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Related Fisheries Management of Fish and Phytoplankton Biodiversity with Relationship to Primary Productivity of the Govardhan Sagar Lake, Udaipur, Rajasthan

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Abstract

The present study on the related fisheries management of fish and phytoplankton biodiversity with relationship to primary productivity of the Goverdhan sagar Lake was conducted during October 2017 to September 2018. The Lake has a fairly rich fish fauna and so far, 18 species representing 6 families have been recorded in the present investigation, of these, 9 species predominantly contributed to the commercial fisheries of the Lake. In the present study, water quality parameters such as transparency, pH, alkalinity, free carbon dioxide, air and water temperature, dissolved oxygen, primary productivity, 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 the Goverdhan sagar Lake was found to be 0.70 g cm^3 h^{-1}, NPP (0.57 g cm^3 h^{-1}) and CR was found to be 0.27 g cm^3 h^{-1} in the surface. Algae in fresh water have numerous environmental functions and are based upon the recycling of nutrients. Totally 36 species of phytoplankton belonging to different taxonomic group were identified. Among these 09 species to belong to Bacillariophyceae, 12 species to chlorophyceae, 12 species to cyanophyceae and 03 speceis to desmidiaceae. The Indian major carps were dominated the catch by contributing 85% of the total landings from the Lake whereas minor carps and catfishes were reported as 8.5% and 6.5% respectively.

Keywords: Goverdhan sagar lake, phytoplankton diversity, primary productivity

1. Introduction

India is one of the mega biodiversity countries in the world and occupies ninth position in terms of freshwater mega biodiversity. In India, there are 2,500 species of fishes; of which, 930 live in freshwater and 1570 are marine (Kumar and Patra, 2013). Out of these, 400 species are commercially important which includes wild and culturable species (Das, 1994). 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 (Khanna et al., 2012).

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 ha of water area. Out of this, large and medium reservoirs constitute about 02.5 mha of water area, small reservoirs and ponds contribute 1.76 lakh ha, whereas, 0.30 lakh ha water area is available in the form of rivers and canals (Bhatt et al., 2016). Goverdhan Sagar is a shallow Lake with a Catchment area of 2.56 sq.km, maximum depth (Zm) of 7.62m, maximum length (L) 1.97 km, maximum width (bx) 0.72 km and a shoreline of 3888.8 meters with relatively fringed margins and an area of 30.81 ha. The Lake is totally rain-fed and retains water throughout the year. The over-flooded Pichhola Lake and Kotra river feeds water to the Goverdhan Sagar. (Mishra et al., 2016).

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 (Mishra et al., 2012). 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 (Chinnaiah et al., 2010). Biological 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 the water body. Such parameters influence the primary productivity 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 (Friedland et al., 2012). Considering the local conditions in the account, an attempt was made to find out the fish and phytoplankton biodiversity with relationship to primary productivity of the Goverdhan sagar Lake, Udaipur.

2. Materials and Methods

2.1. Sample collection

In the present study, three sampling stations were selected in the Goverdhan sagar Lake for collection and analysis at weekly interval. Total 3 stations of selected for this work (Station A, B and C). In order to study the biodiversity, samples of fishes were collected from the commercial catches and sample netting during the fishing year 2017-18 at landing center of the Goverdhan sagar Lake. As far as possible fishes were identified in the field itself using standard manuals (Day, 1994; Talwar and Jhingran, 1991). 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 (APHA, 2005). The calculation was done as under

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 cm^3 h^{-1})=GOP×0.375/1.2×h

Net Primary Productivity (g cm^3 h^{-1})=NOP×0.375/1.2×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
1.375=A factor value (1 g of oxygen is equal to 0.375 g of carbon)

2.3. Plankton analysis

For these 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. The qualitative analysis of phytoplankton was done using standard procedure (Senthikumar and Sivakumar, 2008). 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 18 fish species belonging to 6 families were found from the Goverdhan sagar Lake. Thus, the fish faunal structure appears fairly rich. Out of the recorded 18 fish species, only 11 species *viz*., Catla, Mrigala, Rohu, Kharpata, Sarsi, Puthi, Chal, Pabda, Lanchi, Singhi and Channa contributed to the

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

No.	Family	Species	
		Scientific name	Local name
1.	Cyprinidae	*Catla catla* (Ham.)	Catla
		Labeo rohita (Ham.)	Rohu
		Labeo calbasu (Ham.)	Kharpata
		Labeo gonius	Sarsi
		Cirrhinus mrigala (Ham.)	Mrigala
		Puntius sophore (Ham.)	Puthi
		Tor khudree	Mahseer
		Cirrhina reba	Reba
		Chela bacaila	Chal
2.	Channidae	*Channa channa*	Channa
		Channa puncatatus	Girhi
3.	Notopteridae	*Notopterus notopterus* (Pallas)	Patola
4.	Mastacembelidae	*Mastacembelus armatus*	Bam
5.	Siluridae	*Ompak pabda* (Bloch)	Pabda
		Wallago attu (Bloch)	Lanchi
		Heteropneustes fossilils (Bloch)	Singhi
6.	Baridae	*Mystus seenghala*	Singhara
		Mystus aor	Pitar

commercial catch of this reservoir. Indian major carps have dominated the fishery of the Lake followed by the minor carps and catfishes.

In general, the Indian major carps appear to contribute around 85% to the total landings of the Goverdhan sagar Lake. While the percent contributions of minor carps and catfishes in the total catch were only 8.5% and 6.5%, respectively. 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 fish species formed 5.88 % of the total minor carp catch. The catfishes have also made a smaller contribution to the landings of the Goverdhan sagar Lake, the highest catfish landing being of *Wallago attu* followed by *Mystus seenghala*, *Ompak bimaculatus* and *Mastacembelus armatus* were seen in Table 2. Datta and Majumdar (1970) made an extensive survey at 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 are from (Bhatt et al., 2018; Khan and Pathan, 2016).

Table 2: Species composition of the total fish landing from the Goverdhan sagar Lake during study period 2017-18

No.	Fish group	Composition (%)	
		In group	In total fish production
1.	*Major Carps*	100.00	85.00
	Catla catla (Ham.)	65.88	56.00
	Labeo rohita (Ham.)	15.29	13.00
	Cirrhinus mrigala (Ham.)	18.82	16.00
2.	Minor carps	100.00	8.50
	Labeo spp.	76.47	6.50
	Puntius spp.	17.64	1.50
	Miscellaneous	5.88	0.50
3.	*Cat Fishes*	100.00	6.50
	Wallago attu	30.76	2.00
	Ompak pabda	24.61	1.60
	Mastacembelus armatus	12.30	0.80
	Mystus seenghala	27.69	1.80
	Miscellaneous	4.61	0.30

3.2. Primary productivity

The results pertaining to gross and net primary productivities of the Goverdhan sagar Lake during the study period (October 2017 to September 2018) 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 0.40, 0.42 and 0.44 g cm^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 cm^3 h^{-1}. The average values of NPP were 0.36, 0.40 and 0.37 g cm^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 cm^3 h^{-1}. The corresponding average values of CR were 0.12, 0.15 and 0.13 g cm^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 Goverdhan sagar Lake 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 Goverdhan sagar Lake during the present was represented by four major group's *viz.,* Cyanophyceae, Chlorophyceae, Bacillariophyceae and Desmidiaceae. Overall 36 genera of algae were recorded in Goverdhan sagar Lake 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 et al. (2015) 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.

Table 3: Weekly observation of biological characteristics of surface water at station "A" of Goverdhan sagar Lake, 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 cm^{-3} h^1)																	
2	GPP g cm^{-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 cm^{-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 cm^{-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 biological characteristics of surface water at station "B" of Goverdhan sagar Lake, 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 cm^{-3} h^{1})																	
2	GPP g cm^{-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 cm^{-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 cm^{-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

Table 5: Weekly observation of biological characteristics of surface water at station "C" of Goverdhan sagar Lake, 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 cm^{-3} h^{1})																	
2	GPP g cm^{-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 cm^{-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 cm^{-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

Mishra et al. (2016) 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 6: Correlation matrix of different water quality parameters of the Goverdhan sagar Lake, Udaipur

Parameters	Air temp.	Water temp.	pH	Depth of Vis.	O_2	CO_2	HCO_3	Alkaline	EC	TDS	NO_3
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*
GPP	0.2403	0.3355	0.4112	0.4851	0.4039	-0.2727	-0.4441	-0.6147*	-0.0451	-0.0668	-0.5245
NPP	0.2351	0.3101	0.6017*	0.4487	0.3960	-0.2928	-0.3131	-0.3824	0.2148	-0.0147	-0.4552
CR	0.0413	0.1068	-0.4718	0.1433	0.670	0.0239	-0.4066	-0.6986*	-0.1987	-0.2568	-0.2478
TPP	0.5151	0.6275	0.3856	0.3333	-0.0617	0.3345	-0.4243	-0.1580	-0.5324	-0.2354	-0.3658

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Parameters	HPO_4	GPP	NPP	CR	TPP
Air temp.					
Water temp.					
pH					
Depth of vis.					
O_2					
CO_3					
HCO_3					
Alkaline					
EC					
TDS					
NO_3					
HPO_4	1				
GPP	-0.5467	1			
NPP	-0.5287	0.9360	1		
CR	-0.1107	0.2870	-0.0685	1	
TPP	-0.6890	0.0635	0.0798	-0.0393	1

Table 7: Annual average values of phytoplankton (Cell ml^{-1}) at three stations of Goverdhan sagar Lake, Udaipur

Major groups	Station A	Station B	Station C	Overall Average	Major groups	Station A	Station B	Station C	Overall Average
Cyanophyceae					*Asterionella*	6.25	7.75	-	7.00
Anabaena	9.89	8.44	7.20	8.11	*Pinnularia*	6.25	8.25	-	7.25
Nostoc	11.29	10.43	9.71	9.97	Total	59.93	69.43	60.71	61.90
Polycystis	8.00	9.27	-	9.15	Chlorophyceae				
Oscillatoria	-	-	12.00	11.13	*Pediastrum*	6.50	6.60	7.00	6.53
Agmenellum	6.00	7.57	-	6.79	*Protococcus*	7.00	7.33	6.00	6.33
Coelospharium	4.71	4.71	-	4.71	*Ulothrix*	8.10	7.80	10.86	9.08
Microcystis	6.90	8.00	11.17	8.91	*Chlamydomonas*	-	-	11.13	10.57
Meriosmopedia	9.60	10.00	-	9.80	*Spirogyra*	11.80	10.20	11.13	10.85
Spirulina	7.80	9.33	12.20	9.83	*Tetrasporacylindrica*	3.88	3.63	-	3.76
Aphanocapsa	3.75	5.40	-	5.58	*Ankistrodesmus*	10.75	9.75	13.67	10.96
Synechocystis	2.33	3.29	-	2.81	*Hydrodictyon*	6.80	7.20	-	7.00
Arthrospira	8.40	9.20	10.71	9.19	*Volvox*	8.88	9.67	10.17	9.31
Total	78.67	85.65	63.00	74.67	*Chlorella*	12.50	11.88	15.50	13.22
Bacillariophyceae					*Coelastrum*	8.75	9.25	9.50	9.00
Synedra	5.29	6.29	10.22	7.59	*Zygnema*	7.60	8.80	-	8.20
Nitzschia	8.11	7.89	12.67	9.75	Total	92.55	92.10	94.94	90.02
Fragilaria	6.75	7.88	7.88	7.22	Desmidiaceae				
Navicula	7.17	8.17	11.00	8.71	*Cosmarium*	4.13	4.63	4.75	4.21
Diatoma	6.45	7.55	6.78	6.89	*Ganatozygon*	6.17	-	-	6.17
Tabellaria	5.33	6.83	-	6.33	*Closterium*	9.13	7.00	12.50	9.91
Cyclotella	8.33	8.83	12.17	9.88	Total	19.42	11.63	17.25	15.66

4. Conclusion

In any biological system biodiversity can influence both fauna and greenery. Biodiversity contributes both straight forwardly and in a roundabout way to human, for example, nourishment for good wellbeing, security, social relationship, life and opportunity of decisions and so on. Be that as it may, the misfortunes in biodiversity and change in environment benefit have unfavorably influenced the prosperity. This is contemplate clarifies that Goverdhan sagar Lake is in rich biodiversity of phytoplankton, fishes and need to preservation later on.

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