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Studies on the fish and phytoplankton biodiversity with relationship to primary productivity of the Pichhola Lake, Udaipur, Rajasthan

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Abstract
The present study on "Fish and Phytoplankton biodiversity with relationship to primary productivity of the Pichhola Lake, Udaipur, Rajasthan" was conducted during September 2016 to September 2017. The lake has a fairly rich fish fauna and so far 20 species representing 7 families have been recorded in the present investigation, of these, 9 species predominantly contributed to the commercial fisheries of this lake. In the present Physico-chemical features such as air and water temperature, transparency, pH, alkalinity, free carbon dioxide, dissolved oxygen, primary productivity, electrical conductivity, nitrate-nitrogen and orthophosphate were done along with qualitative and quantitative estimation of phytoplankton. The study indicated that the average primary productivity (GPP) of Pichhola Lake was found to be 0.52.0 g C m^3 h^{-1} in the surface. During the study period, the Indian major crops dominated the catch by contributing 90 percent of the total landings from this lake. Besides Indian major carps, minor carps and catfishes were reported to be 8.84 and 0.9 percent, respectively. Among the Indian major carps, the *Catla catla* (70%) dominated the groups followed by *Labeo rohita* (25%) and *Cirrhinus mrigala* (5%).

Keywords: Fish biodiversity, Pichhola Lake, phytoplankton diversity, primary productivity

1. Introduction
Rajasthan is 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 [2].

The present study was carried out during September 2016 to September 2017 in the Pichhola Lake. The Pichhola Lake is an artificial fresh water lake, created in the year 1362 AD, named after the nearby Picholi village (24.572"N and 73.679"E). It has a storage capacity of 13.08 million cubic meters. To manage the overflowing lake during the rainy season, one channel has been made connecting to Berach River [3].

India is one of the mega biodiversity countries in the world and occupies ninth position in terms of freshwater mega biodiversity [15]. In India, there are 2,500 species of fishes; which, 930 live in freshwater and 1570 are marine [11]. Out of these 400 species are commercially important which includes wild and culturable species [6]. The aquatic ecosystems have been subjected to various forms of environmental stress, during the past few decades. Most of such environmental problems are man-made and thus increased human activities in the catchment area of various aquatic systems have affected the natural processes of these systems adversely thereby threatening the survival and growth of biotic communities [4, 5].

Phytoplanktons 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 of 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 the photosynthetic process [12].

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 [9].

The current research work is conducted to find out Fish and Phytoplankton biodiversity with relationship to primary productivity of the Pichhola Lake. An attempt was made to assess the current water quality status and possibilities of fisheries development of the Lake Pichhola.

2. Materials and Methods

For the present study, three sampling stations were selected in the Pichhola Lake for collection and analysis at weekly interval. Total 3 stations selected for this work (Station A, B and C).

2.1 Sample collection

In order to study the biodiversity, samples of fishes were collected from the commercial catches and sample netting during the fishing year 2016-17 at landing center of the Pichhola Lake. As far as possible fishes were identified in the field itself using standard manuals [8, 17]. Species that could not be identified in the field were preserved in 4 percent formalin and brought to the laboratory for identification.

2.2 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 three hours. Oxygen (O^2) estimations in the BOD bottles were made following usual Winkler's method [1]. The calculation was done as shown below

Gross Oxygen Production (GOP) mg l^{-1}	= LB-DB
Net Oxygen Production (NOP) mg l^{-1}	= LB-IB
Community Respiration (CR) mg l^{-1}	= IB-DB

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

Gross Primary Productivity (g C m^{-3} h^{-1}) = GOP x 0.375/1.2 x h		
Net Primary Productivity (g C m^{-3} h^{-1}) = NOP x 0.375/1.2 x h		
Where,		
LB	=	Dissolved oxygen in light bottle
DB	=	Dissolved oxygen in dark bottle
IB	=	Dissolved oxygen in the 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 of carbon)

2.3 Plankton analysis

For this 50 liters of water was filtered through bolting silk no. 25 (mesh size 60 µm) and plankton thus obtained were preserved in Lugol's solution for further quantitative and qualitative analyses. For quantitative and qualitative analysis of phytoplankton using [1]. The identification of phytoplankton was restricted only upto major groups *viz.*, Cyanophycean, Chlorophyceae, Bacillariophyceae and Desmidiaceae.

3. Results and Discussion

3.1 Fish Diversity

The fish faunal varieties found in the present investigation have been depicted in Table.1. This table clearly indicates that total 20 fish species belonging to 7 families were found from the Pichhola Lake. Thus, the fish faunal structure appears fairly rich. Out of the recorded 20 fish species, only 11 species *viz*., Catla, Mrigala, Rohu, Kharpata, Sarsi, Puthi, Chal, Pabda, Lanchi, Singhi and Channa contributed to the commercial catch of this reservoir. Indian major carps have dominated the fishery of the lake followed by the minor carps and catfishes (Table.2). In general, the Indian major carps appear to contribute around 85% to the total landings of the Pichhola Lake. While the percent contributions of minor carps and catfishes in the total catch were only 8.5% and 6.5%, respectively (Fig.1). Amongst the Indian major carps, *Catla catla* dominated by (65.88%) followed by *Labeo rohita* (15.29%) and *Cirrhinus mrigala* (18.82%).

Further, in the case of minor carps, *Labeo gonius* dominated with a contribution of 76.47% followed by *Puntius sophore* (17.64%). Other fishe species, formed 5.88 % of the total minor carp catch. The catfishes have also made a smaller contribution to the landings of the Pichhola Lake, the highest catfish landing being of *Wallago attu* (30.76%) followed by *Mystus seenghala* (24.61%), *Ompak bimaculatus* (12.30%) and *Mastacembelus armatus* (27.69%). Datta and Majumdar (1970) made an extensive survey of 93 collection stations in 14 districts of Rajasthan from which fishes were obtained and reported 75 fish species. Other many researchers were notable contributions on the fish fauna of the Rajasthan area [10, 16, 13].

3.2 Primary Productivity

The results pertaining to gross and net primary productivities of the lake Pichhola during the study period (September 2016 to September 2017) are presented in Tables 3 to 5. In general, the GPP ranged between 0.30 to 0.60, 0.30 to 0.65 and 0.35 to 0.70 g C m^{-3} h^{-1} at stations A, B and C, respectively. The average values of GPP were 0.48, 0.52 and 0.54 g C m^{-3} h^{-1}.

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 0.20-0.50, 0.25-0.55 and 0.25-0.45 g C m^{-3} h^{-1}. The average values of NPP were 0.36, 0.40 and 0.37 g C m^{-3} h^{-1}.

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 0.05 to 0.20, 0.10 to 0.20 and 0.05 to 0.20 g C m^{-3} h^{-1}. The corresponding average values of CR were 0.12, 0.15 and 0.13 g C m^{-3} h^{-1}.

The statistical correlation of CR was found positive GPP. However, there was a negative relationship with, NPP and total phytoplankton. All water quality parameters of the Lake Pichhola were shown in Table 6.

3.3 Phytoplankton Diversity

The phytoplankters constitute the bulk of primary producers and are the base of food chains in any water body. The phytoplanktonic community of the Lake Pichhola during the present was represented by four major group's *viz.*, Cyanophyceae, Chlorophyceae, Bacillariophyceae and

Desmidiaceae. Overall 36 genera of algae were recorded in Lake Pichhola during the present study. Out of the total 36 genera, 12 were from Cyanophyceae, 9 from Bacillariophyceae, 12 from Chlorophyceae, and 3 belongs to Desmidiaceae.

However, Kumar [12] were found the phytoplanktonic community of water body was represented by six groups namely Chlorophyceae, Bacillariophyceae, Desmidiaceae, Xanthophyceae, Myxophyceae and Dinophyceae. Total 58 forms were identified and out of these 28 belonged to Chlorophyceae, 11 to Bacillariophyceae, 9 to Myxophyceae, 4 to Dinophyceae, 3 to Desmidiaceae and 3 to Xanthophyceae in the water of Udai Sagar. Mishra [14] were found that the average phytoplankton count in Goverdhan Sagar was 36.71 No/ml distributed in 29 genera in the order of dominance - Chlorophyceae, Bacillariophyceae, Cyanophyceae and Desmidiaceae. Apparently, therefore, there is a significant decline in the biodiversity of phytoplankton.

The monthly average values of all three stations of overall mean phytoplankton density were more at station C *i.e.* (150.00 Cells ml-1) followed by station B (148.11 Cells ml-1) and Station A (142.50 Cells ml-1). The trend of dominance among the three phytoplankton groups at station A was Chlorophyceae > Cyanophyceae > Bacillariophyceae > Desmidiaceae. At station B the trend of dominance was Cyanophyceae > Chlorophyceae > Bacillariophyceae > Desmidiaceae. However, at stations C the relative dominance of four algal groups was Cyanophyceae > Bacillariophyceae > Chlorophyceae > Desmidiaceae. The overall dominance of phytoplankton is similar to the trend found at station A (Table 7).

Table 1: List of fish fauna represented in the catch from the Lake Pichhola, Udaipur

No.	Family	Species	
		Scientific name	Local name
1	Cyprinidae	1. *Catla catla* (Ham.)	Catla
		2. *Labeo rohita* (Ham.)	Rohu
		3. *Labeo calbasu* (Ham.)	Kharpata
		4. *Labeo gonius*	Sarsi
		5. *Cirrhinus mrigala* (Ham.)	Mrigala
		6. *Puntius sophore* (Ham.)	Puthi
		7. *Tor khudree*	Mahseer
		8. *Cirrhina reba*	Reba
		9. *Chela bacaila*	Chal
2	Channidae	10. *Channa channa*	Channa
		11. *Channa marulius* (Ham.)	Sawal
		12. *Channa puncatatus*	Girhi
3	Notopteridae	13. *Notopterus notopterus* (Pallas)	Patola
4	Mastacembelidae	14. *Mastacembelus armatus*	Bam
5	Siluridae	15. *Ompak pabda* (Bloch)	Pabda
		16. *Wallago attu* (Bloch)	Lanchi
		17. *Heteropneustes fossilils* (Bloch)	Singhi
6	Ambassidae	18. *Parambassia ranga*	Glass fish
7	Baridae	19. *Mystus seenghala*	Singhara
		20. *Mystus aor*	Pitar

Table 2: Percentage composition of prominent fish species in total landing from the Lake Pichhola during period 2016-17

No.	Fish group	Percent composition	
		In group	In total fish production
1	Major Carps	100%	85%
	Catla catla (Ham.)	65.88%	56%
	Labeo rohita (Ham.)	15.29%	13%
	Cirrhinus mrigala (Ham.)	18.82%	16%
2	Minor Carps	100%	8.5%
	Labeo spp.	76.47%	6.5%
	Puntius spp.	17.64%	1.5%
	Miscellaneous	5.88%	0.5%
3	Cat Fishes	100%	6.5%
	Wallago attu	30.76%	2.0%
	Ompak pabda	24.61%	1.6%
	Mastacembelus armatus	12.30%	0.8%
	Mystus seenghala	27.69%	1.8%
	Miscellaneous	4.61%	0.3%

Table 3: Weekly observation of Physico-chemical and biological characteristics of surface water at station "A" of Lake Pichhola, Udaipur

No.	Parameters	I (%)	II (%)	III (%)	IV (%)	V (%)	VI (%)	VII (%)	VIII (%)	IX (%)	X (%)	XI (%)	XII (%)	Avg. (%)	S.D (%)	Min. (%)	Max. (%)	C.V. (%)
1	PP (g C m^{-3} h^{1})																	
2	GPP (g C m^{-3} h^{1})	0.40	0.35	0.60	0.30	0.60	0.45	0.50	0.60	0.55	0.60	0.30	0.50	0.48	0.12	0.30	0.60	4.07
3	NPP (g C m^{-3} h^{1})	0.35	0.45	0.20	0.25	0.50	0.40	0.35	0.20	0.45	0.40	0.30	0.50	0.36	0.11	0.20	0.50	3.39
4	CR (g C m^{-3} h^{1})	0.05	0.05	0.15	0.10	0.05	0.15	0.10	0.20	0.10	0.20	0.15	0.10	0.12	0.05	0.05	0.20	2.17

PP= Primary productivity, GPP= Gross primary productivity, NPP= Net primary productivity, CR= Community respiration

Table 4: Weekly observation of Physico-chemical and biological characteristics of surface water at station "B" of Lake Pichhola, Udaipur

No.	Parameters	I (%)	II (%)	III (%)	IV (%)	V (%)	VI (%)	VII (%)	VIII (%)	IX (%)	X (%)	XI (%)	XII (%)	Avg. (%)	S.D (%)	Min. (%)	Max. (%)	C.V. (%)
1	PP (g C m^{-3} h^{1})																	
2	GPP (g C m^{-3} h^{1})	0.30	0.50	0.65	0.40	0.55	0.60	0.65	0.30	0.50	0.65	0.60	0.55	0.52	0.13	0.30	0.65	4.10
3	NPP (g C m^{-3} h^{1})	0.25	0.40	0.35	0.45	0.25	0.30	0.50	0.40	0.55	0.45	0.55	0.40	0.40	0.10	0.25	0.55	3.91
4	CR (g C m^{-3} h^{1})	0.15	0.15	0.20	0.15	0.15	0.10	0.20	0.25	0.10	0.15	0.10	0.15	0.15	0.05	0.10	0.25	3.42

PP= Primary productivity, GPP= Gross primary productivity, NPP= Net primary productivity, CR= Community respiration

Table 5: Weekly observation of Physico-chemical and biological characteristics of surface water at station "C" of Lake Pichhola, Udaipur

No.	Parameters	I (%)	II (%)	III (%)	IV (%)	V (%)	VI (%)	VII (%)	VIII (%)	IX (%)	X (%)	XI (%)	XII (%)	Avg. (%)	S.D (%)	Min. (%)	Max. (%)	C.V. (%)
1	PP (g C m^{-3} h^{1})																	
2	GPP (g C m^{-3} h^{1})	0.40	0.50	0.70	0.65	0.55	0.70	0.65	0.60	0.50	0.40	0.35	0.45	0.54	0.12	0.35	0.70	4.38
3	NPP (g C m^{-3} h^{1})	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	0.09	0.25	0.55	4.16
4	CR (g C m^{-3} h^{1})	0.10	0.05	0.20	0.20	0.20	0.05	0.10	0.15	0.15	0.05	0.10	0.20	0.13	0.06	0.05	0.20	2.08

PP= Primary productivity, GPP= Gross primary productivity, NPP= Net primary productivity, CR= Community respiration

Table 6: Correlation matrix of different water quality parameters of the Lake Pichhola, Udaipur

Parameters	Air temp.	Water temp.	pH	Depth of Vis.	O_2	CO_2	HCO_3	Alkaline	EC	TDS	NO_3	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												
O_2	-0.1347	-0.0012	0.4150	0.0424	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									
Alkaline	-0.4131	-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	0.4741	0.4851	0.9589*	1						
NO_3	-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	-0.4939	-0.0885	0.2933	0.3164	0.2823	0.3659	0.5707*	1				
GPP	0.2403	0.3355	0.4112	0.4851	0.4039	-0.2727	-0.4441	-0.6147*	-0.0451	-0.0668	-0.5245	-0.5467	1			
NPP	0.2351	0.3101	0.6017*	0.4487	0.3960	-0.2928	-0.3131	-0.3824	0.2148	-0.0147	-0.4552	-0.5287	0.9360	1		
CR	0.0413	0.1068	-0.4718	0.1433	0.670	0.0239	-0.4066	-0.6986*	-0.1987	-0.2568	-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	-0.5324	-0.2354	-0.3658	-0.6890	0.0635	0.0798	-0.0393	1

Table 7: Annual average values of phytoplankton (Cell ml-1) at four stations of Lake Pichhola, Udaipur

Major groups	Station A	Station B	Station C	Overall Avg.
Cyanophyceae				
Anabaena	9.89	8.44	7.20	8.11
Nostoc	11.29	10.43	9.71	9.97
Polycystis	8.00	9.27	-	9.15
Oscillatoria	-	-	12.00	11.13
Agmenellum	6.00	7.57	-	6.79
Coelospharium	4.71	4.71	-	4.71
Microcystis	6.90	8.00	11.17	8.91
Meriosmopedia	9.60	10.00	-	9.80
Spirulina	7.80	9.33	12.20	9.83
Aphanocapsa	3.75	5.40	-	5.58
Synechocystis	2.33	3.29	-	2.81
Arthrospira	8.40	9.20	10.71	9.19
Total	78.67	85.65	63.00	74.67
Bacillariophyceae				
Synedra	5.29	6.29	10.22	7.59
Nitzschia	8.11	7.89	12.67	9.75
Fragilaria	6.75	7.88	7.88	7.22
Navicula	7.17	8.17	11.00	8.71
Diatoma	6.45	7.55	6.78	6.89
Tabellaria	5.33	6.83	-	6.33
Cyclotella	8.33	8.83	12.17	9.88
Asterionella	6.25	7.75	-	7.00
Pinnularia	6.25	8.25	-	7.25
Total	59.93	69.43	60.71	61.90
Chlorophyceae				
Pediastrum	6.50	6.60	7.00	6.53
Protococcus	7.00	7.33	6.00	6.33
Ulothrix	8.10	7.80	10.86	9.08

Chlamydomonas	-	-	11.13	10.57
Spirogyra	11.80	10.20	11.13	10.85
Tetrasporacylindrica	3.88	3.63	-	3.76
Ankistrodesmus	10.75	9.75	13.67	10.96
Hydrodictyon	6.80	7.20	-	7.00
Volvox	8.88	9.67	10.17	9.31
Chlorella	12.50	11.88	15.50	13.22
Coelastrum	8.75	9.25	9.50	9.00
Zygnema	7.60	8.80	-	8.20
Total	92.55	92.10	94.94	90.02
Desmidiaceae				
Cosmarium	4.13	4.63	4.75	4.21
Ganatozygon	6.17	-	-	6.17
Closterium	9.13	7.00	12.50	9.91
Total	19.42	11.63	17.25	15.66

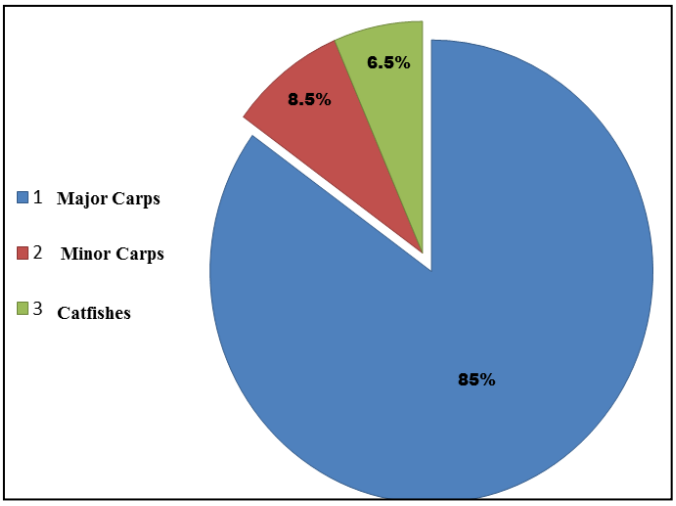

Fig 1: Fish groups percentage in total catch in Lake Pichhola

4. Conclusion

In any aquatic ecosystem biodiversity can affect both fauna and flora. Biodiversity contributes both directly and indirectly to human such as food for good health, security, social relationship, life and freedom of choices, etc. In last decade people interfere with the ecosystem and over-exploitation of natural resources its result that biodiversity decreases. But the losses in biodiversity and change in ecosystem service have adversely affected the well-being. The present study is relevant to fish and phytoplankton biodiversity with relationship to primary productivity of the Lake Pichhola. This is study explains that Lake Pichhola is in rich biodiversity of phytoplankton, fishes and need to conservation in the future.

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