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ECOLOGY, DISTRIBUTION AND DIVERSITY OF PHYTOPLANKTON IN TEETHA WETLAND, TUMAKURU DISTRICT, KARNATAKA, INDIA.

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ABSTRACT: *In the present experiment, phytoplankton belonging to 41 species under 23 genera was observed from Teetha wetland ecosystem during the period of investigation from June 2011 to May 2013. Results revealed that, Bacillariophyceae was found to be the dominant group of phytoplankton (39.13 %) followed by Chlorococcales and Cyanophyceae each with (21.74 %), desmids (13.04 %) and Euglenoids (4.35 %). Teetha Lake is found to be rich in phytoplankton diversity and hence productive. Summer period marked an increase in phytoplankton density. Physicochemical factors like Temperature, pH, Sulphate, Potassium, Nitrate nitrogen, Ammonical nitrogen and Silica were found to be the important factors influencing the growth of phytoplankton and they exhibited significant positive correlation with total phytoplankton. Based on Nygaard's trophic state indices the wetland is said to be oligotrophic. Inter-relationship of various physicochemical factors and their role with seasonal dynamics of phytoplankton is here by discussed.*

KEY WORDS: Correlation, Diversity, Physicochemical factors, Phytoplankton, Wetland.

INTRODUCTION

Phytoplankton in wetland ecosystem acts as primary producers and forms a bulk of food as well as host for zooplankton, fishes and other organisms (Waniek and Holliday, 2006). Wetlands considered having functions on hydrologic flux, storage and biological productivity. Maintenance of healthy aquatic ecosystem is depending on physicochemical factors of water and biological diversity of the ecosystem. Planktonic study is a useful tool for the water quality assessment and contributes to understanding the basic nature and general economy of wetlands. Phytoplankton acts as producers and occupies lowest trophic level in aquatic ecosystem food chain. Phytoplankton forms the basis of food chain, bio purifiers and bio indicators of the wetland ecosystem (Monika et a*l*., 2004; Ariyadej et al., 2004). Phytoplankton functions as the primary producers in wet lands by fixing the energy and its subsequent transfer to higher trophic levels (Wetzel, 1983). Primary productivity has been measured for aquatic ecosystem by several workers (Singh, 1998; Synudeen Sahib, 2002; Mandal et al., 2005; Hujare and Mule, 2007). Hence, the quality and quantity of phytoplankton population bear much influence on the water quality and production potential of wet land ecosystem. Phytoplankton plays a key role in maintaining the equilibrium between abiotic and biotic components of the wetland ecosystem (Pandey et al., 2004). Use of phytoplankton density, diversity and their association as biological indicators in water quality assessment and trophic status studied by Chaturvedi et al., (1999). Seasonal variation of phytoplankton in lakes has been studied by Kaur et al., (2001) and Jarousha, (2001). Species composition, abundance and diversity of phytoplankton are monitored by environmental factors like physicochemical properties of water, meteorological properties of particular region, morphometric and hydrographic characters of the wetland ecosystem (Dahl and Wilson, 2000). Phytoplankton plays a role in regulating atmospheric temperature via photosynthesis. Wetland ecosystems of Karnataka have attracted the attention of number of scientists leading to the studies on ecology and distribution of phytoplankton and their importance as indicator of pollution and tropic status of the water body (Hegde and Bharati, 1985; Puttaiah and Somashekar, 1987; Ravikumar and Puttaiah 1996; Vengadesh Perumal et al., 2009; Bhosale et al., 2010a). Literature survey reveals that, limnological work on Teetha wetland ecosystem has not been kept up so far. Hence, an attempt has been made in the present investigation to study the seasonal variations of phytoplankton population in relation to certain physicochemical characteristics of wetland.

MATERIALS AND METHODS

Morphometry of the wetland

Teetha wetland ecosystem is a perennial fresh water body situated towards north-east 30 Kms from Tumakuru city at 13˚ 25^{I} to 13˚ 30^{I} north side and 77˚ 15^{1} to 77˚ 20^{1} east longitude with an area of 1.32 Km^2 constructed in the year 1985-86 across the river Jayamangali, a tributary of Uttarapinakini. The lake is irregular in shape and water in the lake is held by raised east-west earthern bund on either flank with central spill way (Figure 1). Average depth of the lake is 4.5 to 6.5 meters. Lake water is used for agricultural practices, drinking, washing clothes, bathing cattle and other domestic activities as shown in figure 2.

Figure 1. Teetha wetland

Figure 2. Teetha wetland showing anthropogenic activities

Lake is situated by the side of famous pilgrim centre Sri Goravanahalli Lakshmi Temple. Water in the lake is also used for anthropogenic activities by large number of devotees visiting the temple. Swimming and fishing are commonly seen during the day hours.

Water and Phytoplankton analysis

Water and phytoplankton samples were collected at monthly intervals as depicted in figure 3 for a period of two years from June 2011 to May 2013, covering three seasons such as pre-monsoon (Feb-May), monsoon (June-Sept) and post-monsoon (Oct-Jan). Four representative samples were mixed thoroughly for composite sample and filled in black coloured carboys of 2 litres capacity. Water samples were analysed for different parameters following standard methods (Trivedy and Goel, 1984; APHA, 1995). Plankton samples were collected with a standard conical townet (No.25, mesh 64 µm) and were fixed in 1% lugol's solution. Quantitative enumeration of phytoplankton was done using Sedge Wick Rafter counting chamber. Identification of phytoplankton up to the level of species was made by following the standard procedures suggested by Biswas (1949); Prescott (1982); Sarode and Kamat (1984). Statistical analysis was done using Carl Pearson's correlation co-efficient formula.

Figure 3. Water samples collection at Teetha wetland

RESULTS AND DISCUSSION

Phytoplankton population in Teetha wetland ecosystem was composed of 5 major groups namely *Bacillariophyceae*, *Chlorophyceae*, *Cyanophyceae*, *Euglenophyceae and Desmidaceae*. Among these *Bacillariophyceae* (Diatoms) (39.13 %) formed the bulk of phytoplankton followed by *Chlorophyceae* (Chlorococcales) and *Cyanophyceae* (Blue-Greens) (21.74 %) each, *Desmidaceae* (Desmids) (13.04 %) and E*uglenophyceae* (Euglenoids) (4.35 %) (Figure 4).

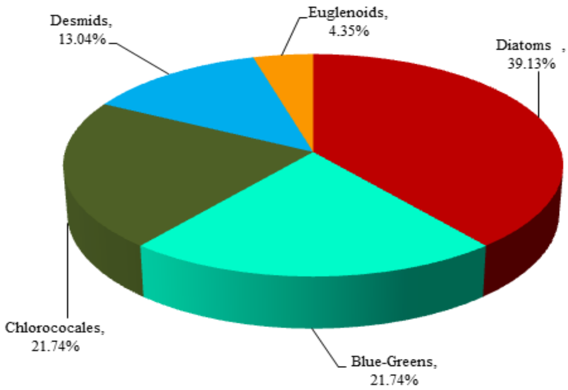

Figure 4. Graph showing relative abundance of phytoplankton in Teetha wetland.

Totally 41 species under 23 genera belonging to 5 different classes were encountered during the present investigation (Table 1) and seasonal variations in the distribution of phytoplankton are presented in Table 2.

Table 1. Phytoplankton recorded from Teetha wetland during 2011-2013.

DIATOMS	***BLUE-GREENS***
Cymbella turgidula,	*Chrococcus turgidus,*
Cymbella cuspidate,	*Coelosphaerium Kuetzingianum,*
Gyrosigma accuminatum,	*Coelosphaerium naegelianum,*
Gyrosigma kutzingii,	*Gloeocapsa magma,*
Navicula cuspidate,	*Gloeocapsa repustris,*
Navicula reinhardtii,	*Gloeocapsa sanguinea,*
Naricula salinarum,	*Merismopedia glauca,*
Nitzchia recta,	*Merismopedia punctata,*
Nitzchia acicularis	*Microcystis aeruginosa,*
Surirella robusta	*Microcystis marginata*
	Microcystis viridis
CHLOROCOCCALES	*DESMIDS*
Krichneriella lunaris,	*Closterium gracile,*
Oocysis gigas,	*Closterium lunula,*
Pediastrum duplex,	*Cosmarium melanosporum,*
Pediastrum simplex,	*cosmarium portuberans,*
Pediastrum tetras,	*Cosmarium retusiformac*
Selenastrum gracile,	*Staurastrum gracile*
Selenastrum westii,	
Tetraedon caudatus	*EUGLENOIDS*
Tetraedon minimum	*Euglena minuta,*
	Euglena polymorpha
	Euglena viridis

Table 2. Seasonal variations in phytoplankton groups in Teetha wetland (O/L)

Sl.No.	Phytoplankton	2011-2012			2012-2013		
		Rainy	Winter	Summer	Rainy	Winter	Summer
1.	Diatoms	5700	4018	6452	5241	3892	6180
2.	Blue-greens	8895	9624	12206	9252	10081	12039
3.	Chlorococcales	17118	17393	17562	17266	17384	17592
4.	Euglenoids	59	53	56	54	47	52
5.	Desmids	11	6	8	9	5	7

Diatoms reached their peak during pre-monsoon coupled with higher temperature. Diatoms contributes 39.13 % of the total phytoplankton of Teetha wetland occupies dominating position. Blue-greens contribute 21.74 % of the total phytoplankton of Teetha wetland. Seasonal dynamics of Blue-greens are positively correlated with air and water temperature. Chlorococcales contribute 21.74 % of the total phytoplankton of Teetha wetland. Seasonally minimum density was observed in rainy season and maximum in summer season. Desmids recorded maximum in rainy and minimum in winter months, contribute 13.04 % of the total phytoplankton of Teetha wetland. Seasonal variations of euglenoids were found that, their density was maximum during summer followed by rainy and minimum during winter months, contribute 4.35 % of the total phytoplankton.

Among phytoplankton community, diatoms play a very important role ecologically as they comprise of major components of producers in wetland ecosystem (Zalewski et al., 1997). Diatoms are ubiquitous, unicellular microorganisms form the basic bulk of planktonic population in freshwaters characterised by siliceous cell wall (Round et al., 1990). Sabata and Nayar (1987) recorded highest number of diatoms during summer coupled with silica. Blue-greens are cosmopolitan in nature play a significant role in wetland ecosystem. Blue-greens exhibited heavy growth in polluted water bodies and dominated over Chlorophyceae and Bacillariophyceae (Paramasivam and Srinivasan, 1981). Bloom of blue-green algae in wetland is an obvious sign of cultural eutrophication caused by addition of sewage effluents (Goldman and Horne, 1983). They are photosynthetic prokaryotes derive electrons during assimilation of carbon dioxide by simple redox process and present in almost all fresh water forms. Tripathi and Pandey (1995) observed maximum number of blue-greens during summer and minimum in winter. Temperature plays an important role in the periodicity of blue green algae as emphasized by Mahar et al., (2004). Chlorococcales occur as greenish scum on the surface of stagnant water. Factors like high temperature and bright sunlight are favourable for the growth of chlorococcales. In the present investigation, temperature has no bearing on chlorococcales growth. Seasonally maximum density is recorded during post-monsoon and low during monsoon. Factors like turbidity, conductivity, total hardness and chloride are positively correlated with chlorococcales dynamics. Desmids are sensitive organisms, act as indicators of water pollution. Abundance of desmids clearly indicates the unpolluted condition of the wetland (Sabir et al., 2007). Desmids population showed significant positive correlation with air and water temperature, pH, sulphate and nitrate. Euglenoids density and diversity is positively correlated with air and water temperature, sulphate, nitrates and silica. Ashesh Tiwari and Chauhan (2006) reported that, in Kitham lake, Agra, euglenoids density was maximum during summer followed by rainy and minimum during winter months. Euglenoids occur in greater number in polluted water bodies. Tripathi and Pandey (1995) have recorded maximum euglenoids during monsoon and low during post-monsoon.

Table 3. Yearly averages of physicochemical parameters of Teetha wetland (Values in mg/l)

Physicochemical parameters	2011-2012	2012-2013
Air temperature	30.25	30
Water temperature	27.5	26
pH	7.08	7
Turbidity	11.98	12
Conductivity	95.91	100
Dissolved oxygen	7.96	8.2
Free carbon dioxide	0.73	2.6
Biological oxygen demand	1.79	2.5
Chemical oxygen demand	33.33	35
Total hardness	110.83	115
Total alkalinity	15.83	66
Calcium	21.91	21
Magnesium	13.69	15
Potassium	53.82	53
Sulphate	31.06	30
Chloride	47.69	47
Organic nitrogen	1.13	0.9
Ammonical nitrogen	1.71	1.8
Total kjeldahl nitrogen	2.84	2.7
Phosphate	0.26	0.3
Nitrate nitrogen	0.68	0.7
Silica	40.96	40
Total solids	125	135

All five groups of phytoplankton except desmids recorded their peak abundance during pre-monsoon period. Long duration of photoperiod coupled with high temperature favoured their growth during this period. Data on physico-chemical parameters of water having direct bearing upon the distribution and ecology of various phytoplankton communities in Teetha wetland is given in Table 3. Under normal conditions in enclosed water bodies of tropical impoundments, a continuous high population of phytoplankton occurs throughout the year with a bloom in summer (Ganapati and Raman, 1979). Water temperature in the present experiment varied from 25 ˚C to 28 ˚C. Water temperature plays an important role in controlling the occurrence and abundance of phytoplankton (Nazneen, 1980). As temperature has no direct effect upon aquatic organisms up to 40 ˚C there is no direct effect on fauna and flora. Enhanced growth of algal flora noticed in the present study during pre-monsoon period could be attributed to increased temperature and light (Kopoczynska, 1980). In the present investigation *Bacillariophyceae* showed significant positive correlation with water temperature ($r = 0.695$: $p<0.05$), Sulphate ($r = 0.703$: $p<0.05$), Nitrate nitrogen ($r = 0.724$: $p<0.05$) and Silica ($r = 0.748$: $p<0.05$). Kaur et al., (2000) revealed that, temperature plays a major role in influencing species richness and diversity and it is true in the present experiment. Seasonal change in productivity is related to variation in temperature. Similar findings were reported by Sondergaard and Sand-Jensen (1979); Spencer and King (1989). Temperature is an important factor regulates biogeochemical activities in the wetland environment. Fluctuation in water temperature in the present experiment was due to sampling time and season (Jayaraman et al., 2003; Tiwari et al., 2004).

Table 4. Correlation matrix of physicochemical parameters V/s physicochemical parameters of Teetha wetland (2011-2013).

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23
P1	1.000																						
P2	0.880 0.000*	1.000																					
P3	-0.029 0.892	-0.038 0.859	1.000																				
P4	0.261 0.218	0.340 0.105	-0.316 0.132	1.000																			
P5	0.324 0.324	0.515 0.010*	-0.361 0.083	0.402 0.052	1.000																		
P6	-0.211 0.323	-0.351 0.093	-0.176 0.410	-0.228 0.285	-0.397 0.055	1.000																	
P7	-0.409 0.047	-0.379 0.068	-0.078 0.717	0.049 0.820	-0.000 0.998	-0.075 0.727	1.000																
P8	0.259 0.222	0.092 0.668	-0.244 0.251	-0.180 0.400	0.119 0.579	0.408 0.048*	-0.281 0.184	1.000															
P9	-0.203 0.341	-0.252 0.234	0.268 0.205	-0.397 0.055	-0.329 0.117	0.286 0.175	-0.211 0.323	0.244 0.251	1.000														
P10	0.081 0.706	0.131 0.543	0.359 0.085	0.105 0.626	0.129 0.548	-0.607 0.002*	0.066 0.758	-0.501 0.013*	-0.212 0.321	1.000													
P11	-0.364 0.081	-0.374 0.071	-0.158 0.462	0.307 0.144	0.097 0.652	0.058 0.786	0.812 0.000*	-0.265 0.210	-0.177 0.409	0.110 0.610	1.000												
P12	-0.102 0.635	-0.118 0.581	0.021 0.921	0.180 0.401	-0.385 0.063	0.011 0.958	0.213 0.318	-0.451 0.027	-0.103 0.633	0.402 0.052	0.304 0.148	1.000											
P13	0.165 0.440	0.227 0.285	0.330 0.116	-0.051 0.813	0.452 0.026*	-0.599 0.002*	-0.116 0.588	-0.103 0.633	-0.118 0.583	0.629 0.001*	-0.153 0.477	-0.460 0.024	1.000										
P14	0.089 0.681	-0.043 0.843	0.265 0.211	-0.009 0.965	-0.562 0.004*	0.046 0.830	-0.310 0.140	-0.023 0.914	0.099 0.646	-0.245 0.249	-0.373 0.072	-0.062 0.775	-0.185 0.387	1.000									
P15	0.642 0.001*	0.693 0.000*	0.008 0.969	0.155 0.469	0.581 0.003*	-0.456 0.025	-0.368 0.077	0.145 0.499	-0.271 0.200	0.147 0.492	-0.388 0.061	-0.304 0.149	0.401 0.052	-0.169 0.431	1.000								
P16	-0.163 0.448	0.006 0.978	0.135 0.529	0.160 0.456	0.123 0.567	-0.452 0.027*	0.193 0.366	-0.521 0.009*	-0.176 0.410	0.830 0.000*	0.324 0.123	0.509 0.011*	0.373 0.072	-0.360 0.084	-0.045 0.835	1.000							
P17	-0.094 0.661	-0.038 0.858	0.158 0.461	-0.252 0.235	-0.198 0.353	0.177 0.407	-0.161 0.452	0.260 0.220	0.251 0.237	-0.605 0.002*	-0.192 0.368	-0.225 0.290	-0.396 0.056	0.274 0.194	0.085 0.693	-0.490 0.015	1.000						
P18	-0.090 0.675	-0.338 0.106	0.130 0.546	-0.383 0.065	-0.699 0.000*	0.367 0.078	-0.042 0.846	0.148 0.489	0.343 0.101	-0.231 0.278	-0.302 0.151	0.017 0.936	-0.238 0.262	0.444 0.030*	-0.359 0.085	-0.430 0.036*	-0.015 0.944	1.000					
P19	-0.126 0.557	-0.193 0.367	0.202 0.345	-0.404 0.050	-0.505 0.012*	0.330 0.115	-0.163 0.446	0.301 0.153	0.384 0.064	-0.647 0.001*	-0.313 0.136	-0.192 0.368	-0.464 0.022*	0.452 0.026*	-0.093 0.666	-0.638 0.001*	0.883 0.000*	0.455 0.025*	1.000				
P20	0.452 0.027*	0.552 0.005*	-0.061 0.775	0.504 0.012	0.565 0.004	-0.625 0.001	-0.133 0.535	-0.078 0.717	-0.156 0.466	0.253 0.233	-0.082 0.703	-0.196 0.358	0.412 0.045	0.035 0.869	0.608 0.002*	0.172 0.423	-0.221 0.300	-0.339 0.106	-0.355 0.089	1.000			
P21	0.437 0.033*	0.451 0.027*	-0.225 0.291	0.112 0.603	0.679 0.000*	-0.184 0.389	-0.284 0.179	0.497 0.013	-0.095 0.660	-0.084 0.697	-0.213 0.137	-0.538 0.007*	0.375 0.071	-0.244 0.250	0.747 0.000*	-0.179 0.402	-0.014 0.947	-0.297 0.159	-0.152 0.478	0.526 0.008*	1.000		
P22	0.466 0.022*	0.554 0.005*	0.166 0.439	0.354 0.089	0.451 0.027*	-0.797 0.000*	-0.247 0.244	-0.213 0.319	-0.234 0.271	0.440 0.031*	-0.207 0.331	-0.164 0.443	0.567 0.004*	0.144 0.501	0.624 0.001*	0.294 0.163	-0.129 0.548	-0.378 0.069	-0.292 0.166	0.885 0.000*	0.426 0.038	1.000	
P23	-0.360 0.084	-0.271 0.200	0.038 0.862	-0.052 0.809	0.007 0.974	-0.057 0.792	0.362 0.082	-0.151 0.481	-0.184 0.389	0.328 0.118	0.410 0.046	0.368 0.077	0.005 0.982	-0.459 0.024*	-0.131 0.542	0.455 0.025	0.036 0.867	-0.296 0.160	-0.107 0.620	-0.415 0.044*	-0.217 0.309	-0.335 0.109	1.000

+ = Positive Correlation, - = Negative Correlation, * = Significant at 5% level

There are several views regarding the effect of pH on phytoplankton population. Nandan and Patel (1992) observed that, high pH values promote the algal growth and results in blooms. Verma and Mohanty (1995) have reported a direct relationship between pH and phytoplankton. In the present study, pH has no direct bearing on the distribution of phytoplankton except Desmids group that is positively correlated with pH ($r = 0.433$: $p<0.05$). However, Robert et al., (1974) suggested that, pH 5.0 to 8.5 is ideal for phytoplankton growth and this was found to be true in the present study. Dissolved oxygen is a useful parameter in assessing water quality and providing a check in pollution. Dissolved oxygen presented negative correlation with phytoplankton due to the fact that at increased temperatures, dissolved oxygen content of water is decreased. Thus if temperature is positively correlated with phytoplankton, while dissolved oxygen is negatively corrected with temperature, then resulting correlation between dissolved oxygen and phytoplankton will be negative (Table. 4). Samuel et al., (1979) observed inverse relationship between phytoplankton and dissolved oxygen. Total hardness established inverse relationship with chlorococcales ($r = -0.448$: $p<0.05$) and the other groups remained independent of this parameter. Water hardness is due to carbonates, bicarbonates, chloride and sulphate of calcium and magnesium. Total hardness of water depends upon soil characteristics in wetlands.

Sulphate is a naturally occurring anion and an important mineral substance for the growth of phytoplankton. Sulphate concentration in wetland increases due to sewage and domestic activities as well as enters the water body from the catchment area through surface runoff, since the lake is bordered by agricultural lands with sulphate based fertilizers are used in plenty. Relatively higher sulphate concentrations could be attributed to surface run off from the agricultural lands in the monsoon period. Among the five groups of phytoplankton, Diatoms ($r = 0.703$), Euglenoids ($r = 0.757$), Desmids ($r = 0.513$) and Blue-greens ($r = 0.873$) were observed at 0.05 % level. Nandan and Patel (1992) observed similar trend in Viswamitri River in Gujarat. Zutshi and Khan (1988) stated that, polluted water is comparatively rich in sulphate and in the present results it varied between 15.34 to 135.57 mg/l, falls within BIS permissible limit. Important nutrients which affect the growth of phytoplankton are nitrate, phosphate and silicate. Higher concentration of nitrate is an indication of organic pollution and eutrophication. In the present study relatively low nitrate values were observed (Table 3) suggesting oligotrophic status of the water body. Among five groups of phytoplankton, Diatoms ($r = 0.748$), Euglenoids ($r = 0.425$), Desmids ($r = 0.780$) and Blue-greens ($r = 0.70$) at 0.05 % showed significant positive correlation with nitrates concentration (Table 4) and is in agreement with Nandan and Patel (1992). Phosphate is considered as one of the important nutrient limiting phytoplankton growth (Welch et al., 1978). In the present study total phytoplankton remained independent of phosphate concentration. Krishnamurthy and Bharati (1996) stressed the importance of silicate in the periodicity of Diatoms. Silicates formed the main nutrient in Diatom metabolism. Munawar (1974) reported that, there is a direct relationship between concentration of silicates and the density of diatoms. In the present study significant positive correlation ($r = 0.748$) at 0.05% level emerged between silicate and Diatoms. It revealed that, silica concentration is not only the parameter regulates diatoms population in wetland. Similar observations were made by Hosmani et al., (1999) and Ying Ouyang, (2005).

CONCLUSIONS

It can be concluded from the present observations that, Teetha wetland shows the seasonal variations in hydrography. Phytoplankton diversity, distribution and richness are almost similar to that of any other wetland systems. Teetha wetland with 41 species belonging to 23 genera is rich in phytoplankton diversity and hence productive. Based on the results of Nygaard's trophic state indices Teetha wetland is said to be oligotrophic. Present data on physico-chemical parameters in relation to phytoplankton distribution and abundance forms a useful tool for further ecological assessment and monitoring of wetlands.

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