2012 to March 2013. Objectives of this study included characterizing temporal phytoplankton dynamics with related variables and evaluating the interaction between seasonal variations of phytoplankton abundance and environmental variables in Meghadrigedda reservoir.

Materials and methods:

Study area: Meghadrigedda reservoir was constructed in 1977 in Visakhapatnam with gross capacity of 1169 million cubic foot, combined catchment area of 135.90 square meters. The geographical coordinates are 17°46'30"N; 83°10'51"E at Meghadrigedda reservoir, Visakhapatnam District, Andhra Pradesh, India. The water from the reservoir is being used for drinking and irrigation purposes. Water samples were collected on a monthly basis from the reservoir for a period of 1 year between April 2012 and March 2013. For the present study, five sampling points were selected. Samples were taken from the same location all the times.

Physicochemical Analyses: Surface water was collected from all the five sampling sites. Collections were made using plastic containers of 2-L capacity. The plastic containers were rinsed thoroughly with sampling water before use. After filling the containers, they were sealed and transferred to the laboratory for physicochemical analysis. Water temperature was recorded in the field using sensitive mercury thermometer. The pH of the samples was determined using digital pH meter. The transparency of water to light was measured by using Secchi disc. Physicochemical parameters of the water were analyzed according to standard methods (APHA, AWWA, and WEF, 2005)

Phytoplankton analyses: Plankton net (mesh size 25 µm) was swept on surface water and plankton was collected and transferred in to plastic container and fixed in 4% formalin. Then plankton samples were centrifuged at 1500-2000 rpm for 10-12 min. The phytoplanktons settled were diluted to a desirable concentration in such a way that they could be easily counted individually under compound binocular microscope and phytoplanktons were measured and multiplied with the dilution factors, using Sedgwick Rafter cell APHA (2005) as was described by Welch ,1948; Smith, 1950, Trivedi and Goel, 1986, Kodarkar *et al.*, 1991. Identification of the planktons was done following Smith, 1950; Desikachary,1959; Kudo, 1986 and Pennak,1989. Pearson correlation matrix was used to establish the relationship among various environmental variables and phytoplankton density with the help of SPSS 16.0 for windows.

Results

A total of 40 genera, and 63 species, which belong to Chlorophyta (19 genera, 35 species), Bacillariophyta (8 genera, 13 species), Cyanophyta (11 genera, 12 species), Euglenophyta (2 genus, 3 species) respectively, were determined from the water samples. The phytoplankton species observed at Meghadrigedda reservoir were shown in table-1. The maximum and minimum proportion of the community composition of Chlorophyceae 1095 (0.41%) at station 4 and 802 (44.78%) at station 1, Bacillariophyceae 714 (35.41 %) at station 2 and 554 (25.51%) at station 2, Cyanophyceae 424 (19.52%) at station 4 and 237(11.75%) at station 2, Euglenophyceae 151(7.5 %) at station 2 and 62 (3.76 %) at station three. (Table-2)

Table–1. The phytoplankton species observed at Meghadrigedda Reservoir during April 2012 – March2013.

Chlorophyceae	**Bacillariophyceae**
Astrococus palmella	*Cyclotella meneghiniana*
Coelastrum astroideum	*Cymbella affinis*
Closterium pronum	*C. delicatula*
Coenococcus planctonicus	*Fragilaria crotonensis*
Cosmarium auriculatum	*Navicula subtilis*
C. botrytis	*N. pupula*
C. dentiferum,	*N..reinholdi*
C. formulosum,	*N. viridula*
C.hammeri,	*Nitzschia denticula*
C.holmiense	*Pinnularia viridis*
C.impressulum,	*P.gibba*
C.polynicum	*Prorocentrum micans,*
C.subcostatum	*Rhopalodia gibba*
C.turpine	
Eudorina elegans	**Cyanophyceae**
Gloeocystis Gloeocystis	*Anabaena constica*
Hydrodictyon reticulatum	*Aphaocapsa biformis*
Micractinium pusillum	*Aphanotheca clathrata*
Oedogonium capilliforme	*Chroococcus minor*
Pandorina morum	*C. turgidus*
Pediastrum angulosum	*Eucapsis alpine*
P.boryanum	*Eucapsis alpine*
P. duplex	*Gloeotheca rupestris*

P. simplex	*Gomphospheria apomia*
Scenedesmus acuminatus	*Lyngbya majuscule*
S. obliquus	*Nostoc commune*
S. quadricauda	*Oscillatoria limosa*
Spirogyra longata	*Spirulina platensis*
Staurostrum crenulatum	
S.manfelditii	**Euglenophyceae**
Tetraspora cylindrical	*Euglena acus*
Ulothrix zonata	*E. viridis*
Volvox aureus	*Phacus curvicauda*
Zygnema pectinatum	
Z. gangeticum	

Table–2.Total seasonal variations of phytoplanktons's (org L^{-1}) at Meghadrigedda Reservoir during April 2012 – March2013.

Station	order	summer	monsoon	winter	total	percentage
1	Chlorophyceae	442	90	270	802	44.78
	Bacillariophyceae	286	94	211	591	33
	Cyanophyceae	**135**	**48**	**105**	288	16.08
	Euglenophyceae	**54**	**18**	**38**	110	6.14
2	Chlorophyceae	**487**	**129**	**298**	914	45.34
	Bacillariophyceae	320	109	285	714	35.41
	Cyanophyceae	**123**	**39**	**75**	237	11.75
	Euglenophyceae	**67**	**38**	**46**	151	7.5
3	Chlorophyceae	**449**	**97**	**255**	801	48.54
	Bacillariophyceae	234	73	190	497	30.1
	Cyanophyceae	**143**	**49**	**98**	290	17.6
	Euglenophyceae	**38**	**6**	**18**	62	3.76
4	Chlorophyceae	**588**	**150**	**357**	1095	50.41
	Bacillariophyceae	287	87	180	554	25.51
	Cyanophyceae	**209**	**77**	**138**	424	19.52
	Euglenophyceae	**51**	**15**	**33**	99	4.56
5	Chlorophyceae	**534**	**126**	**281**	941	45.19
	Bacillariophyceae	329	123	242	694	33.38
	Cyanophyceae	**152**	**62**	**101**	315	15.13
	Euglenophyceae	**63**	**25**	**44**	132	6.3

Physical–chemical characteristics of water samples showed the variations of physical and chemical factors with time from April 2012 to March 2013. The temperature, pH , Biological Oxygen Demand , Sulphate and transparency were showed increase in trend durind summer months where as nitrates and phosphates increase during rainy months.The collected data was presented season wise (summer, monsoon, winter) in table-3. Correlation

Coefficient (r) among the physico-chemical properties and phytoplankton of Meghadrigedda reservoir were shown in table-4.

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Table–3. Physico-Chemical parameters of Meghadrigedda Reservoir during April 2012 – March2013.

	Station	Temp ^0C	pH	DO mgL^{-1}	BOD mgL^{-1}	SO_4 mgL^{-1}	NO_3 mgL^{-1}	PO_4 mgL^{-1}	Transparency cm
Summer	1	25.40	7.02	3.83	3.55	11.56	0.99	0.019	47.72
	2	25.39	7.05	3.90	3.62	11.05	0.99	0.018	50.02
	3	26.13	7.05	3.88	3.54	11.73	1.00	0.022	46.52
	4	26.00	7.03	3.93	3.55	11.22	1.02	0.026	50.10
	5	25.28	7.03	3.90	3.61	11.51	1.00	0.020	48.57
Monsoon	1	24.11	6.68	5.90	2.00	10.99	1.31	0.0282	30.40
	2	23.57	6.70	6.08	1.95	10.87	1.33	0.0282	27.07
	3	24.01	6.75	5.90	2.00	10.60	1.32	0.0307	30.25
	4	23.76	6.68	6.03	1.95	10.45	1.33	0.0305	29.60
	5	23.84	6.70	6.03	2.15	10.68	1.25	0.0312	30.40
Winter	1	20.41	6.80	4.5	2.40	9.23	1.30	0.0287	33.82
	2	20.40	6.80	5.025	2.31	9.26	1.30	0.0315	34.55
	3	20.26	6.83	4.51	2.29	8.51	1.30	0.0312	33.42
	4	20.33	6.83	4.65	2.28	8.54	1.33	0.0315	34.82
	5	20.29	6.80	4.42	2.28	8.65	1.33	0.0302	34.97

Table–4. Correlation Coefficient (r) among the physico-chemical properties and phytoplanktons of Meghadrigedda reservoir from April2012 to March2013.

	temp	*pH*	*DO*	*BOD*	*SO4*	*NO3*	*PO4*	*Transp*	*Phyto*
temp	*1.00*								
pH	*0.51*	*1.00*							
DO	*-0.16*	*-0.93*	*1.00*						
BOD	*0.63*	*0.99*	*-0.87*	*1.00*					
SO4	*1.00*	*0.44*	*-0.09*	*0.57*	*1.00*				
NO3	*-0.77*	*-0.94*	*0.76*	*-0.98*	*-0.72*	*1.00*			
PO4	*-0.81*	*-0.92*	*0.72*	*-0.97*	*-0.76*	*1.00*	*1.00*		
Transprency	*0.58*	*1.00*	*-0.90*	*1.00*	*0.52*	*-0.97*	*-0.95*	*1.00*	
Total phytoplankton	*0.32*	*0.98*	*-0.99*	*0.94*	*0.25*	*-0.85*	*-0.82*	*0.96*	*1.00*

Discussion:

The water temperature in Meghadrigedda reservoir varied significantly with time (ranged from 20.2 °C in post monsoon at station three to 26.1 °C in summer at station three), but not with station. The total phytoplankton abundance showed positive correlation with temperature (r=0.32). The dissolved oxygen concentration in reservoir ranged from 3.82 mg L^{-1} in summer at station one to 6.08 mg L^{-1} at station three and four in monsoon. The negative correlation of DO with temperature (r= –0 .16) at all sampling sites is in agreement with Das, 2000; Sumitra *et al*., 2007; Sharma, 2007 and Rajasekhar *et al.*,2007. DO showed negative correlation with total phytoplankton abundance (r= –0.99). pH values fluctuates from 6.6 to 7.05 in pre monsoon at stations two and three. The results found to be well agreed with investigations carried out by Renuka devi and Narasimha Rao, 2013 in Meghadrigedda reservoir and Rajasekhar *et al.,* 2007. pH correlated positively with total phytoplankton abundance((r=0.98). BOD ranged from 1.94 mg L^{-1} in monsoon at station four to 3.61 mg L^{-1} in summer at station two. Similar results were obtained by Jyothi and Narasimha Rao, 2013b; Renuka and Narasimha Rao, 2013; Kamble and Kukate, 2008; Rajasekhar *et al.*, 2007. BOD showed an inverse correlation with DO (r= –0.87). This was because of the utilization of DO in the oxidation of organic pollutants (Mohan and Omana, 2007; Jindal and Sharma, 2011). BOD correlated positively with (r=0.94). Sulphates ranged from 8.50 mg L^{-1} in winter at station three to 11.73 mg L^{-1} in summer at station three. High value of Sulphates in summer may be due to sulphate released by the decomposition of organic matter, and low value of Sulphates in winter might be due to absorption by phytoplankton population. Similar observations were made by Sunkad, 2002; Reddy Vasumathi *et al.*,2009.

Phosphates ranged from 0.018 mg L^{-1} in summer at station two to 0.031 mg L^{-1} in monsoon and winter at stations five and four. Nitrates ranged from 0.98 mg L^{-1} in summer at station one to 1.42 mg L^{-1} in monsoon at station three. During summer months, the reduction in nitrates and phosphates could be due to algal assimilation and other biochemical mechanisms and higher during monsoon may be due to surface run off along with fertilizer leached from catchment area, those released from sediment in the reservoir. Similar findings were reported by Sivakumar and Karuppasamy,2008; Hujare, 2005; Chisty, 2002. Phosphates and Nitrates showed negative correlation with phytoplankton abundance. Water clarity and the ecological quality of shallow lakes could be predicted quite well from water transparency (Perdrozo *et al.,* 2008; Kasprzak *et al*., 2008). The water transparency fluctuated from 27.07cm in monsoon at station two to 50.10cm in summer at station four. In study period transparency showed significant positive relationship with water temperature (r=0.58). Low values of transparency in monsoon may be due to influx of rain water from catchments area, cloudiness, less penetration of light and high turbidity due to suspended inert particulate matter. However, high values of transparency in summer may be due to clear atmosphere and high light penetration. Similar results have been reported by Gaur Archana *et al.,* 2009, Kadam *et al.,* 2007. Total phytoplankton abundance showed positive correlation with transparency (r= 0.96).

In the present investigation, the phytoplankton fluctuates seasonally. The maximum abundance appeared at the station four in summer, while the station three had a minimum abundance in monsoon. During summer, increase in temperature enhanced the rate of decomposition followed by evaporation, increase in nutrient concentration and presence of abundant food in the form of photosynthesis (Santhanam and Perumal, 2003). Low density during the monsoon season is attributed to heavy flood and fresh water inflow (Krishnamoorthy *et al.*, 2007). Similar results were reported by Wojciechowska *et al.*, 2007; Devika *et al.*, 2006; Chellappa *et al.*, 2008; Laskar and Gupta, 2009;Hassan *et al.*, 2010; Jyothi and Narasimha Rao, 2013a, Nafeesa *et al.*, 2011b ;Tarakeshwar *et al.*, 2011. The peak phytoplankton abundance in summer would indicate the dam water contained most of the nutrients required for phytoplankton growth. Present observations revealed that Chlorophyceae were dominant followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. Similar observations were made by Jyothi and Narasimha Rao. 2013a; Adesalu, 2010; Laskar and Gupta, 2009; Balasingh and Shamal, 2007 ;Tiwari and Chauhan, 2006.

Long-term monitoring is required for a better estimation of the state and conditions of Meghadrigedda reservoir. It suggested a possibility of prediction and elucidation for phytoplankton variability patterns by some simple physico-chemical parameters. Despite the complexity of aquatic system, this study improves understanding of different roles of environmental variables upon phytoplankton variability.

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