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Seasonal Distribution of Phytoplankton in Riwada Reservoir, Visakhapatnam, Andhra Pradesh, India

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Abstract

The present study deals with seasonal variations, correlation coefficient and biodiversity indices of phytoplankton during April 2011 to March 2012 in the Riwada reservoir, Visakhapatnam, Andhra Pradesh, India. Sampling was performed at five stations during pre-monsoon, monsoon and post monsoon. There were a total of 57 genera belonging to four major groups i.e., Chlorophyceae (27 genera), Bacillariophyceae (14 genera), Cyanophyceae (13 genera) and Euglenophyceae (three genera). Maximum and minimum total phytoplankton population and percentages were recorded at station three in pre monsoon and at station two during monsoon. The maximum and minimum species richness (Menhinick index R_2) were found to be 1.29 at station one and 1.10 at station three respectively. Maximum and minimum species diversity (H^1) were found at station four (3.98) and station two (3.71). Maximum species evenness was recorded at stations one, being four and five; minimum species evenness was recorded at station two. Correlation coefficient matrix indicated significant positive relationship with water temperature, pH, transparency, biological oxygen demand and chlorides, negative relationship with electric conductivity, total solids, total dissolved solids, total hardness, dissolved oxygen, nitrates, sulphates and phosphates of water. The diversity indices showed that the reservoir have a well balanced phytoplankton community.

Keywords:biodiversity indices, correlation coefficient, phytoplankton, seasonal variations, species diversity, species richness, species evenness

Introduction

Phytoplanktons are important in an environmental impact study in as much as they are extremely responsive to change in the environment and thus indicate environmental changes and fluctuations that may occur (Ingole *et al.,* 2010). They have a short life span and responds quickly to environmental changes (Zębek, 2004). Phytoplanktons play an important role in the biosynthesis of organic matter in aquatic ecosystems, which directly or indirectly serve all the organisms of a water body as food (Anjana *et al*., 1998). Several researchers Leela *et al.* (2010), Nafeesa *et al.* (2011a) and Shanker (2010) have studied and opined that limnological characteristics of any waterbody alter the phytoplankton diversity. Much work has been carried out in India on the phytoplankton of fresh water habitats (Jawale and Kumawat, 2000; Sahat *et al.,* 2001; Das *et al.,* 2002; More and Nandan, 2003; Sirsat *et al.,* 2004; Mishra, 2005; Khapekar and Nandkar, 2007; Magar, 2008; Laskar and Gupta, 2009; Purushothama *et al*., 2011; Roy *et al*., 2011; Sayeswara *et al.,* 2011). Hosamani and Bharathi (1980) studied the use of phytoplankton in classifying water bodies and found it as significant.

To maintain healthy, aquatic ecosystem are dependents on the abiotic properties of water and the biological diversity of the ecosystem (Harikrishnan *et al.,* 1999). Diversity, distribution, abundance and variation in the biotic factors provide information of energy turnover in the aquatic systems (Shinde *et al.,* 2011). Hence, for any scientific utilization of water resources plankton study is of primary interest. Algae, mostly autotrophic organisms, receive most of their nutrition from dissolved chemicals in water. Thus, many authors believe that they should be good indicators of the conditions prevailing in the aquatic environment and algae are widely used as bio indicators to monitor eutrophication, pollution and water quality (Round, 1984). The abundance of algae of different kinds is rather closely associated with restricted seasonal periodicity, differing of course in widely separated geographical locations (Smith, 1951). Furthermore, their standing crops exhibit variations that depend on several factors, including the supply of major nutrients, light availability, grazing by zooplankton, water mixing regimes, basin morphometry (Sommer *et al.,* 1986). Within reservoirs, the irregular dynamics of inflow and variable flushing rates markedly alter environmental conditions for biotic communities (Chalinda *et al*., 2004). A reservoir can be viewed as a very dynamic lake in which a significant portion of its volume possesses characteristics of, and functions biologically as, a river (Wetzel, 2001).

Accordingly, the goal of this study was to assess seasonal variation, total percentage, species richness, species diversity, species evenness of phytoplankton and correlation coefficient in Riwada reservoir, Visakhapatnam, Andhra Pradesh, India. The reservoir was constructed on the river Sharada in 1982 with the storage capacity of 3600 million

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cubic feet and total catchment area of 448 square kilometres. The reservoir water is used for drinking and irrigation purposes. Nevertheless, no recent study has been documented in this reservoir concerning the phytoplankton community structure, which necessitates constant monitoring of ecological conditions.

Materials and methods

In the present study plankton sampling was taken for one year from April 2011 to March 2012, at five different stations during pre-monsoon (February, March, April and May), monsoon (June, July, August and September) and post-monsoon (October, November, December and January). The geographical coordination are 17°59'48" N 82°59'18" E at Riwada Dam, Visakhapatnam District, Andhrapradesh, India.

Plankton net (mesh size 25 µm) was swept on surface water and plankton was collected and transferred into 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), and Dhanapathi (2000). Species diversity, species richness and species evenness were calculated as for Ludwick and Reynold (1998).

Three indices were used to obtain estimation of species diversity, species richness and species evenness.

1. Shannon and Weaver (1949) and Simpson (1949) diversity index values were obtained by using the following equation:

$$H' = -\sum_{i=1}^{S} (Pi \ln Pi) \qquad \text{(Shannon's index)}$$

$$\lambda = \frac{-\sum_{i=1}^{S} n_i(n_i - 1)}{n(n-1)} \qquad \text{(Simpson index)}$$

Where,

Pi = Proportion of the first species.

The proportions are given $Pi=ni/n$

2. Species richness (R_1 and R_2) obtained using the following equation:

$$R_1 = \frac{(S-1)}{\ln(n)} \qquad \text{(Margalef, 1958)}$$

$$R_2 = \frac{S}{\sqrt{n}} \qquad \text{(Menhinick, 1964)}$$

Where,

R = Index of species richness

S = Total number of species

n = Total number of individuals

3. Species evenness was determined by using the following expression.

Shannon's equitability (EH) can be calculated by dividing H by H_{max} (here $H_{max} = \ln S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

$$(E_H) = \frac{H}{H_{max}} = \frac{H}{\ln S}$$

H = Shannon diversity index

S = number of species in sample

Results and discussion

Microscopic examination of phytoplanktons revealed that there were four groups consisting of 57 genera of phytoplankton in order Chlorophyceae (27 genera), Bacillariophyceae (14 genera), Cyanophyceae (13 genera) and Euglenophyceae (three genera). The species observed were:*Ankistrodesmus falcatus, Asterococus palmella, Chlorella vulgaris, Coenococcus planctonicus, Closterium* sp., *Coelastrum* sp., *Cosmarium* sp., *Crucigenia* sp., *Eudorina elegans, Gloeocystis* sp., *Glaucocystis* sp., *Hydrodictyon* sp., *Micractinium* sp., *Oedogonium* sp., *Oocystis* sp., *Pandorina* sp., *Pediastrum* sp., *Scenedesmus* sp., *Selenastrum* sp., *Spirogyra* sp., *Staurostrum* sp., *Staurodesmus* sp., *Staurogenia* sp., *Tetraspora* sp., *Tetraedron* sp., *Ulothrix* sp., *Volvox* sp., *Zygnema* sp., (Chlorophyceae); *Cyclotella* sp., *Cymbella* sp., *Diatom* sp., *Fragillaria* sp., *Gomphonema* sp., *Hydrosera* sp., *Melosira* sp., *Navicula* sp., *Nitzschia* sp., *Pinnularia* sp., *Prorocentrum* sp., *Rhopalodia gibba, Synedra ulna, Tabellaria flocculosa* (Bacillariophyceae)*; Anabaena* sp.,*Anabaenopsis raciborski, Aphaocapsa biformis, Aphanotheca clathrata, Chroococcus* sp., *Gloeotheca rupestris, Gomphosphaeria aponina, Lyngbya majuscule, Nostoc commune, Oscillatoria* sp., *Peridinium anglicum, Spirulina* sp., (Cyanophyceae)*; Euglena* sp., *Phacus* sp., and *Trachelomonas* sp. (Euglenophyceae). Orderwise recorded total population density of phytoplanktons showed maximum Chlorophyceae (2172 org l^{-1}) at station 3, minimum Chlorophyceae (1516 org l^{-1}) at station 1 (Tab. 1).

Maximum Bacillariophyceae (1847 org l^{-1}) at station three, minimum Bacillariophyceae (1445 org l^{-1}) at station two were identified. Maximum Cyanophyceae (930 org l^{-1}) at station three, minimum Cyanophyceae (618 org l^{-1}) at station oen were reported. Maximum Euglenophyceae (249 org l^{-1}) and minimum Euglenophyceae (117 org l^{-1}) were observed at station three and station two, respectively. Maximum and minimum percentage of Chlorophyceae was recorded at station five (42.68%) and station one (39.84%). Maximum and minimum percentage of Bacillariophyceae was recorded at station one (40.64%) and station four (35.32%). Maximum and minimum percentage

Tab. 1. Total seasonal variations of phytoplanktons's (orgs/liter) at Riwada Reservoir during April 2011 - March 2012

Site	Order	Premonsoon	Monsoon	Post Monsoon	Total	%
Station1	Chlorophyceae	720	290	506	1516	39.84
	Bacillariophyceae	724	279	543	1546	40.64
	Cyanophyceae	334	105	179	618	16.24
	Euglenophyceae	61	28	36	125	3.28
Station2	Chlorophyceae	750	338	503	1591	41.89
	Bacillariophyceae	651	283	511	1445	38.05
	Cyanophyceae	336	106	203	645	16.98
	Euglenophyceae	47	22	48	117	3.08
Station3	Chlorophyceae	988	385	799	2172	41.79
	Bacillariophyceae	837	381	629	1847	35.53
	Cyanophyceae	431	193	306	930	17.89
	Euglenophyceae	118	59	72	249	4.79
Station4	Chlorophyceae	921	351	606	1878	41.22
	Bacillariophyceae	732	326	551	1609	35.32
	Cyanophyceae	407	233	279	919	20.17
	Euglenophyceae	85	23	42	150	3.29
Station5	Chlorophyceae	894	358	589	1841	42.68
	Bacillariophyceae	701	309	519	1529	35.45
	Cyanophyceae	403	134	270	807	18.72
	Euglenophyceae	77	25	34	136	3.15

of Cyanophyceae was recorded at station four (20.17%) and station one (16.24%). Maximum and minimum percentage of Euglenophyceae was recorded at station three (4.79%) and station two (3.08%). Present observations showed that Chlorophyceae were dominant followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. Similar observations were made by Tiwari and Chauhan (2006), Balasingh and Shamal (2007), Laskar and Gupta (2009) and Adesalu (2010).

In the present investigation, the phytoplankton fluctuates seasonally and its productivity was high during premonsoon and low in monsoon. This may be due to cloudy weather, low transparency and heavy flood caused decline of phytoplankton density. 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). Hassan *et al.* (2010) reported minimum density of phytoplankton during monsoon and maximum during summer in Euphrates River, Iraq. Devika *et al.* (2006) also recorded high population during summer and suggested that this might be due to physical rather than chemical conditions in which the water temperature and transparency had a direct relationship with phytoplankton population. The results found to be well agreed with investigations carried out by Sukumaran and Das (2002), Banakar *et al.* (2005), Begum and Narayana (2006), Laskar and Gupta (2009), Nafeesa *et al*. (2011b), Tarakeshwar *et al.* (2011). Phytoplankton showed significant positive relationship with water temperature, pH, transparency, biological oxygen demand and chlorides. It showed significant negative relationship with electric conductivity, total solids, total dissolved solids, Total hardness, dissolved oxygen, nitrates, sulphate and phosphate (Tab. 2).

Maximum species richness was recorded 8.83 Margalef's index (R_1) and 1.29 Menhinick index (R_2) at station one, minimum Species richness was recorded 7.67 Margalef's index (R_1) and 1.10 Menhinick index (R_2) at station two and station three. Maximum species diversity was recorded 0.05 Simpson's index (λ) at station two and 3.98 Shannon - Weiner index (H') at station one and station four; minimum species diversity was recorded 0.03 Simpson's index (λ) at station one, station four and station five; and 3.71 Shannon - Weiner index (H') at station two. Maximum species evenness was recorded at stations one, four and five; minimum species evenness was recorded at station two (Tab. 3).

A number of previous reviews focused on phytoplanktons diversity (Harris, 1986; Shinde *et al.*, 2011). Phytoplanktons species diversity index, Simpson's index (λ) which varied from 0 to 1, gives the probability that two individuals drawn at random from a population belong to the same species. Simply stated, if the probability was high that both individuals belong to the same species, then the diversity of the community sample was low. Shannon's index (H') encompasses species richness and spices evenness components as overall index of diversity. The higher values of Shannon's Index (H'), indicated the greater species diversity. The greater species diversity means large food chain and more of inter-specific interactions and greater possibilities for negative feedback control that reduced

Tab. 2. Correlation coefficient (r) among the physico-chemical properties and phytoplanktons of Riwada reservoir from April 2011 to March 2012

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
A	1																
B	0.3916	1															
C	-0.6267	-0.9044	1														
D	-0.4225	-0.8675	0.8887	1													
E	0.4954	0.9409	-0.9453	-0.9622	1												
F	-0.5801	-0.8586	0.9232	0.9075	-0.9540	1											
G	-0.5359	-0.9227	0.9406	0.9503	-0.9879	0.9747	1										
H	-0.7071	-0.8875	0.9601	0.8952	-0.9487	0.9619	0.9660	1									
I	0.0672	-0.5716	0.3956	0.4735	-0.4866	0.4629	0.4956	0.4154	1								
J	-0.4348	-0.9347	0.9394	0.8558	-0.9267	0.8836	0.8993	0.8851	0.5054	1							
K	-0.5617	-0.8939	0.9474	0.8832	-0.9558	0.9559	0.9487	0.9468	0.4184	0.9484	1						
L	0.9403	0.6288	-0.7854	-0.6512	0.7249	-0.7736	-0.7461	-0.8720	-0.1352	-0.6377	-0.7634	1					
M	0.5070	0.9437	-0.9497	-0.9513	0.9931	-0.9493	-0.9911	-0.9506	-0.4772	-0.9194	-0.9527	0.7241	1				
N	0.3524	0.8439	-0.8348	-0.9113	0.9054	-0.9013	-0.8958	-0.8501	-0.4022	-0.8702	-0.8873	0.5865	0.8946	1			
O	0.3052	0.8644	-0.8756	-0.9334	0.9302	-0.9265	-0.92762	-0.8639	-0.4929	-0.8859	-0.8974	0.5459	0.9208	0.9642	1		
O	0.4176	0.7807	-0.7954	-0.8917	0.8862	-0.9028	-0.89252	-0.8478	-0.3617	-0.7886	-0.8530	0.6405	0.8798	0.9545	0.9261	1	
P	0.4174	0.6206	-0.7349	-0.7259	0.7042	-0.7763	-0.7061	-0.7394	-0.2438	-0.6947	-0.7403	0.5761	0.6887	0.8687	0.8428	0.8284	1

Data were the mean value of monthly collected samples. Correlation is high significant at $p < 0.01$ level, Correlation is significant at $p < 0.05$ level;
A - Water Temperature, B -pH, C -Electric Conductivity,D -Dissolved Oxygen, E - Biological Oxygen Demand, F -Hardness, G -Total Dissolved Solids, H -Total Solids, I - Sulphates, J -Nitrates, K -Phosphates, L - Chlorides, M -Transparency, N - Chlorophyceae, O - Bacillariophyceae, P - Cyanophyceae, Q -Euglenophyceae

Tab. 3. Annual variations of phytoplanktons's, biodiversity indices at Riwada Reservoir during April 2011-March 2012

Indices	Index	Station1	Station2	Station3	Station4	Station5
Species Richness	N_0	72	61	66	71	70
	R_1	8.83	7.67	7.94	8.57	8.48
	R_2	1.29	1.22	1.10	1.19	1.20
Species Diversity	λ	0.03	0.05	0.04	0.03	0.03
	H'	3.98	3.71	3.81	3.98	3.97
Species Evenness	E	0.93	0.90	0.91	0.93	0.93

(N_0):No. of all species (λ):Simpson's index
(R_1):Margalef's index (H'):Shannon - Weiner index
(R_2):Menhinick index E:Evenness index

oscillations and hence increases the stability of the community. Equitability (evenness) was relatively high during the raining season indicating a reduction in the plankton diversity at this period (Adesalu and Nwankwo, 2008). Evenness indices indicate whether all species in a sample are equally abundant. This means that species evenness decreased with increasing size of the plankton population.

Quantitative counts showed clear seasonal variation in phytoplankton cell numbers with maximum during early summer and autumn. Seasonal variations in abundance and composition of reservoir phytoplanktons are usually affected by the discharge, morphometry, hydrology, trophic status, and light availability (Indra and Sivaji, 2006; Kumari *et al.*, 2006; Leveque, 2006; Reynolds, 2006; Shiddamallayya and Pratima, 2008; Kolayli and Sahin, 2009).

Conclusions

In the present study, the phytoplanktons population density was recorded maximum at station three due to River Sharada water entering in the dam with agricultural, domestic and anthropogenic waste. This diversity indices showed that the reservoir under study have a well balanced phytoplankton community that enjoyed an even representation of several species indicating the dynamic nature of aquatic ecosystem.

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