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Primary productivity and phytoplankton diversity in relation to fisheries potential of the Lake Udai Sagar, Udaipur

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Abstract

The present investigation was done in February to April 2015 dealt with the phytoplankton diversity in relation to primary productivity of Lake Udai Sagar, Udaipur. In the present Physico-chemical features such as air and temperature, transparency, pH, alkalinity, free carbon dioxide, dissolved oxygen, primary productivity, electrical conductivity, nitrate-nitrogen, orthophosphate and qualitative and quantitative estimation of phytoplankton.

The study indicated that the mean primary productivity (GPP) of reservoir Udai Sagar was found to be $0.50 \text{ g C m}^3 \text{ h}^{-1}$ in surface. On the basis of mean primary productivity, the fish production potential of reservoir Udai Sagar showed considerable scope for the enhancement of present average production.

Keywords: Primary productivity, Phytoplankton, fish production potential

1. Introduction

Rajasthan is the India's largest state in terms of area and is also one of the most diverse states where tradition and royal glory meet in a riot of colors. Rajasthan is also endowed with varied surface freshwater resources like reservoirs, seasonal and a couple of perennial rivers, canals, small tanks and ponds. In an earlier estimate Rajasthan was having around 4.23 lakh hectares of water area. Out of this, large and medium reservoirs constitute about 2.47 lakh hectares of water area, small reservoirs and ponds contribute 1.76 lakh hectares. Whereas, 0.30 lakh hectare water area is available in the form of rivers and canals (Source-DOF Rajasthan 2011).

The present study was carried out during February to April 2015 in Udai Sagar Lake. The Udai Sagar Lake, under investigation, was constructed during the year 1565 across the river Berach. Udai Sagar is situated in Udaipur district of Rajasthan ($73^\circ 47'0''\text{E}$ and $24^\circ 33' 0''\text{N}$). It has a storage capacity of 23.4milli cubic meter. To manage the overflowing lake during rainy season, one channel has been made connecting to Berach River. It commands a culturable commended area of 4656.7 ha. With irrigable area of 1944 ha.

Physico-chemical features such as temperature, transparency, pH, alkalinity, free carbon dioxide, dissolved oxygen, electrical conductivity, nitrate-nitrogen, orthophosphate *etc.* of any water body grossly determine the trophic status of that water body. These parameters influence the primary productivity (phytoplankton) and in turn the growth of the fish. The primary productivity of different water bodies has been widely investigated to assess the fish production potentialities of a water body to formulate appropriate fishery management policies.

Phytoplankton are the main primary producers in water bodies and influence structure and density of consumers and characteristics of water. Moreover, phytoplanktonic organisms are sensitive indicators, as phytoplankton structure and metabolism change quickly in response to environmental changes. Growth rate and variability of phytoplankton are subject to cyclic changes: fluctuation and succession. Phytoplanktons constitute a major part of aquatic vegetation, they being primary producers which support the growth of aquatic fauna and produce oxygen by photosynthetic process. Some of them may cause pollution by changing the quality of water in which they grow. They are good indicators of water quality and capacity of water to sustain heterotrophic communities. Phytoplankton play a vital role in biosynthesis of organic substance in lentic ecosystem, on which directly depends all the living organisms in aquatic system as source of food. Even if they have no immediate effect on fish yield, they are at least fairly good indicators of the biological productivity.

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In general, the growth of a fish is influenced by the quality and quantity of food material available and consumed. Thus, any variation in quality and quantity of food materials will affect the growth rate of the fish. The qualitative and quantitative variations of natural food materials in a water body are influenced by several abiotic and biotic factors. A comparative study of plankton and productivity of certain Udaipur waters in comparison to the selected waters of Rajasthan have been carried out (Sharma, 1980) [7].

Primary productivity of various water bodies has been studied by several workers in order to predict their fish production potential and to formulate fishery management policies. Ayyappan and Gupta studied the primary productivity of Ramasamudra Tank situated in Karnataka. Natarajan and Pathak have advocated the significance of physico-chemical primary productivity studies in the management of inland water. Kohli estimated the gross as well as net primary productivity and nutrient status of various water bodies of Southern Rajasthan. Das estimated the potential fish production of Yerrakalva, peninsular reservoir of Andhra Pradesh. Sengupta *et al.* used gross primary production for predicting the yield as stocked recovery.

In Rajasthan, for the estimation of fish production potential of different water bodies, their primary productivity has been studied by several workers. Sharma and Durve studied the trophic status and fisheries potential of various water bodies of Rajasthan. Gupta studied the primary productivity of Jaisamand Lake situated in Udaipur (Rajasthan). Ujjania studied the primary productivity of three water bodies viz. Mahi bajaj sagar, Surwania dam and Assan pond situated in Southern Rajasthan.

The current research work is conducted to find out the phytoplankton diversity in relation to primary productivity of Lake Udai Sagar. Attempt was made to assess the current water quality status and possibilities of fisheries development of Lake Udai Sagar.

2. Materials and Methods

For the present study, three sampling stations were selected in the lake Udai Sagar for collection and analysis at weekly interval. Station 'A' is located on the South Eastern shore, station 'B' at the eastern shore and station 'C' is located on the Western side.

2.1 Primary Productivity

Primary productivity was measured at all the three stations following light and dark bottles method. For this purpose, glass stoppered black and white BOD bottles of 250 ml were used. The bottles were suspended about 15 cm below the water line. The incubation period was kept three hours. Oxygen (O₂) estimations in the BOD bottles were made following usual Winkler's method (APHA, 2005). The calculation was done as under

$$\begin{aligned} \text{Gross Oxygen Production (GOP) mg l}^{-1} &= \text{LB-DB} \\ \text{Net Oxygen Production (NOP) mg l}^{-1} &= \text{LB-IB} \\ \text{Community Respiration (CR) mg l}^{-1} &= \text{IB-DB} \end{aligned}$$

The values of gross and net primary productivity were calculated as follows

$$\begin{aligned} \text{Gross Primary Productivity (g C m}^{-3} \text{ h}^{-1}) &= \text{GOP} \times 0.375/1.2 \times \text{h} \\ \text{Net Primary Productivity (g C m}^{-3} \text{ h}^{-1}) &= \text{NOP} \times 0.375/1.2 \times \text{h} \end{aligned}$$

Where,

LB	=	Dissolved oxygen in light bottle
DB	=	Dissolved oxygen in dark bottle
IB	=	Dissolved oxygen in initial bottle
H	=	Duration of incubation or exposure
1.2	=	A constant
0.375	=	A factor value (1 g of oxygen is equal to 0.375 g carbon)

2.2 Plankton analysis

For this 50 litres of water was filtered through bolting silk No. 25 (mesh size 60 µm) and plankton thus obtained was preserved in Lugol's solution for further quantitative and qualitative analyses. For quantitative and qualitative analysis of phytoplankton using (APHA, 1989). Needham and Needham (1962), Edmondson (1965), and Adoni (1985). The identification of phytoplankton was restricted only upto major groups viz., Cyanophyceae, Chlorophyceae, Bacillariophyceae and Desmidiaceae.

3. Results and Discussion

The results pertaining to gross and net primary productivities of Udai Sagar during the study period (February to April) are presented in Tables 4.1 to 4.3. In general, the GPP ranged between 0.35 to 0.65, 0.35 to 0.60 and 0.35 to 0.65 g C m⁻³ h⁻¹ at stations A, B and C, respectively. The average values of GPP were 0.52, 0.47 and 0.50.

The statistical relationship of GPP was found positive with NPP, community respiration (CR) and total phytoplankton.

The respective values of net primary productivity (NPP) at stations A, B and C ranged from 0.15-0.50, 0.25-0.45 and 0.25-0.45 g C m⁻³ h⁻¹. The average values of NPP were 0.37, 0.36 and 0.37.

The statistical relationship of NPP was found positive with GPP and total phytoplankton. The respective values of community respiration (CR) at stations A, B and C ranged from 0.10 to 0.20, 0.05 to 0.20 and 0.05 to 0.20 g C m⁻³ h⁻¹. The corresponding average values of CR were 0.15, 0.10 and 0.12.

The statistical correlation of CR was found positive GPP. However, there was a negative relationship with, NPP and total phytoplankton.

3.1. Phytoplankton

The phytoplankters constitute bulk of primary producers and are the base of food chains in any water body. The phytoplanktonic community of Udai Sagar during the present was represented by four major group's viz., Cyanophyceae, Chlorophyceae, Bacillariophyceae and Desmidiaceae. Overall 36 genera of algae were identified (Table 4.8). Out of the total 36 genera, 13 were from Cyanophyceae (blue green algae), 11 from Chlorophyceae (green algae) 9 from Bacillariophyceae (diatoms) and 3 belonged to Desmidiaceae. The most prominent phytoplankters during the study were *Microcystis aeruginosa*, *Anabaena* sp. *Nostoc* sp. *Spirulina* sp. and *Phormidium* sp. from group Cyanophyceae. While *Volvox* sp. *Spirogyra* sp. *Chlorella* sp. *Ulothrix* sp. and *Pediastrum* sp. from group Chlorophyceae. As evident from the study, Cyanophyceae dominated over Chlorophyceae, Bacillariophyceae followed by Desmidiaceae. Sharma, (1980) [7], Solomon, (1994) and Shekhawat, (1997) observed dominance of blue green algae in Udaipur waters. Baghela, (2006) observed the dominance of Chlorophyceae in oligotrophic lake Jawai Dam.

The average phytoplankton density was *i.e.*, 226.08 Cells ml⁻¹

(Table 4.9). The highest phytoplankton density (294.00 Cells ml^{-1}) was observed on XI Week, 2015 at station A. whereas the lowest (134.00 Cells ml^{-1}) V Week, 2015 at station C (Tables 4.5 to 4.7). Considering the average phytoplanktonic biomass, Cyanophyceae was the most dominant (75.50, 87.33, 91.17 Cells ml^{-1}) followed by Chlorophyceae (67.08, 71.08, 51.50 Cells ml^{-1}) Bacillariophyceae (80.33, 78.08, 48.50 Cells ml^{-1}) Desmidiaceae (13.00, 9.50, 5.17 Cells ml^{-1}) at station A, B and

C, respectively (Table 4.5 to 4.7).

Out of the four major groups of phytoplankton stated earlier, the cyanophyceae and Chlorophyceae were dominant, followed by Bacillariophyceae and Desmidiaceae (Table 4.5 to 4.7 and Plate-1)

The statistical correlation of phytoplankton was found positive with GPP and NPP. However, there was a negative relationship with community respiration (CR).

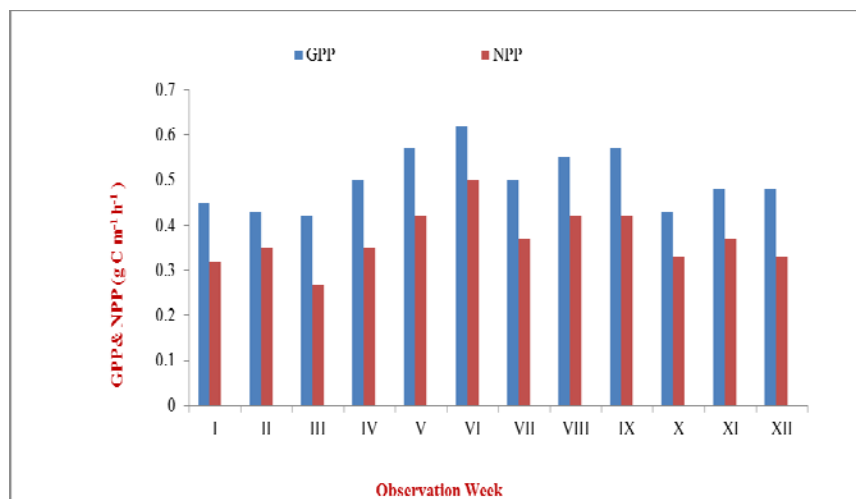


Fig 4.3: Weekly variations in Gross Primary Productivity (GPP) and Net Primary Productivity (NPP), in surface water of Lake Udai Sagar

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Table 1.1: Weekly observation of Physico-chemical and biological characteristics of surface water at station “A” of Lake Udai Sagar, Udaipur

S. No.	Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Avg.	S.D	Min.	Max.	C.V. (%)
1	Primary productivity (g C m ⁻³ h ⁻¹)																	
2	Gross primary productivity	0.60	0.50	0.35	0.60	0.60	0.65	0.60	0.45	0.55	0.40	0.65	0.40	0.52	0.10	0.35	0.65	19.23
3	Net primary productivity	0.45	0.35	0.15	0.45	0.40	0.50	0.40	0.35	0.45	0.25	0.50	0.25	0.37	0.10	0.15	0.50	27.02
4	Community respiration	0.15	0.15	0.20	0.15	0.20	0.15	0.20	0.10	0.10	0.15	0.15	0.15	0.15	0.03	0.10	0.20	20.0

Table 1.2: Weekly observation of Physico-chemical and biological characteristics of surface water at station “B” of Lake Udai Sagar, Udaipur

S. No.	Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Avg.	S.D	Min.	Max.	C.V. (%)
14	Primary productivity (g C m ⁻³ h ⁻¹)																	
(i)	Gross primary productivity	0.40	0.40	0.40	0.35	0.45	0.60	0.45	0.60	0.55	0.50	0.45	0.50	0.47	0.08	0.35	0.60	17.02
(ii)	Net primary productivity	0.25	0.35	0.35	0.25	0.40	0.45	0.35	0.45	0.35	0.40	0.35	0.40	0.36	0.06	0.25	0.45	16.66
(iii)	Community respiration	0.15	0.05	0.05	0.10	0.05	0.15	0.10	0.15	0.20	0.10	0.10	0.10	0.10	0.04	0.05	0.20	40.0

Table 1.3: Weekly observation of Physico-chemical and biological characteristics of surface water at station “C” of Lake Udai Sagar, Udaipur

S. No.	Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Avg.	S.D	Min.	Max.	C.V. (%)
1	Primary productivity (g C m ⁻³ h ⁻¹)																	
2	Gross primary productivity	0.35	0.40	0.50	0.55	0.65	0.60	0.45	0.60	0.60	0.40	0.35	0.55	0.50	0.10	0.35	0.65	20.0
3	Net primary productivity	0.25	0.35	0.30	0.35	0.45	0.55	0.35	0.45	0.45	0.35	0.25	0.35	0.37	0.08	0.25	0.45	21.62
4	Community respiration	0.10	0.05	0.20	0.20	0.20	0.05	0.10	0.15	0.15	0.05	0.10	0.20	0.12	0.06	0.05	0.20	50.0

Table 1.4: Correlation matrix of different water quality parameter of Lake Udai Sagar, Udaipur

Parameters	Air temp.	Water temp.	pH	Depth of vis.	D O ₂	Free CO ₂	CO ₃	HCO ₃	Total Alk.	EC	TDS	NO ₃ -N	HPO ₄	GPP	NPP	CR	TPP
Air temp.	1					-											
Water temp.	0.9666**	1				-											
pH	0.4624	0.5358	1			-											
Depth of vis.	0.9388**	0.9272**	0.4790	1		-											
Dissolved O ₂	-0.1347	-0.0012	0.4150	0.0424	1	-											
Free CO ₂	-	-	-	-	-	1											
CO ₃	0.1631	0.1722	-0.0728	-0.0098	0.0946	-	1										
HCO ₃	-0.5263	-0.5896*	0.0355	-0.5675*	0.1629	-	-0.107	1									
Total Alk.	-0.4134	-0.5111	0.0730	-0.5923*	-0.2075	-	0.0624	0.7759**	1								
EC	-0.8052**	-0.8602**	-0.2926	-0.7345**	0.0128	-	-0.3613	0.5325	0.5303	1							
TDS	-0.8571**	-0.9073**	-0.4204	-0.7761**	-0.0761	-	-0.27	0.4740	0.4801	0.9589**	1						
NO ₃ -N	-0.7331**	-0.7927**	-0.5554*	-0.8378**	-0.3117	-	0.2451	0.4277	0.5989*	0.6009*	0.7225**	1					
HPO ₄	-0.3142	-0.5004	-0.5967*	-0.3627	-0.4952	-	-0.0885	0.2903	0.3164	0.2803	0.3696	0.5707*	1				
GPP	0.2403	0.3355	0.4112	0.4814	0.4039	-	-0.2727	-0.4441	-0.6147*	-0.0435	-0.0668	-0.5245	-0.5467	1			
NPP	0.2351	0.3101	0.6017*	0.4487	0.3960	-	-0.2928	-0.3131	-0.3834	0.0274	-0.0179	-0.4552	-0.5287	0.9360**	1		
CR	0.0413	0.1068	-0.4718	0.1433	0.0670	-	0.0239	-0.4066	-0.6986**	-0.1981	-0.1406	-0.2478	-0.1107	0.2870	-0.0685	1	
TPP	0.5151	0.6275*	0.3856	0.3333	-0.0617	-	0.3345	-0.4243	-0.1580	-0.5317	-0.6028 ^s	-0.3696	-0.6890 ⁸⁸	0.0623	0.0793	-0.0393	1