Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: www.environmentaljournal.org
Volume 1, Issue 3: 274-285

Open Access **Research Article**

Studies on Limnological Characteristic, Planktonic Diversity and Fishes (Species) in Lake Pichhola, Udaipur, Rajasthan (India)

Sharma Riddhi, Sharma Vipul, Sharma Madhu Sudan, Verma Bhoopendra Kumar, Modi Rachana and Gaur Kuldeep Singh

Limnology and Fisheries Research Laboratory, Department of Zoology, University College of Science, M. L. Sukhadia University, Udaipur (Rajasthan) India

Corresponding authors: madhu_limnology@yahoo.co.in, bhoopendraverma@yahoo.com

Abstract:

Limnological parameter and plankton diversity are an important criterion for determining the suitability of water for irrigation and drinking purpose. Lake Pichhola has greatest importance for humankind. The specific status of limnological characteristic and diversity of plankton in lake Pichhola have been studied through seasonal surveys in two annual cycles (2005-06 and 2006-07) and annual survey of fishes in two annual cycles (2005-06 and 2006-07). The water remained moderately alkaline (pH 7.5) while electrical conductance (0.3958 mS/cm), TDS (237.5mg/l), chloride (176mg/l), hardness (174.33mg/l) and alkalinity (207.16mg/l) showed low mean values. Average dissolved oxygen levels were at 5.75mg/l while average nitrate and phosphate levels were 3.70mg/l and 2.79mg/l respectively. On the basis of water quality parameters in general, lake Pichhola was found to be eutrophic. A high rate of primary production (302.085mgc/m^2/hr), diversity of phytoplankton (58 forms), zooplankton (104 forms) and fish (15 species) were also observed during the study period. Therefore, lake Pichhola has rich number of species and biodiversity of aquatic animals.

Keywords: Eutrophic, lake Pichhola, Limnological characteristic, phytoplankton, zooplankton

1.0 Introduction:

Biological production in any aquatic body gives direct correlation with its physico-chemical status which can be used as trophic status and fisheries resources potential (Jhingran et al., 1969). Life in aquatic environment is largely governed by physico-chemical characteristics and their stability. These characteristics have enabled biota to develop many adaptations that improve sustained productivity and regulate lake metabolism. Studies on limnology of udaipur lakes have been made covering different aspect (Vyas, 1968; Sharma et al., 1984; Sharma et al., 1996; Sharma Vipul et al., 2009; Sharma Riddhi et al., 2009). The most characteristic criterion to assess the trophic structure of a lake remains to be primary productivity studies. The food chain in lake ecosystem is very simple comprising phytoplankton and aquatic vegetation as primary producers, zooplankton as primary consumers, small fishes as secondary consumers and large fishes as tertiary consumers. Plankton is the most sensitive floating community which is being the first target of water pollution, thus any undesirable change in aquatic ecosystem affects diversity as well as biomass of this community. The measurement of planktons productivity helps to understand conservation ratio at various trophic level and resources as an essential input for proper management of lake. Some notable studies on phytoplankton and zooplankton diversity have been made by Rao and Choubey, 1990; Deorari, 1993; Ariyadej et al., 2004; Mishra et al., 2010; and Joseph and Yamakanamardi, 2011).

Fishes occupy all three levels such as primary, secondary, tertiary consumer of food web in aquatic ecosystem. Man being the top carnivore in this food system as it is a very good source of protein. Fish protein is supposed to be cheapest. The production of million calories would take 15-20 mandays by fishing and 56 mandays by beef farming (Rath, 2000). The investigations on the Indian fresh water fishes have mainly been restricted to taxonomy (Talwar and Jhingran 1991, Jayaram 1999). As udaipur is blessed with good number of lakes and known as ‘The city of lake’. Every year, lacs of tourist come from all over the globe to visit udaipur city and lake provide water to the city dweller. So study on Limnological characteristic of lake has high importance, the study of their trophic status may help in optimum utilization and conservation. Therefore, the present investigation attempt to study of Limnological parameter and their relationship, phytoplankton, zooplankton status and diversity and fishes (species) in lake Pichhola udaipur (Rajasthan) during the study period.

2.0 Materials and Methods:

2.1 Study Area:

Pichhola is an old lake believed to be constructed by a Banjara at the end of 14^{th} century which later renovated in 1560 A.D. by Maharana Udai Singh. The river Sisarma, a tributary of the river Kotra is the main source of water for the lake. lake pichhola is situated in udaipur district of Rajasthan at Latitude 24°34'N and Longitude 73°40'E. The water spread area of the lake is 6.96 Km^2. The length of the lake is 3.6 Km and the maximum depth of the lake is 8 m. towards the central western part. The maximum and mean width of the Lake is 2.61 and 1.93 Km. respectively. Lake Pichhola commands a total catchment area of about 12,700 hr.

2.2 Sampling and Analyses:

2.2.1 Physico-chemical Analysis:

During the study, water samples were collected at seasonal interval during 2005-06 and 2006-07, using clean 1L-polyethylene bottle for analysis of water variables in the laboratory from pre-selected station of the Lake. The water quality parameters such as air and water temperature, pH, depth of visibility, alkalinity (Carbonate and bicarbonate), dissolved oxygen and primary productivity were measured in the field itself. LCD portable digital multistem thermometer of –50°C to 150°C range was used to measure water temperature, digital pH meter HANNA-pHep was used for measuring hydrogen ion concentration (pH), depth of visibility was measured by a standard Secchi disc of 20 cm diameter, Total dissolved solids were estimated by digital (Hold) TDS meter and results are expressed in ppm or mg/l. However, for the electrical conductivity, nitrate nitrogen, orthophosphate, silicates and fluorides samples were brought to laboratory in bottles of 500 ml. capacity and analyzed within 24 hours. These physico-chemical parameters were analyzed following Standard Method (APHA, 2005). Prior to this, the samples were secured in refrigerator. Conductivity was measured by 'Systronics' direct reading conductivity meter (308), ELICO ion analyser LI 126 was used for determining fluoride ions in the water. Primary productivity was estimated using light and dark bottle method. Methods stated by (Pandey and Sharma, 2003; APHA, 2005) were followed for water analysis.

2.2.2 Plankton Analysis:

For Plankton study, samples were collected from surface water, littoral region and bottom mud. For qualitative analysis, the plankton samples were collected by towing Hensen's standard plankton net with uniform speed. The net was made of no. 25 bolting silk. The plankton sample so collected was fixed in 70% ethyl alcohol. For quantitative estimation of the zooplankton, 50 litres of surface water was filtered through a small plankton net made up of the bolting silk number 25. Sub-samples of small quantities (10 ml) were taken and counting of zooplankton was done in counting chamber under a C.Z. Inverted microscope. Zooplankton numbers were expressed as individuals per liter. Identification of zooplankton was done after (George, 1961; Edmondson, 1992; and Perumal et al., 1998).

2.2.3 Fishes Analysis:

For the study of icthyofauna, fishes were collected with the help of local government contractor and some illegal fishermen from the lakes and identified after (Day, 1978; Jayram and Das, 2000; Jayaram and Sanyal, 2003; and Jayram, 1999, 2010).

Fig. a: Geographical Representation of Lake Pichhola in Rajasthan

3.0 Results and Discussions:

Results of Limnological study are summarized in Table- 1. Air temperature varied between 22^{o}C in winter 2006-07 to 39.4^{o}C in summer 2006-07. Water temperature was observed to be highest during summer 2006-07 (33.9^{o}C) and lowest during winter 2005-06 (18.2^{o}C). The overall average value of air and water temperature was 31.28^{o}C and 27.3^{o}C respectively. A good synchronization between temperature and dissolved oxygen was seen. Temperature showed a significant inverse relationship with dissolved oxygen. Such an inverse relationship has also been observed (Ranu, 2001; Chisty, 2002; Sumitra et al., 2007; Sharma, 2007).

Table 1. Physicochemical Parameters of Lake Pichhola during 2005-07

NO	Parameters	2005-06			2006-07			Average	Standard Deviation
		Winter	Summer	Monsoon	Winter	Summer	Monsoon		
1.	Air temperature (^{o}C)	24.8	36.2	30.3	22	39.4	35	31.28	6.83
2.	Water temperature (^{o}C)	18.2	32	29	19.4	33.9	29.7	27.03	6.62
3.	Depth of visibility (cm.)	140.60	149.6	98	131.2	136	87.4	123.8	25.07
4.	pH	7.2	8	6.9	7.5	8.3	7.1	7.5	0.54
5.	Dissolved oxygen (mg/l)	7	5.2	5.9	6	4.8	5.6	5.75	0.76
6.	Alkalinity (mg/l)	154	254	192	206	242	195	207.16	36.37
7.	Hardness (mg/l)	150	184	162	174	230	146	174.33	30.79
8.	TDS (mg/l)	210	278	227	229	266	215	237.5	27.92
9.	Conductivity (mS/cm)	0.35	0.46	0.38	0.38	0.44	0.35	0.39	0.46
10.	Chlorides (mg/l)	162	220	138	150	214	172	176	33.80
11.	Nitrates (mg/l)	3.76	4.38	2.77	3.87	4.43	2.99	3.70	0.69
12.	Phosphates (mg/l)	2.87	3.48	2.11	2.73	3.51	2.08	2.79	0.62
13.	Silicates (mg/l)	0.1	0.148	0.06	0.086	0.09	0.068	0.09	0.03
14.	Fluorides (mg/l)	3.33	1.70	2.03	3.3	3.41	2.51	2.71	0.74
15.	GPP (mgc/m^2/hr)	375	312.5	250	437.5	250	187.5	302.08	92.00
16.	NPP (mgc/m^2/hr)	250	187.5	125	250	125	62.5	166.66	75.69
17.	Respiration (mgc/m^2/hr)	125	225	150	187.5	225	75	164.58	59.38
18.	Phytoplankton density (no./l)	1383	1095	896	1051	898	1360	1113.83	215.1
19.	Zooplankton density (no./l)	84	88	69	90	77	79	81.16	7.78

In the present study, average depth of visibility was 123.8cm with maximum of 149.6cm in summer 2005-06 and minimum of 87.4cm in monsoon 2006-07. These varying trends reveal that during monsoon season water was turbid, pH fluctuated between 6.9 to 8.3. The minimum pH was recorded in monsoon 2005-06 which was mainly attributed to rain water after a long dry period, and maximum pH was recorded during summer 2006-07. Sharma (1980) noted pH range of 7.7 to 8.7 and 7.4 to 9.2 in lake Pichhola and Fatehsagar respectively. Sumitra et al. (2007) observed values between 8.3 to 9.3 of lake Pichhola while Chisty (2002) noted a wide range of pH (6.4 to 9.1) in different water bodies in and around Udaipur.

According to the study, lake Pichhola was characterized by low levels of dissolved oxygen with average value of 5.75mg/l. The highest oxygen value of 7mg/l was observed in winter season of 2005-06 and lowest value of 4.8mg/l was observed in summer 2006-07. The peak value during winter was also observed (Kolekar, 2006; Negi et al., 2006; Upadhaya and Dwivedi, 2006; Sharma, 2007; Malara, 2008). Dissolved oxygen shows a significant negative relation with temperature, alkalinity, total hardness, electrical conductance, nitrate, phosphate, chloride, silicate and respiration. The observed high value of dissolved oxygen in winter due to the high solubility at low temperature and less degradation of organic matter. During the study, the highest value of total alkalinity was in summer 2005-06 (254mg/l) and lowest value was observed in winter 2005-06 (154mg/l). Total alkalinity shows a positive relationship with temperature, depth of visibility, pH, total hardness, TDS, conductivity, chloride, nitrate, phosphate, silicate and respiration. The average value of total hardness during the study was 174.33mg/l with lowest value of 146mg/l during monsoon 2006-07 and highest value of 230mg/l during summer 2006-07. This increase in total hardness during summer period is due to higher photosynthetic activity, free carbon dioxide is utilized and bicarbonates are converted into carbonates and precipitated as calcium salts thus increasing hardness (Reid and Wood, 1976).

Electrical conductance was high during summer season, whereas winter and monsoon season didn't show much variation. The summer season of 2005-06 showed highest value of 0.4633 mS/cm of conductance and lowest value of 0.35 mS/cm was observed in winter 2005-06. In lake Pichhola, Sumitra et al. (2007) however, observed a narrow range (0.55-0.86 mS/cm) of conductivity. During 2004-06 Sharma (2007) observed conductivity to vary between 0.35 to 0.706 mS/cm in Pichhola lake. Seasonal variation in the conductivity may be due to the increase concentration of salt because of discharge effluent and organic matter. In the present study, Total Dissolved Solid (TDS) ranged between 210mg/l to 278mg/l with lowest during winter 2005-06 and highest during summer 2005-06 respectively. This observation is supported by the study of Sumitra et al. (2007) during 1997-98, where high TDS were found in summers at two sampling stations in lake Pichhola. Sharma (2007) noted the range of TDS between 243 to 424mg/l during monsoon and winter respectively, in lake Pichhola. Higher concentration of TDS also due to the discharge savage and organic matter by the interference of human.

Chloride concentration varied between 138mg/l noted during monsoon 2005-06 to 220mg/l during summer 2005-06. These observations are supported by the study of Sumitra et al. (2007), Sharma (2007) in lake Pichhola. Higher chloride concentration during the summer because high temperature and consequent evaporation. In rainy season, lower concentration of this factor due to dilution. According to the study, rich contents of nitrates were observed, with maximum of 4.43mg/l during summer 2005-06 and minimum of 2.76875mg/l during monsoon 2005-06. This can be attributed to high evaporation which increases the concentration during summers. Sharma (2007) noted nitrate content to be maximum (5.094mg/l) in summer 2005-06 and minimum (0.9967) in winter 2004-05. Nitrate showed positive relation with temperature, pH, alkalinity, total hardness, TDS, electrical conductivity, chloride, phosphate, silicate, fluoride and productivity, and negative relation with dissolved oxygen. Present study observed maximum orthophosphate content of 3.519mg/l during summer 2006-07 and minimum of 2.0808mg/l during monsoon 2006-07. Higher values of phosphate during summer months were also reported (Solomon, 1994; Shekhawat, 1997; Sarang, 2001; Sharma, 2007). Higher phosphate content during summer because of high temperature can evaporate water and increases concentration. The value of silicate ranged between 0.058 to 0.148 mg/l with maximum during summer 2005-06 and minimum during monsoon 2005-06. Vijay Laxmi (2003) reported the range of silicate to oscillate between 0.002 to 0.009 and 0.01 to 0.04 in two dry Bundhs of Udaipur district. Kaushal and Sharma (2007) observed silicates to range between 2.2 to 3.8 mg/l in selected reservoirs of Eastern Rajasthan. Silicate showed negative correlation with dissolved oxygen and fluoride. Domestic sewage, human activity, industrial effluent and rock weathering add to phosphate content in water.

In the present study, the values of fluoride varied between 1.7 to 3.41 mg/l, with maximum value during summer 2006-07 and minimum during monsoon 2005-06. According to WHO (1997), permissible limit for fluoride in drinking water is 1.0mg/l. Gupta and Verma (2007) in their study on Deeg town Bharatpur, observed fluoride to range between 2.11 to 2.27 mg/l in PHED supply water. Fluoride showed positive correlation with depth of visibility, pH, dissolved oxygen, hardness, nitrate, phosphate, GPP and NPP. Trophic status of an ecosystem depends upon rate of energy flow which may be assessed by estimating primary production. Results revealed that, high peaks or maxima were observed in winter 2006 (375mgc/m2/hr GPP and 250mgc/m2/hr NPP) and winter 2007 (437.51mgc/m2/hr GPP and 250mgc/m2/hr NPP). Lake Pichhola had a minimum value of Community Respiration as 75mgc/m2/hr in monsoon 2006-07 and maximum value of 225mgc/m2/hr in summer months of both the years. Naz et al. (2006), Sharma (2007) and Malara (2008) also recorded high winter productivity in their studies on tropical freshwater bodies in comparison to summer. Gross Primary Production was found to have positive correlation with dissolved oxygen, depth of visibility, pH, fluorides, nitrates, phosphates and silicates.

Table 2: Biological Diversity of Phytoplanktonic Groups Based on Menhinick's Index in the Pichhola Lake

Year	Season	Chlorophyceae	DesmidiaCeae	Xanthophyceae	Myxophyceae	Dinophyceae	Bacillariophyceae
2005-06	Winter	0.49	0.18	-	0.25	0.37	0.21
	Summer	0.56	-	-	0.36	0.23	0.32
	Monsoon	0.32	0.20	-	0.09	-	0.30
2006-07	Winter	0.50	0.26	0.25	0.40	0.14	0.31
	Summer	0.51	0.20	-	0.29	-	0.23
	Monsoon	0.55	0.15	0.33	0.52	-	0.50

Table 3: Biological diversity of Zooplanktonic Groups and based on Menhinick's Index in the Pichhola Lake

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.
2005-06	Winter	1.51	2.66	2.59	2.12	-	1.15	1.00
	Summer	1.8	3.53	2.68	1.76	1.41	-	1.00
	Monsoon	1.73	3.93	2.77	1.34	1.00	-	-
2006-07	Winter	2.26	3.21	2.40	1.50	0.70	1.41	-
	Summer	2.21	2.93	3.23	2.30	1.15	0.89	1.41
	Monsoon	2.00	3.60	2.66	2.00	1.00	-	-

Table 4: Total diversity of Phytoplanktonic and Zooplanktonic Groups based on Menhinick's Index in the Pichhola Lake during 2005-07

Plankters	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Total
Phytoplankton	0.67	0.72	0.46	0.77	0.63	0.92	0.70
Zooplankton	4.58	5.33	5.29	4.63	5.58	5.17	4.71

The phytoplankters constitute bulk of primary producers and are the base of food chains in any water body. The phytoplanktonic community of water body during the present study 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 lake Pichhola (Table 6). The most prominent phytoplankters during the study were Oedogonium sp., Spirogyra sp., Volvox sp., Ulothrix sp. and Pediastrum sp. from group Chlorophyceae. While Microsystis sp. and Coccochlaris sp. dominated Myxophyceae. As evident from the study, Chlorophyceae dominated over Bacillariophyceae followed by Myxophyceae, on the contrary (Sharma, 1980; Solomon, 1994; Shekhawat, 1997) observed dominance of blue green algae in Udaipur waters. The present results may be reasoned as the lake was filled with new water after a long dryness. Baghela (2006) observed the dominance of Chlorophyceae in Oligotrophic Lake Jawai Dam. The total phytoplankton diversity represented in form of Menhinick's index was observed to be 0.7095 (table 2 and 4).

Lake Pichhola harbour diverse taxonomic groups of zooplankton representing Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda. During present investigation, 9 forms of protozoans belonging to 8 genera and 9 species were reported. Rotifers were represented by 20 genera and 40 species. Along with these, 29 species of Cladocerans belonging to 12 genera, and 10 genera and 11 species belonging to Copepoda are enlisted. Besides these, 5 species of Ostracoda were also recorded. After including occasional zooplankters like insects and their larvae, crustacean larvae, spiders and mites total 104 forms of zooplankters were recorded (table 7). According to the Menhinick's index of diversity, Rotifers indicated highest diversity throughout the study period followed by Cladocerans, Protozoans, Copepods, Ostracods, Insects and others (table 3 and 4).

In the present investigation, 15 species of fishes belonging to 6 family and 13 genera were reported from Pichhola lake namely Notopterus notopterus Catla catla, Cirrhinus cirrhinus, Ctenopharygodon idellus, Labeo gonius, Labeo rohita, Puntius sarana sarana, Puntius ticto, Chela cachius, Garra gotyla gotyla, Aorichthys seenghala, Mystus cavasius, Heteropneustes fossilis, Xenentodon cancila and Gambusia affinis (table 5).

Table 5: List of Fishes Occurred in Lake Pichhola during 2005-07

No.	Fishes	2005-06	2006-07	No.	Fishes	2005-06	2006-07
1.	Order: Osteoglossiformes Family: Notopteridae *Notopterus notopterus(Pallas)*	+	+	9.	Subfamily: Cultrinae *Chela Cachius (Ham-Buch)*	-	+
					Subfamily: Garrinae		
	Order: Cypriniformes Family: Cyprinidae Subfamily: Cyprininae			10.	*Garra gotyla gotyla (Gray)*	-	+
					Order: Siluriformes Family: Bagridae		
2.	*Catla catla*	+	+	11.	*Aorichthys seenghala (Sykes)*	+	+
3.	*Cirrhinus cirrhinus(Bioch)*	+	+	12.	*Mystus Cavasius (Ham-Buch)*	+	+
4.	*Ctenopharyngodon idellus(Val.)*	+	+		Family: Heteropneustidae		
5.	*Labeo gonius(Ham-Buch)*	+	+	13.	*Heteropneustes fossilis (Bloch)*	+	+
6.	*Labeo rohita (Ham-Buch)*	+	+		Famiily: Belonidae		
7.	*Puntius sarana sarana(Ham-Buch)*	+	+	14.	*Xenentodon cancila (Ham-Buch)*	+	+
8.	*Puntius ticto(Ham-Buch)*	+	+		Family: Poeciliidae		
				15.	*Gambusia affinis (Baird and Girard)*	+	+

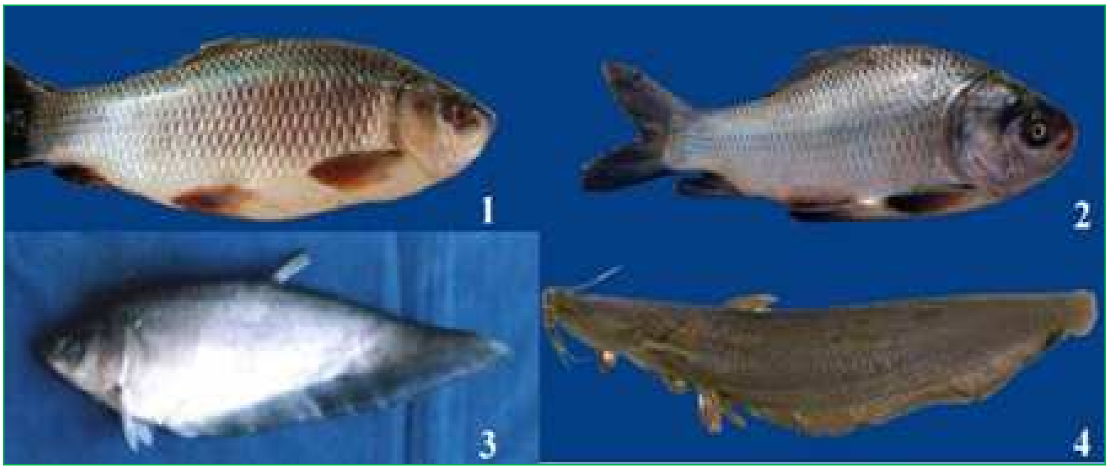

Fig. c: Most Common Fishes in Lake Pichhola: 1. *Labeo rohita*, 2. *Catla catla* 3. *Heteropneustus fossilis*, 4. *Notopterus notopterus*.

Table 6: List of Phytoplankters Observed during the Year 2005-07

No.	Name of Phytoplankters	Pichhola Lake 2005-06 W	S	M	2006-07 W	S	M
	A) CHLOROPHYCEAE						
1.	*Volvox sp.*	125	50	62	118	38	75
2.	*Eudorina sp.*	-	-	44	-	-	40
3.	*Pandorina sp.*	-	-	-	-	20	40
4.	*Scenedesmus sp.*	60	10	-	-	25	65
5.	*Chlorella sp.*	-	-	30	20	-	-
6.	*Ankistrodesmus sp.*	-	-	70	-	-	-
7.	*Coelastrum sp.*	75	-	-	-	-	-
8.	*Spirogyra sp.*	110	-	-	125	-	105
9.	*Oedogonium sp.*	113	-	150	120	-	140
10.	*Ulothrix sp.*	90	-	-	85	50	100
11.	*Cladophora sp.*	-	-	50	30	20	65
12.	*Chlamydomonas sp.*	-	25	-	-	-	-
13.	*Mougeotia sp.*	20	-	-	25	-	30
14.	*Pediastrum sp.*	30	40	70	55	35	80
15.	*Oocystis sp.*	10	25	-	10	60	-
16.	*Zygnema sp.*	25	-	-	-	-	10
17.	*Hydrodictyon sp.*	15	-	-	-	-	-
18.	*Microspora sp.*	5	10	-	25	10	15
19.	*Spaerocystis sp.*	15	-	-	-	-	-
20.	*Asterococcus sp.*	-	30	-	-	-	-
21.	*Closteriopsis sp.*	-	10	-	-	-	-
22.	*Schizomeris sp.*	-	-	-	20	-	-
23.	*Oedocladium sp.*	-	-	-	30	-	-
24.	*Actinastrum sp.*	-	-	-	10	-	-
25.	*Kirchneriella sp.*	-	-	-	-	45	20
26.	*Nephrocytium sp.*	-	-	-	-	-	15
27.	*Zygnemopsis sp.*	-	-	-	-	-	20
28.	*Pleodorina sp.*	-	-	-	-	-	20
	B) DESMIDIACEAE						
29.	*Cosmarium sp.*	30	-	-	25	25	40
30.	*Desmidium sp.*	-	-	25	-	-	-
31.	*Sphaerozosma sp.*	-	-	-	30	-	-
	D) XANTHOPHYCEAE						
32.	*Chlorobotrys so.*	-	-	-	-	-	10
33.	*Botrydiopsis sp.*	-	-	-	15	-	-
34.	*Botryococcus sp.*	-	-	-	-	-	25
	E) MYXOPHYCEAE						
35.	*Microcystis sp.*	60	100	-	-	150	-
36.	*Agmenellum sp.*	-	-	-	-	75	40
37.	*Anabaena sp.*	-	-	-	30	10	25
38.	*Oscillatoria sp.*	-	30	-	20	30	10
39.	*Nostoc sp.*	30	15	-	50	-	10
40.	*Spirulina sp.*	20	20	-	35	-	-
41.	*Coccochlaris sp.*	130	100	120	80	-	-
42.	*Gomphosphaeria sp.*	-	5	-	8	-	15
43.	*Lyngbya sp.*	-	-	-	-	20	30
	F) DINOPHYCEAE						
44.	*Glenidium sp.*	25	70	-	-	-	-
45.	*Peridinium sp.*	30	80	-	45	-	-
46.	*Ceratium sp.*	10	-	-	-	-	-
47.	*sphaerodinium sp.*	-	15	-	-	-	-
	G) BACILLARIOPHYCEAE						
48.	*Cyclotella sp.*	65	40	-	-	-	60
49.	*Synedra sp.*	-	-	-	-	75	30
50.	*Fragillaria sp.*	-	20	40	-	-	30
51.	*Navicula sp.*	100	120	-	-	-	50
52.	*Pinnularia sp.*	-	-	-	-	40	15
53.	*Nitzschia sp.*	-	50	75	-	-	40
54.	*Asterionella sp.*	-	-	60	-	-	-
55.	*Amphora sp.*	-	90	-	-	-	20
56.	*Gomphonema sp.*	-	-	25	10	-	20
57.	*Cymbella sp.*	90	65	75	-	80	50
58.	*Bacillaria sp.*	100	75	-	30	90	-

Table 7: List of Zooplankters observed during the year 2005-07

S. No.	Name of Zooplankter	Pichhola lake 2005-06			Pichhola lake 2006-07		
		W	S	M	W	S	M
	Protozoa Sub phylum – Sarcomastigophora, Super class – Mastigophora Class – Phytomastigophora, Order – Volvocida Family – Volvocacae						
1.	*Volvox*	3	1	1	2	1	1
	Family – Nebelidae						
2.	*Euglena acur*			1			2
3.	*Euglena sp.*	1				2	1
	Class – Rhizopodea, Order - Amoebida						
4.	*Amoeba sp.*		3	-	1	2	
	Order – Arcellinida, Family – Arcellidae						
5.	*Arcella discoida*		2	1		1	1
	Family – Difflugidae						
6.	*Difflugia sp.*		1		1	2	1
	Sub-phylum Ciliophora, Class – Ciliata Family – Paramecidae						
7.	*Paramecium sp.*		2		1	1	
	Family – Peridiniaceae						
8.	*Peridinium sp.*	1	2		1		
	Family – Frontonida						
9.	*Phacus sp.*	2			1	1	3
	Rotifera Family – Brachionidae						
10.	*Brachionus angularis*			3			1
11.	*Brachionus angularis bidens*			1			
12.	*Brachionus calyciflorus*	1	2	1		3	
13.	*Brachionus calyciflorus with post lateral spines*		2			1	
14.	*Brachionus calyciflorus with an eggs*		1				
15.	*Brachionus diversicornis*			6	2		3
16.	*Brachionus diversicornis with an egg*				1		
17.	*Brachionus quadridentatus*	1	1	2			
18.	*Brachionus quadridentatus with egg*			1			
19.	*Brachionus falcatus*		4	3	3		2
20.	*Brachionus falcatus with an egg*		1				
21.	*Brachionus forficula*	1	3	1			
22.	*Brachionus caudatus*		1	2			1

23.	*Brachionus bidentata*			2			
24.	*Keratella tropica*	2	5	1	3		1
25.	*Keratella tropica asymmetrica*		1		1		1
26.	*Keratella tropica heterospina*	3	2			1	
27.	*Keratella tropica with an egg*	1	2		1	1	
28.	*Keratella vulga*	3			1		
29.	*Keratella cochleris*			3	1		2
30.	*Lopocharis salpina*						1
31.	*Mytilina ventralis*			2	1		3
32.	*Anuraeopsis fissa*		3	1		1	
33.	*Trichotria tetractis*			2			4
34.	*Trichotria similis*		1				
	Family – Lecanidae						
35.	*Lecane luna*		1		1		4
36.	*Lecane depressa*		1				3
37.	*Cephalodella mucronata*						2
38.	*Cephalodella exigua*						1
39.	*Monostyla bulla*	2			1	1	3
40.	*Monostyla quradridenta*					1	2
	Family – Calurinae						
41.	*Lepadella ovalis*			1	1		3
42.	*Lepadella patella*						1
	Family – Trichocercidae						
43.	*Tricocerca cylindrico*		2	1			
44	*Tricocerca longiseta*	1		1		1	
45.	*Platyias quadricornis*			2	1		2
	Family – Asplanchnidae						
46.	*Asplanchna herricki*					2	
47.	*Asplanchna brightwelli*	1	3	1			
48.	*Asplanchna priodonta*			1			
49.	*Asplanchnopsis*	1	1				
	Family – Synchaetidae						
50.	*Polyarthra vulgaris*		2	1		1	1
51.	*Family – Testudinellidae*						
52.	*Filinia longiseta*		3		1		
53.	*Filinia terminalis*		1				
54.	*Filinia tetramatris*			2			
55.	*Testudinella patina*			2		1	3
56.	*Horella mira*		1	2			1
	Family – Hexarthridae						
57.	*Hexarthra mira*		2	1			1
	Bdelloid						
58.	*Philodina*			1			3
	Cladocerans – Family – Sididae						
59.	*Diphonosoma leuchtenbergianum*	1	1		3		
60.	*Diphonosoma brachyurum*	3	1		2	1	
	Family – Daphnidae						
61.	*Ceriodaphnia rigaudi*	5	2	2	7	3	1
62.	*Ceriodaphnia laticaudata*				1		2
63.	*Ceriodaphnia lacustris*	1	1		4	1	
64.	*Ceriodaphnia acanthine*	1					1
65.	*Daphnia lumholtzi*	1			2	1	
66.	*Daphnia ambigua*	7	2	1	5	3	2
67.	*Daphnia dubia*	1					
68.	*Simocephalus vetulus*		1		2		

69.	*Scapholeberis kingi*	2					1
	Family – Moinidae						
70.	*Moina micrura*	2				1	
71.	*Moina macrocopa*			1	3		
72.	*Moina rosea*			1	2	1	
	Family – Bosminidae						
73.	*Bosminopsis deitersi*	3	1		2	1	
74.	*Bosmina longirostris*	5	3	1	3		1
75.	*Bosmina coregoni*	5	2	1	6	2	
	Family – Macrotpricidae						
76.	*Macrothrix rosea*	1		1	3	2	
	Family – Chydoridae						
77.	*Chydorus globosus*	2		1		1	
78.	*Chydorus gibbus*			2	4		2
79.	*Chydorus sphaericus*	4			3	1	2
80.	*Chydorus ovalis*					3	2
81.	*Chydorus faviformis*					1	1
82.	*Leydigia*				2		
	Sub Family – Aloninae						
83.	*Alona macrocopa*		3		2		
84.	*Alona karau*		1			2	
85.	*Alonella nana*	3	2			4	
86.	*Alonella globosa*			2		1	
87.	*Alonella dentifera*	1				2	1
88.	Phylum – Arthropoda						
	Class – Crustacea						
	Sub-class – Calanoida						
	Order – Calanoida						
	Family – Diaptomidae						
89.	*Allodiaptomus raoi*	1			1	2	
90.	*Heliodiaptomus viddus*	2	2	1			1
91.	*Phyllodiaptomus*					1	
92.	*Rhinediaptomus*					2	
93.	*Neodiaptomus*		2		1		
	Order – Cyclopoida, Family – Cyclopidae						
94.	*Cyclops leuckarti*	1		3		2	1
95.	*Mesocylops hyalinus*	1	2		2		1
96.	*Paracyclops affinis*		1			2	
97.	*Microcyclops bicolor*	1				1	
98.	*Mesocyclops leuckartii*					1	1
	Family – Canthocamptidae						
99.	*Nauplii*	2	1	1		1	
	Ostracoda						
100.	*Heterocypris*		1	1	2		
101.	*Cyclocypris*						1
102.	*Stenocypris*		1			2	
103.	*Eucypris*					1	
104.	*Centroypris*						
	Arthropoda insecta						
105.	*Insects*						
106.	*Insects larva*	1			1	3	
	Hemiptera						
107.	*Water mites*	2			1	2	
	Natonectidae						
108.	*Arachnids water spiders*	1	1			2	

4.0 Conclusion:

In any aquatic ecosystem limnological characteristic can affect both fauna and flora. Biodiversity contribute both directly and indirectly to human such as food for good health, security, social relationship, life and freedom for choice etc. In last decade people interfere with 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 limnological study, biodiversity of plankton and fishes (species) in lake pichhola. This study explains that lake pichhola are in rich biodiversity of plankton, fishes and need to conservation in future.

5.0 Acknowledgement:

The author extremely thankful to UGC for provided fund for success to this type of research work and department of zoology for providing all facilities in laboratory.

References:

1. APHA. (2005): Standard Methods for the Examination of water and Waste water, American Public Health Association, 21st Ed.
2. Ariyadej, C., Tansakul, R., Tansakul, P., Angsupanich and Saowapa. (2004): Phytoplankton diversity and its relationships to the physico-chemical environment in the Banglang Reservoir, Yala Province. *Song Klanakarin J. Sci. Technol.,* 26(5): 595-607.
3. Baghela, B. S. (2006): Studies on Biodiversity, Survival and Density of Freshwater Zooplankton in Relation to Salinity changes. Ph.D. Thesis Submitted to M.L. Sukhadia University, Udaipur.
4. Chisty, N. (2002): Studies on Biodiversity of Freshwater Zooplankton in Relation to Toxicity of Selected Heavy Metals. Ph.D. Thesis Submitted to M.L. Sukhadia University, Udaipur.
5. Day, F. (1878): The Fishes of India: Being a Natural History of The Fishes known to Inhabit the Seas and Fresh Waters of India, Burma and Ceylon. Texts Atlas (fourth Indian Reprint 1994) – Jagmander Book Agency (formerly today and tomorrows Book agency). New Delhi Text 778, Atlas 204 pp.
6. Deorari, B. P. (1993): Productive potential of a manmade reservoir of Tarai of Uttar Pradesh with particular reference to Fish fauna. Ph. D. thesis Submitted to Rohilkhand University, Bareilly, 291 pp.
7. Edmondson, W. T. (1992): Fresh Water Biology. IInd Ed. *John Wiley and Sons*. Inc. New York., 1248pp.
8. George, M. G. (1961): Observation on the Rotifers from Shallow Ponds in Delhi. *Curr. Sci*., 30: 268-269.
9. Gupta, B. K. and Verma, S. S. (2007): Physico-chemical Studies of Drinking water Quality of Town Deeg (Bharatpur) Rajasthan during Pre-monsoon Season. Proceedings of DAE-BRNS, *National Symposium on Limnology*.
10. Jayaram, K. C. (1999): The fresh Water Fishes of the Indian Region- Narendra Publishing House, Delhi, India. 551 pp.
11. Jayaram, K. C. (1999): The fresh water fishes of the Indian region- Narendra Publishing House, Delhi, India. 551 pp.
12. Jayaram, K. C. (2010): The Freshwater Fishes of the Indian Region. Second Edition. Narendra Publishing House, Delhi. 616pp.
13. Jayaram, K. C. and Dhas, J. J. (2000): Revision of the Genus Labeo from Indian Region with a Discussion on its Phylogeny and Zoogeography. Occasional Paper No. 183. Records of the Zoological Survey of India, Kolkata., 143pp.
14. Jayaram, K. C. and Sanyal, A. (2003): A Taxonomic Revision of the Fishes of the Genus Mystus Scopoli (Family: Bagridae). Occasional Paper No. 207. Records of the Zoological Survey of India, Kolkata, 136pp.
15. Jingran, V. G., Natrajan, A. V., Banarjee, S. M. and David, A. (1965): Methodology on Reservoir Fisheries Investigation in India. Bull. *Cant. Inl. Fish. Res. Ins.* Barrackpore, 12: 1-109.
16. Joshep, B. and Yamakanamardi, M. S. (2011): Monthly changes in the Abundance and Biomass of Zooplankton and Water quality Parameter in Kukkarahalli Lake of Mysore, *India. J. Environ. Bio.* 32: 551-557.
17. Kaushal, D. K. and Sharma, V. K. (2007): Limnology and Productivity of Selected Reservoirs of Eastern Rajasthan. Proceedings of DAE-BRNS, *National Symposium on Limnology.*
18. Kolekar, V. (2006): Ecology and Fisheries Status of Keetham Lake of Agra (U. P.) in Early Nineteens. *Him. J. Env. Zool.* Vol. 20 (1): 253-260.
19. Malara, H. (2008): Biodiversity of Planktonic and Littoral Rotifers in Water Bodies of South Rajasthan. Ph.D. Thesis Submitted to M.L. Sukhadia University, Udaipur.
20. Mishra, A., Chakraborty, S. K., Jaiswar A. K., Sharma A. P., Deshmukhe, G., and Mohan, M. (2010): Plankton diversity in Dhaura and

Baigul reservoirs of Uttarakhand. *Indian J. Fish.,* 57(3) : 19-27, 2010

21. Naz, S., Musfaqua, N. and Sharminz, (2006): Primary Productivity of an Artificial Lake in Rajashahi, Bangladesh. *Nat. Env. Poll. Tech*. 5(1): 139-141.
22. Negi, R. K., Johan, N. S. and Negi, T. (2006): Study of the Physico-chemical Parameters of Water of Pongdam Reservoir, Himachal Pradesh: A Ramsar site. *Him.I. Env. Zool*., 20 (2): 247-256
23. Pandey, J. and Sharma, M. S. (2003): Env. Sci. Practical and Field Manual, Yash Pub. House, Bikaner.
24. Peumal, P., Swampathkumar, P. and Santhanam, P. K. (1998): Zooplankton of Parangipettal costal water. Monogr. Series, Vol. I. *UGC- SAP, CAS in Marine Biology,* Annamali University, Parangipettai. P. 31.
25. Ranu (2001): Studies on Toxicity of Textile Effluents to Fresh Water Zooplankton. Ph.D. thesis Submitted to MLSU, Udaipur.
26. Rao, K. S. and Choubey, U. (1990): Studies on phytoplankton dynamics and productivity fluctuations in Gandhi Sagar Reservoir. *National workshop on reservoir fisheries,* Special Publication. A.F.S.I. Branc., 3: 103-106.
27. Rath, R. K. (2000): Freshwater aquaculture (2nd Ed.) Scientific Publishers (India), Jodhpur. 445.
28. Reid, G. K. and Wood, R. D. (1976): Ecology of Inland Waters and Estuaries. *D. Van Nostand Company,* New York.
29. Sarang, N. (2001): Selected Aspects of Limnology and Productivity of Jaisamand Lake, Udaipur (Rajasthan). M.Sc. Thesis Submitted to MPUAT, Udaipur (Rajasthan).
30. Sharma, K. (2007): Recent Limnological changes in Different Parameters of Ranisar and Padamsar lakes. Ph. D. Thesis Submitted to J. N. V. University, Jodhpur Rajasthan.
31. Sharma, L. L. (1980): Some Limnological Aspects of Udaipur Waters in Comparison to Selected Waters of Rajasthan Ph.D. thesis Submitted to University of Udaipur.
32. Sharma, L. L. and Gupta, M. C. (1994): Seasonal Variations in Selected Limnochemical Parameters of Amarchand Reservoir, Southern Rajasthan. *Poll. Res.,* 13(2): 217-226.
33. Sharma, L. L., Sharma, M. S., Lodha, R. M. and Durve, V. S. (1996): J.S.S. Report on Present Status of Udaipur lakes. 1-116pp.
34. Sharma, M. S., Sharma, L. L. and Durve, V. S. (1984): Eutrophication of Lake Pichhola in Udaipur, Rajasthan. *Poll. Res.,* 3(2): 39-44.
35. Sharma, R., Sharma V., Malera, H. and Sharma, M. S. (2009): Study of Microbiology of Udaipur Lakes in Relation to Different Limnological Parameter. *Poll. Res.,* 28(4): 565-569.
36. Sharma, V. (2007): Biodiversity of Planktonic and Littoral Cladocerans in Water Bodies of South Rajasthan. Ph.D. Thesis Submitted to M.L. Sukhadia University, Udaipur.
37. Sharma, V., Ridhhi, S., Malera, H. and Sharma, M. S. (2009): Zooplanktonic Diversity and Trophic Status of Mahi Dam in Relation to Physico-chemical Characteristics of its Water. *Poll. Res.,* 28 (4): 571-576.
38. Shekhawat, P. S. (1997): Some Aspects of Hydrobiology of a Temple Tank of Udaipur for Assessing it's Trophic status for Fish Rearing. M.Sc. Thesis Submitted to RAU, Bikaner.
39. Solomon, I. J. J. (1994): Current Trends in Eutrophication of the Lakes Pichhola and Fatehsagar. M.Sc. Thesis Submitted to RAU, Bikaner.
40. Sumitra, M., Sharma, R., Sharma V. and Sharma, M. S. (2007). Trophic Status of Lake Pichhola in Relation to Physico-chemical Characteristics of its Water. *National symposium on Limnology.* 244-248pp.
41. Talwar, P.K., Jhingran, A .G. (1991): Inland Fishes of India and adjacent countries Vol. 1 and 2. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 1158 pp.
42. Upadhayay, B. L. and Dwivedi, D. D. (2006): Impact of Human Activities on Physico-chemical Characterstics of Mansi Ganga water at Goverdhan (Mathura). *Him.J.Env.Zool.,* 20(1):131-133.
43. Vijaylaxmi, P. (2003): Biological Productivity of Two dry Bundhs of Udaipur, Rajasthan in Relation to Growth and Diet selectivity of Major Carp Fry and Fingerlings. Ph.D. Thesis Submitted to M.L. Sukhadia University, Udaipur.
44. Vyas, L. N. (1968): Studies on the Phytoplankton Ecology of Pichhola Lake Udaipur. Proc. *Symp. Recent. Adv. Tro. Ecology.,* 334-337.
45. W.H.O. (1973): Guidelnes for Drinking Water Quality, World Health Organisation, Geneva.