

**PHYSICO-CHEMICAL FEATURES AND PRIMARY
PRODUCTIVITY OF LAKE PICHHOLA (UDAIPUR,
RAJASTHAN) IN RELATION TO FISH PRODUCTION
POTENTIAL**

विश्वविद्यालय, राजस्थान, उदयपुर, राजस्थान
महाराणा प्रताप विश्वविद्यालय, कृषि एवं प्रौद्योगिकी विभाग, उदयपुर

VARUN MISHRA

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**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE
AND TECHNOLOGY, UDAIPUR - 313001 (RAJASTHAN)**

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY**

COLLEGE OF FISHERIES, UDAIPUR

CERTIFICATE - I

Dated: / /

This is to certify that **Mr. Varun Mishra** has successfully completed the Comprehensive Examination held on **03/01/2015** as required under the regulations for the degree of **Doctor of Philosophy in Aquaculture**.

Dr O. P. Sharma

Professor & Head
Department of Aquaculture
College of Fisheries, MPUAT,
Udaipur (Raj.)

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR**

CERTIFICATE – II

Dated: / /

This is to certify that this thesis entitled **“Physico-Chemical Features and Primary Productivity of Lake Pichhola (Udaipur, Rajasthan) in Relation to Fish Production Potential”** submitted for the degree of **Doctor of Philosophy** in the subject of **Aquaculture**, embodies bonafide research work carried out by **Mr. Varun Mishra** under my guidance and supervision and that no part of this thesis has been submitted for any degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on **27/12/2016**.

(Dr. O. P. Sharma)
Professor & Head
Department of Aquaculture
College of Fisheries, Udaipur (Raj.)

(Dr. S. K. Sharma)
Major Advisor
Professor
College of Fisheries, Udaipur (Raj.)

(Dr. O. P. Sharma)
Dean
College of Fisheries, MPUAT, Udaipur (Raj.)

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR**

CERTIFICATE – III

Dated: / /

This is to certify that this thesis entitled **“Physico-Chemical Features and Primary Productivity of Lake Pichhola (Udaipur, Rajasthan) in Relation to Fish Production Potential”** submitted by **Mr. Varun Mishra** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Aquaculture**, after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory; we therefore, recommend that the thesis be approved.

(Dr. S. K. Sharma)
Major Advisor

(Dr. B. K. Sharma)
Advisor

(Dr. B. Upadhyay)
Advisor

(Dr. A. K. Gupta)
Advisor

(Dr. O. P. Sharma)
Professor & Head

(Dr. Natwar Singh)
DRI Nominee

(Dr. O. P. Sharma)
Dean
College of Fisheries

External Examiner

Approved

(Dr. R.A. Kaushik)
Director Resident Instructions
Maharana Pratap University of Agriculture and Technology, Udaipur

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY
COLLEGE OF FISHERIES, UDAIPUR**

CERTIFICATE – IV

Dated: / /

This is to certify that **Mr. Varun Mishra** student of Doctor of Philosophy, Department of Aquaculture, College of Fisheries, Udaipur has made all corrections / modifications in the thesis entitled **“Physico-Chemical Features and Primary Productivity of Lake Pichhola (Udaipur, Rajasthan) in Relation to Fish Production Potential”** which were suggested by the external examiner and the advisory committee in the oral examination held on **21/03/2017**. The final copies of the thesis duly bound and corrected were submitted on / /**2017** and are enclosed herewith for approval.

(Dr. S. K. Sharma)
Major Advisor

Enclosed: One original and two copies of bound thesis. Forwarded to the Director, Resident Instruction, Maharana Pratap University of Agriculture and Technology, Udaipur.

(Dr. O. P. Sharma)
Dean
College of Fisheries, Udaipur (Raj)

(Dr. O. P. Sharma)
Professor & Head
Department of Aquaculture
College of Fisheries, Udaipur (Raj)

ABSTRACT

Physico-Chemical Features and Primary Productivity of Lake Pichhola (Udaipur, Rajasthan) in Relation to Fish Production Potential

Varun Mishra^{*}
Research Scholar

Dr. S.K. Sharma^{**}
Major Advisor

The current research work was conducted to find out the production potential of lake Pichhola a highly productive water body of Udaipur in southern Rajasthan. Attempt has been made to assess the current water quality status of lake Pichhola, assess the primary productivity status of lake and its correlation with fish production and to suggest proper management practice for getting the optimum fish production.

Lake Pichhola is a large perennial lake with a maximum depth of 8.5 meter (28 ft.) The lake is spread in an area of 696 ha.

The physico-chemical parameters of lake Pichhola were fairly moderate. The average water quality parameters of the lake during the study period were, air temperature-28.30°C, water temperature-25.07°C, Depth of visibility-85.56 cm., pH-7.68, EC-0.45 mS/cm⁻¹, dissolved oxygen-5.95 mg l⁻¹, free CO₂-17.08 mg l⁻¹, Total dissolved solids-296.83 mg l⁻¹, carbonates-33.74 mg l⁻¹, bicarbonates-136.67 mg l⁻¹, total alkalinity-156.13 mg l⁻¹, orthophosphates-0.14 mg l⁻¹, nitrate-nitrogen-0.60 mg l⁻¹, GPP-0.39 g C m³ h⁻¹, NPP-0.24 g C m³ h⁻¹, CR-0.15 g C m³ h⁻¹. On the basis of relatively moderate levels of nutrients in the lake Pichhola acclaims it in the category of moderately eutrophic nature of water.

During the present investigation, 36 genera of phytoplankton were noticed in lake Pichhola out of which 12 genera represented Cyanophyceae (33.33%), 9 to Bacillariophyceae (25.00%), 12 to Chlorophyceae (33.33%) and 3 genera belongs to Desmidiaceae (8.33%).

The observed scenario of phytoplankton dominance at four stations of lake Pichhola is as under:

Station A: Chlorophyceae > Cyanophyceae > Bacillariophyceae > Desmidiaceae.

^{*} Ph.D. Scholar, Department of Aquaculture, College of Fisheries, MPUAT, Udaipur

^{**} Professor, Department of Aquatic Environment, College of Fisheries, MPUAT, Udaipur

Station B: Cyanophyceae > Chlorophyceae > Bacillariophyceae > Desmidiaceae.

Station C&D: Cyanophyceae > Bacillariophyceae > Chlorophyceae > Desmidiaceae.

From this point of view, lake Pichhola with dominance of Cyanophyceae and Chlorophyceae assigned moderately eutrophic status of the lake with 22 pollution indicating algal genera.

Total 32 species of zooplankton belonging to four major groups *i.e.* Rotifera, Cladocera, Copepoda and Protozoa, were recorded. Out of these, 11 species were from Rotifera (34.37%), 9 from Cladocera (28.12%), 7 from Copepoda (21.87%) and 5 belonged to Protozoa (15.62%).

The observed scenario of zooplankton dominance at four stations studied in lake Pichhola is as under:

Station A: Copepoda > Rotifera > Cladocera > Protozoa.

Station B & D: Rotifera > Cladocera > Copepoda > Protozoa.

Station C: Cladocera > Rotifera > Copepoda > Protozoa.

From the results of water quality parameters, Primary productivity and lake plankton it is appropriate to place this water body somewhere between “mild eutrophic-to-eutrophic water”. Indeed, much of the available nutrient resources are gainfully utilized by the primary producers and thus this is the good example of effective channelization of nutrients into secondary producers *i.e.* fish production. In view of this it is appropriate to further channelize this energy trapped in the form of primary producers (macrophytes and phytoplankton) and available secondary producers *i.e.* zooplankton for the production of suitable fish species.

The potential fish production as calculated on the basis of (Odum, 1971) using GPP ($0.39 \text{ g C m}^{-3} \text{ h}^{-1}$) is 1,83,552.63 kg/yr or 15,296.05 kg/month from scientific management of lake.

Comparing the present fish production of lake Pichhola and the potential fish yield there is a gap of 40.45 per cent as per the Odum's (1971) estimate and a gap of 3.47 per cent as per the MEI estimate (Welcomme, 1972).

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1. INTRODUCTION

India is endowed with a vast and varied expanse of open fresh waters displaying enormous diversity in their biotic and abiotic characteristics. The total 73.59 lakh hectares water resources of India include 19521 kilometers length of rivers and canals, 29.07 lakh hectares of reservoirs, 24.14 lakh hectares of tanks and ponds, 7.98 lakh hectares of flood plains, lakes and derelict water, and 12.40 lakh hectares of brackish water, Srinivasa *et al.*, (2012).

India has an enviable spectrum of biodiversity which matches with few nations in the world. This constitutes approximately 11 per cent of the world's around 22,000 species of fishes out of which 400 species are commercially important and include wild and culturable species (Das and Kapoor, 1990). The aquatic ecosystem has been experiencing various forms of environmental stresses during the past few decades. Most of these environmental problems are anthropogenic through increased human activities in the catchment areas of aquatic systems. These have adversely affected the natural limnological processes of the systems thereby threatening the survival and growth of inhabiting biotic communities.

Indian major carps viz., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* dominate the fishery wealth of Indian reservoirs especially of Rajasthan. Though Indian major carps dominate the reservoir fishery of North India, their contribution to the total catch is progressively getting drastically reduced in comparison to the production potential of reservoirs (Rajkumar, 2005). This is primarily attributed to the improper fishery management practices and deficit seed supply of the native fish fauna including major carps. Thus, there is a need to adopt proper management practices based on location specific studies on the commercially important fish species *vis a vis* an extensive study on the aquatic ecology which provides valuable information on the basic habitat of these fishes.

Rajasthan is the largest state of India with an area of 3,42,239 square kms which is 10.74 per cent area of our country. A large network of seasonal and two perennial rivers, canals, ponds and lakes of the state offer tremendous scope for the development of fisheries.

Incidentally, the Rajasthan state has freshwater as well as saline water resources. It has 4.23 lakh ha. freshwater area besides 30000 ha. as river and canals, 80,000 ha. waterlogged and 1.80 lakh ha. salt affected areas. Fish production has increased to 28200 mt. Fish seed production & stocking has reached to 482.41 million fry. Revenue from fish auction has increased from Rs. 97.5 lakhs into 2540.55 lakhs (25.4 crores). Average production of the State is 200 kg/ha. The total fish production of Rajasthan in 2014-15 was 46313.82 metric ton (Anonymous, 2015).

About 16,500 farmers and fishers of the state are engaged in fisheries related activities but with the targeted fish production. Total water resources available for fisheries in the State are 15560 no. of water bodies covering an area of 4,23,765 hectare excluding rivers and canals (30,000 ha.) and water logged area (80,000 ha.) In addition, 1,80,000 hectare salt affected area is also available. Details of types of water resources, number of water bodies of Rajasthan and their area at FTL is as follows:-

Water Resources of Rajasthan (in Ha)		
Type of Water Resources	No. of Water bodies	Area(FTL in ha)
Minor Tanks & Ponds (< 1 ha)	6913	4745
Medium Tanks & Ponds (1.1 0 10 ha)	6207	25516
Large Tanks & Ponds (10.1 - 100 ha)	2047	63,648
Small Reservoirs (101 -1000 ha)	346	82,396
Medium Reservoirs (1001-5000 ha)	35	64,151
Large Reservoirs (>5000 ha)	12	1,83,309
Total Water Resources	15,560	4,23,765
Rivers and Canals	5000 km	30,000
Waterlogged Areas	-	80,000
Salt Affected Areas	-	1,80,000

According to estimates (Anonymous, 2015) about 77% of water bodies (by numbers) with 66% of FTL area occur in the three division of Rajasthan *i.e.* Ajmer, Udaipur and Kota. Seven viz., namely Bhilwara, Sri Ganganagar, Banswara, Chittorgarh, Tonk, Ajmer and Udaipur have more than 25,000 ha. of water area. constituting 67% of total freshwater resources area of Rajasthan. As per the data

available, 1225 number of water bodies with total area of 26,670.8 ha. exist in Udaipur district.

The state departmental information further reveals that about 60% of the total fish production comes from reservoirs and the rest from tanks and ponds. Resource wise average productivity per hectare is 56 kg. for large reservoirs, 176 kg for small and medium reservoirs, 286 kg for large tanks, 1125 kg for medium tanks and ponds, 1675 kg for small tanks and ponds and 2050 kg for ponds of water logged areas.

Rajasthan is blessed with a vast and varied expanse of open waters displaying enormous diversity in their biotic and abiotic characteristics. Environmental concerns and issues such as biodiversity conservation are therefore becoming prime need of the new millennium at the global level.

Physico-chemical features of any water body grossly influence the trophic status of that water body. These parameters influence the primary productivity (phytoplankton and zooplankton productivity) and in turn the growth of the fish. 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. The primary productivity of different water bodies have been widely investigated to assess the fish production potentialities of a water body and to formulate fishery management policies. A comparative study of plankton and productivity of certain Udaipur waters in comparison to the selected waters of Rajasthan have been carried out by Sharma (1980).

The proposed research is to ascertain the fish production potential of lake Pichhola in Udaipur. The Lake has a historical background and was created in 1362 A.D. by Pichhu Banjara during the ruling period of Maharana Lakha. A Banjara chieftain initially constructed the lake in the 14th century. Rana Udai Singh further raised its embankment in 1560 A.D. The water spread of the lake is 6.96 km² and has a maximum depth of 8.5 m towards the West where the Kotra River drains into the lake. The lake forms the main source of drinking water for the city. The river Sisarma, is the chief source of water to the lake. The lake bears its importance due to its scenic beauty, recreational role, fisheries as well as a source of drinking water for Udaipur

city. The lake is facing a heavy pressure of habitation around it, with certain sites releasing municipal waste directly in the lake water. The lake is girdled by palaces, temples, bathing ghats and forested hills. Presently, the lake is facing ecological degradation due to anthropogenic activities such as disposal of human waste, excessive sedimentation due to soil erosion because of destruction of vegetation in the catchment and dumping of solid waste from nearby habitations. Owing to tourist and ethnic importance this lake is also extensively used by local people for their livelihood through flourishing hotel industry. The lake however, is enriched with a variety of flora and fauna.

In the current research work, primary productivity, phytoplankton and zooplankton production both quality and quantity wise have been investigated along with selected limnological features. These findings have been linked with the fish production and the potential of lake as a fish producer. The fish catch analysis in terms of, species diversity was also carried out. Based on the results of this investigation, fisheries management measures have been suggested at the end.

The principal objectives of the study are thus as follows:

1. To investigate the current status of selected water quality parameters and establish their relationship with selected biotic resources.
2. To perform qualitative and quantitative analyses of lake plankton.
3. To assess the primary productivity status of lake and its correlation with fish production.
4. To assess the biodiversity of ichthyo-fauna of the lake.

2. REVIEW OF LITERATURE

Many attempts have been carried out to classify the lakes on the basis of their productivity since Fritsch (1931) who reviewed the history of lakes classification. Though lakes are 'closed community' they are influenced by many human interferences particularly the addition of nutrient loading. An attempt has been made under this review of literature to incorporate some of the important research works pertaining to Indian freshwater and Udaipur water in particular.

Physico-chemical status in any aquatic body shows a direct correlation with its biological production can be used to determine the trophic status and fisheries potential of the water body. Physico-chemical parameters of different water bodies along with their varied planktonic resources and productivity status were studied by several workers. Apart from the lakes, small reservoirs, farm ponds and tanks *etc.* were also studied for different physico-chemical and productivity aspects (Wallen, 1959, Murphy, 1962, Timms, 1970, Kushlan and Hunt, 1979 and Boyd, 1979).

Primary productivity and water quality:

Primary productivity of several water bodies have been studied by researchers in order to predict their fish production potential. In Rajasthan, studies of plankton and productivity of Udaipur waters in comparison to the selected water of Rajasthan have been carried out by Sharma (1980). Ayyappan and Gupta (1980) studied the primary productivity of Ramasamudra Tank situated in Karnataka. Sugunan, (1989) categorized reservoirs having total alkalinity of 40-90 ppm as medium productive and above 90 ppm as highly productive reservoirs. He also reported that the level of nitrate and phosphate confirms the medium productivity status of these water bodies of southern Rajasthan. Sharma and Durve (1989) studied water clarity in relation to the phytoplankton of 26 waters of Rajasthan state including Udaipur waters. Lampos *et al.*, (1990) worked out the seasonal variations in the primary productivity, phytoplankton and zooplankton abundance in a smaller lake Todos Los Santos (Chile).

Gupta (1991) studied the primary productivity of Daya reservoir. Gupta *et al.*, (1991) studied the primary productivity of a shallow pond of southern Rajasthan and reported higher biological production during month of April.

Pollinger and Berman (1991) have described that primary productivity in tropical lakes are higher than that of temperate lakes. The physico-chemical parameters of Doon valley were studied by Rauthan *et al.*, (1992). Chakrabarty and Saha (1993) reported the physico-chemical and hydro biological features of three stagnant water sources in Darjeeling hills. Sharma *et al.*, (1994) worked on limnology and prospects of fisheries development in five man-made lakes of Udaipur (Rajasthan). Bharadwaj (1995) conducted study on certain hydro biological aspects of two seasonal ponds of Udaipur (Rajasthan).

Ahmed and Sarkar (1997) have studied the limnology and productivity of Indian water bodies such as Khandon (135 ha.) and Umrang (191 ha.) reservoirs situated in North Cachher hills and Jayantia hills of Assam, respectively in north-east India. Habib *et al.*, (1997) investigated seasonal change in phytoplankton community structure in relation to physico-chemical factors in Loh Comond Scotland. Dissolved oxygen and thermal regimes of a Ugandan crater lake were studied by Chapman *et al.*, (1998). Larson and Mark (1998) observed variability of secchi disc readings in an exceptionally deep Coldera lake. Physico-chemical fluctuations of lake Tanganyika were studied by Plisnier *et al.*, (1999). Presing *et al.*, (1999) reported nitrogen uptake by summer phytoplankton in lake Belaton. Seasonal variations of dissolved oxygen and deoxygenation in two tropical Australian reservoirs were investigated by Simon (1999).

Das (2000) studied nine reservoirs including major reservoirs (Srisailem, Nagarjuna Sagar and Somalisa) and three riverine systems of Andhra Pradesh to evaluate their productivity status through physico-chemical determinants and concluded that the nutrient status of ambient water was found to be very poor. Shrivastava *et al.*, (2002) studied primary productivity of Tawa reservoir situated in Madhya Pradesh. Sultan *et al.*, (2003) investigated a small reservoir, Pahunj located at Jhansi in Uttar Pradesh for its physico-chemical features and productivity status and concluded that higher primary productivity indicated congenial environment for biological production. Studies on limnology of Udaipur lakes have been made covering different aspect (Vyas, 1968; Sharma *et al.*, 1984; Sharma *et al.*, 2009;

Sharma *et al.*, 2009). Rajkumar (2005) studied the limnological status and its relationship to the production potential of Daya reservoir of Southern Rajasthan. Balai (2007) studied fish and planktonic biodiversity of Jaisamand reservoir of Udaipur (Rajasthan). Chouhan and Sharma (2007) reported physico-chemical and biological status of a perennial lake the Buddha Pushkar of Ajmer, Rajasthan. In this investigation pollution status was studied with special emphasis on physico-chemical and biological parameters.

Nandan and Magar (2007) studied 16 physico-chemical parameters of the Girma dam of Nashik district from Maharashtra. Paulose and Maheshwari (2007) conducted a comparative study of Jalmahal and Ramgarh lake of Jaipur with special reference to plankton diversity. They opined that high nitrate content of these waters can be correlated with high density of phytoplankton and high rate of organic decomposition. Ramesh *et al.*, (2007) studied the water quality of the Singanallur lake situated in Coimbatore district and reported that the water was unsuitable for the survival of aquatic organisms. Sharma *et al.*, (2007) studied primary productivity and fisheries potential of Daya reservoir, Udaipur, Rajasthan. Ujjania *et al.*, (2007) studied three different water bodies namely Mahi Bajaj Sagar, Survania dam and Aasan pond located in Southern part of Rajasthan (Banswara district) and reported that all the three water bodies were highly productive.

Laskar and Gupta (2009) while performing a seasonal study on phytoplankton diversity and dynamics of Chalta floodplain lake, Barak Valley, Assam recalled that diatoms are used extensively in environmental assessment and monitoring because they have ranges and tolerances for environmental variables like pH, nutrient concentrations, suspended sediment, flow regime, elevation and different types of human disturbances.

Rathore (2011) found a dominance of major carps during her study on limnology and its relationship with fisheries potential and diversity of lake Udaisagar situated in the downstream of lake Pichhola in Southern Rajasthan. She acclaimed that domestic and industrial sewage has increased the eutrophic conditions in the lake by increasing its nitrate and orthophosphate concentration. Sharma *et al.*, (2011) studied the limnological parameters and their relationship, phytoplankton, zooplankton status, diversity of fishes (species) in lake Pichhola and found a high rate of primary production, phytoplankton, zooplankton and 15 number of fish species.

Thirupathaiah *et al.*, (2012) studied the status of physico-chemical characteristic of lower Manair Reservoir at Karimnagar District, Andhra Pradesh. Monthly changes in physico-chemical parameters such as water temperature, pH, turbidity, transparency, total dissolved solids, total hardness, chlorides, phosphate, nitrates, dissolved oxygen and biological oxygen demand. The results indicated that physico-chemical parameters of the water were within the permissible limits and can be used for domestic, irrigation and pisciculture. Lodh *et al.*, (2014) studied physico-chemical parameters of four lakes of Udaipur known as the “City of Lakes” of Tripura state. The studied lakes are Amar Sagar (AS), DhaniSagar (DS), Jagannath Dighi (JD) and Mahadeb Dighi (MD). He evaluate the water quality of the lakes and to identify the pollution sources. Obtained results of physicochemical water quality parameters of studied lakes revealed the fact of pollution load in the lakes. Average Biochemical Oxygen Demand (BOD) as well as the value of ammoniacal nitrogen (NH₃-N) is found high during analysis which conveys high bacteriological load, organic matter disposal and animal waste contamination into the lakes. Mahajan and Billore (2014) studied seasonal variations and assessment of water quality of Nagchoon pond of Khandwa District (M.P.). India and found the water parameters indicate that the reservoir is rich in nutrients. The chloride, nitrate and phosphate are found to be beyond permissible limit. Dhawale and Ghyare (2015) studied the physico-chemical status of water in Pus Dam of Pusad Tehsil of Yavatmal District, Maharashtra and found that physico-chemical parameters of the water were within the permissible limits and can be used for domestic, irrigation and pisciculture. Mohammad *et al.*, (2015) assess the quality of water by using physico-chemical parameters of Wyr reservoir of Khammam district, Telangana, India. Results indicated that the quality of water from this reservoirs within the acceptable values. On the basis of the limnological analysis, it was found that, some physico-chemical parameters showed seasonal fluctuations.

Phytoplankton and productivity:

A detailed consideration of biology of lakes reasonably begins with phytoplankton, its productivity and periodicity, Hutchinson (1967). Thus, the qualitative as well as the quantitative knowledge of these organisms, growing in an ecosystem, is of fundamental importance.

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 plankton 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).

Elo *et al.* (1928) reported effect of climate change on the temperature conditions of lakes. Whereas, much work refers to temperate zone, such studies in India were initiated by Ganpati (1940). Singh (1960) made notable contributions on algal blooms and phytoplankton ecology. Further researchers in this field for Indian water were made by Das (1960), George (1962), Nassar and Datta Munshi (1974) and few others.

Staker *et al.*, (1974) collected phytoplankton samples in Lake Mead 6 times from September 1970 to June 1971 from 8 stations at depths of 0, 3, 5, 10, 20, and 30 m. using Palmer's pollution-tolerant algae indices calculated from phytoplankton data. These indices suggest eutrophic conditions in Lake Mead.

Balsare *et al.*, (1992) worked out the numerical and volumetric variations in plankton populations of a polymictic tropical lake of Bhopal (Madhya Pradesh). Vaishya and Adoni (1993) established the relationship between phytoplankton seasonality and physico-chemical properties in a hyper eutrophic central Indian lake (Sagar lake). Kolekar *et al.*, (1995) studied the plankton abundance of two different pond ecosystems near Guwahati (Assam). Sukumaran and Das (2001) studied the composition and distribution of plankton of selected reservoirs in Karnataka during different seasons. Murugesan *et al.*, (2003) studied the plankton population in 19 reservoirs in Tamil Nadu and exhibited phytoplankton dominance (51.6 to 99.9%) with an exception in Varattapallaim where zooplankton formed the bulk (89.2%). The species diversity of planktonic population varied according to the watershed location

and type of basin. Kaushal and Sharma (2001) and Sharma and Kaushal (2004) suggested fisheries management of small reservoirs of Rajasthan based on their ecological study. Later, Sharma (2007) conducted a study on ecological based fisheries management in 10 small reservoirs of eastern Rajasthan and presented a detailed account of its fisheries status, planktonic diversity, productivity and water quality. Desmidiaceae were completely absent in majority of the reservoirs whereas they formed the bulk in Pechiparai (56.2%) and Manimuthar (30.9%) reservoirs which represented oligotrophic category. Shrivastava *et al.*, (2002) carried out investigation on phytoplankton and primary production in Tawa reservoir.

Bhatnagar *et al.*, (2007) investigated the plankton and ichthyo-fauna in Jhamri dam, Udaipur, Rajasthan. Jagetiya *et al.*, (2007) conducted an experiment on phytoplankton diversity in Raithalias dam, near Chandrabhaga river of Bhilwara, Rajasthan. Lubana *et al.*, (2007) investigated a fresh water reservoir created in 1994 in the Indian desert for its physico-chemical limnology and planktonic components.

Sharan *et al.*, (2007) studied the hydrobiology of village pond in desert region of Rajasthan with special reference to phytoplanktonic community and its relationship with the ionic regime. Somani and Pejaver (2007) evaluate the pollution in the lake Masunda in Thane (Maharashtra) and found presence of 11 pollution tolerant genera using Palmer's algal genus index also using Odum's index and found variations of species. The lake always exhibited lower values of this index, indicating higher pollution status. Vijayvergia (2007) studied composition and periodicity of Cyanophyceae in eutrophic lake Udai Sagar, Udaipur, Rajasthan. In most lowland rivers nitrates and phosphates, derived from agriculture and from sewage are present in abundance for algal growth. Deficiency of silica, however, may lead to the end of vigorous populations of diatoms in spring, which are then often succeeded by mixed plankton, mainly of green algae, throughout the summer.

Kumar and Kumar (2008) studied the phytoplankton diversity in response to abiotic factors in Veeranam lake in the Cuddalore district of Tamil Nadu found that the range of physico-chemical parameters of water such as air-temperature, water temperature, pH, salinity, dissolved oxygen, electrical conductivity and total dissolved solids were: 30.1-36.5°C, 29.0-34.4°C, 7.9-8.4, 1.2-2.5 mg l⁻¹, 7.6-9.2 µS and 2.5-5.2 mg l⁻¹.

Total 160 species of phytoplankton belonging to different taxonomic groups were identified. Among these 74 species to belong to Bacillariophyceae, 43 species to Chlorophyceae, 38 species to Cyanophyceae and 5 species to Euglenophyceae. The phytoplankton density was high (1705 cells l⁻¹) during the summer season and low (760 cells l⁻¹) during the winter season. Bacillariophyceae formed the dominant group.

Kumar and Karuppasamy (2008) studied factors affecting productivity of phytoplankton in a reservoir of Tamilnadu, India. Hulyal and Kaliwal (2009) studied dynamics of phytoplankton in relation to physico-chemical factors of Almatti reservoir of Bijapur District, Karnataka State.

Offem *et al.*, (2011) conducted a plankton-based assessment of the trophic state of three tropical lakes in relation to changes in species composition, and environmental variables and found higher values of species richness, evenness and Shannon-Wiener diversity index for both phytoplankton and zooplankton were recorded in Ejagham lake during the dry season than wet.

Chlorophyceae population was the most abundant group in the river Cauvery followed by Cyanophyceae, Bacillariophyceae and Euglenophyceae similar finding was also reported by Suresh *et al.*, (2011) in Tungabhadra River.

Limnological Studies of Kodaikanal lake (Dindugal District), in Special reference to phytoplankton diversity conducted by Singh and Balasingh (2011) and found a total of 75 species of algae were reported in which 43 species belongs to Chlorophyta, 14 species to Cyanophyta, 13 species to Bacillariophyta, 2 species to Euglenophyta, 2 species to Pyrrophyta and one species to Chrysophyta.

Annalakshmi and Amsath (2012) examined the composition, abundance, frequency of occurrence and diversity of net phytoplankton species inhabiting in river Cauvery and its tributaries river Arasalar at Kumbakonam area (10.110-12.70 E latitude and 78.86-79.85 N longitude), Tamil Nadu, India.

Khanna *et al.*, (2012) analysed water samples for planktonic diversity of river Ganga and found that zooplankton, Protozoa, Rotifera, Cladocera, Copepod, Ostracods constitute the main component and in phytoplankton Diatoms were dominated and class blue green algae, green algae were found least during study period. Majority of zooplankton showed maximum occurrence and abundance during the high salinity period.

Mishra *et al.*, (2012) studied the planktonic biodiversity and fisheries potential of lake Goverdhan Sagar another lake connected to lake Pichhola. He also suggested fisheries management in Goverdhan Sagar in the light of abundance of aquatic macrophytes.

Patil *et al.*, (2012) studied the physico-chemical properties of Shivaji University lakes of Kolhapur city and its impact on phytoplankton population. Tiwari *et al.*, (2012) studied the physico-chemical parameters in order to find their relation to seasonal fluctuation of phytoplanktonic populations in Devi tank 24°3'N latitude and 81°23'E longitude of Vyauhari, Shahdol district of Madhya Pradesh.

Giripunje *et al.*, (2013) reviewed the phytoplankton ecology in freshwater lakes of India discussed the relations of phytoplankton with factors like lake temperature, sunlight exposure period, sunlight penetration, water pH, wind, transparency, seasonal variations, water characteristics, nutrient enrichment and prey-predator relation in the lakes of India. From the results, authors noticed that each lake habitat is different from other lake habitat. Finally, authors concluded that phytoplankton ecology is an indicator for the evaluation of impacts of influencing factors. These factors provide a suitable management plan for lakes.

Ramulu and Benarjee (2013) studied physico-chemical characteristics and plankton diversity and density of a sub urban perennial water body, located in Nagaram village in Warangal district of Andhra Pradesh. The results revealed that transparency, Total solids, Total dissolved solids, and Turbidity was maximum during rainy months. The pH, Conductivity, Hardness, Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) were higher during summer months. The Chloride concentration was high in the month of January. Phytoplankton was represented with 4 groups of which Chlorophyceae was dominant with 15 species followed by Bacillariophyceae (7), Cyanophyceae (6) and Euglenophyceae (3). A total of 31 species of phytoplankton were recorded with similar distribution. Zooplanktons were represented by four groups viz. Rotifera, Cladocera, Copepoda and Ostracoda. A total of 39 species of zooplankton were recorded at all the four identified sampling stations of the tank, with similar distribution. In which Rotifers (16) dominated followed by Cladocera (10), Copepoda (08) and Ostracoda (05). The study helps in better understanding for the management of the Nagaram tank for intensive fish culture.

Thakur *et al.*, (2013) studied the limno biotic status of three selected lakes of Himachal Pradesh using physico-chemical and biological parameters (especially phytoplankton and zooplankton) over a period of 2 years. One hundred forty-eight species belonging to nine groups of phytoplankton and 79 species belonging to five groups of zooplankton were identified from the lakes.

Bordoloi and Baruah (2014) has been assessed phytoplankton in a historical pond of Tinsusukia district (Assam) for water quality and the pollution tolerant phytoplankton genera. A total of 12 Palmer's genera were been reported from the pond having Palmer's score of 28. The pollution index value as well as the water quality parameters along with the presence of some algal indicators indicated highly organically polluted status of the pond and need management interventions

Kotadiya and Mulia (2014) studied the phytoplankton diversity, density and Palmer's Pollution Index of freshwater lake rural area of Ahmedabad concluded that the total phytoplankton count/ml. is more in summer season and Bacillariophyceae is dominant in Ghumalake. The total phytoplankton count/ml. is minimum in monsoon season 158/ml and maximum in summer season 296/ml.

Malhotra *et al.*, (2014) studied phytoplankton diversity of Western Yamuna canal and River Yamuna in Yamunanagar, Haryana, India. Odum's algal index used for analyzing the constituent diversity of algal species and monitoring the water quality. Sixteen taxa from western Yamuna canal and thirty five taxa from River Yamuna have been observed belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae and Dinophyceae. The abundance, distribution, total population, group percentage and species diversity were studied and correlated with pollution indicating water quality characteristics. Species diversity values indicated a decrease from pre effluent point to effluent discharge channel and post effluent discharge point. Maximum value of odum's algal index was observed for *Cladophora* spp. at western Yamuna canal and for *Micrasterias* sp. and *Nvicula* sp. at River Yamuna indicating them as tolerant taxa.

Pradeep *et al.*, (2014) studied seasonal variation in phytoplankton biodiversity of Chandlodia lake. Shashikala *et al.*, (2014) studied the phytoplankton biodiversity in Panvel lakes (Vishrale, Krishnale and Dewale lake) at district- Raigadh (Maharashtra) India. In all the three lakes 16 genera of phytoplankton were recorded. Prakash *et al.*,

(2014) studied the seasonal variations in the structure and dynamics of phytoplankton community of the Kolleru lake in Andhra Pradesh, Fifty six species of phytoplankton belonging to Chlorophyceae (35 species), Bacilariophyceae (6 species), Cyanophyceae (12 species) and Euglenophyceae (2 species) were identified. The highest phytoplankton abundance was observed in summer and the lowest in winter.

Zooplankton and productivity:

Biodiversity is a precious heritage which is blessed by nature to save the planet and mankind. It is a variety of life which encompasses different genus, species, community and ecosystem along with their relative abundance. Fresh water ecosystem includes primary producers as phytoplankton, algae and hydrophytes, primary consumers as zooplankton as well as phytophagous fishes and secondary, tertiary consumers as fishes and some other organisms. Zooplanktons are small animals that float freely in surface water, column of water bodies and whose distribution is primarily determined by water waves and current. Zooplanktons of Indian freshwaters have been studied by various researchers. Rapid development in recent years has led to an increased demand for water and it does depend on ground water. The freshwater zooplankton consists mainly of 4 major groups *i.e.* Protozoa, Rotifera and two orders of Crustacea *viz.*, Cladocera and Copepoda.

Sharma and Sharma (2008) described that zooplankton are integral components of aquatic food webs and contribute significantly to aquatic productivity in freshwater ecosystems. They have been studied from various inland aquatic environs of India, but a review of the limnological literature indicates limited information on their composition, ecology and role in aquatic productivity in the floodplain lakes in particular.

Sharma *et al.*, (2012) studied the zooplanktonic fauna and its relation to Physico-chemical characteristics in Madar Tank, Udaipur, Rajasthan, India and observed that the presence of a number of zooplanktons also indicate that Madar Tank is little organically rich water body. In this tank we reported some zooplanktons are related to oligotrophic water bodies whereas some are related to eutrophic water bodies and some of them are showing their special preference to mesotrophic environment.

Karuthapandi *et al.*, (2013) reported that a total 38 species of different zooplankton groups were explored from the littoral regions of Umda sagar, Hyderabad. Nimbalkar *et al.*, (2013) studied zooplankton diversity in relation to water quality of Ambe Ghosale lake of Thane city, Maharashtra, India. Among these zooplankton communities, Rotifera constitute high species richness with 32 species and 3 species each of Cladocera and Copepoda.

Shashikant (2013) studied the zooplankton biodiversity in Ghotnimbala reservoir in Bhadrawati Tehsil of Chandrapur District and found that the zooplankton biodiversity of reservoir water is represented by seven different groups like Protozoa, Rotifera, Cladocera, Copepoda, Ostracoda, Nematoda and Annelida, with 21 different species. Occurrence of pollution indicator species like *Moina dubia*, *Brachionus angularis*, *Filinia longiseta* confirms that the lake ecosystem is organically polluted due to manmade activities in the catchment area. Watkar and Barbate (2013) studied zooplankton diversity of river Kolar, Saoner, Dist. Nagpur, Maharashtra.

Balai *et al.*, (2014) studied the seasonal variations of zooplankton and selected physico-chemical parameters were studied in Jaisamand lake, a large man-made reservoir in Udaipur (Rajasthan). In the study period, 51 species of zooplankton - 17 species of Rotifera, 18 species of Cladocera, 5 species of Ostracoda and 4 species of Copepoda were observed. Among zooplankton, Rotifera was (727 No.l⁻¹) observed as the dominant group throughout the study period and the highest count was recorded in the summer or pre-monsoon period while low incidence was observed in winter season. Zooplankton community is also correlated with certain physico-chemical parameters. The results of this study indicate that the distribution and density of zooplankton species were influenced by prevailing physical and chemical factors of the aquatic environment.

Manickam *et al.*, (2014) studied the seasonal variations of zooplankton diversity in a perennial reservoir at Thoppaiyar, Dharmapuri District, South India. A total of 55 species of zooplankton were recorded, which includes 19 species of Rotifera, 13 species of Cladocera, 15 species of Copepoda and 8 species of Ostracoda. The population abundance of zooplankton was noticed in the following order: Rotifera > Copepoda > Cladocera > Ostracoda. The present study revealed that the zooplankton productivity was found to be rich in Thoppaiyar reservoir. Further it is

concluded that the Thoppaiyar reservoir could be continuously utilized for aquaculture, if proper water quality management measures are adopted.

Bhavan *et al.*, (2015) studied the diversity of zooplankton was correlated with physico-chemical characteristics of a perennial lake at Sulur, Coimbatore, India. A total of 34 zooplankton species was identified qualitatively, which includes 11 species of Rotifera, 10 species of Cladocera, 7 species of Copepoda and 6 species of Ostracoda. The mean population of each zooplankton groups from all the seasons was recorded in the following order, Rotifers (734 ind./l) > Copepods (586 ind./l) > Cladocerans (583 ind./l) > Ostracods (147 ind./l).

Dede and Deshmukh (2015) recorded zooplankton diversity composition from the Bhima river near Ramwadi Village, Tal. Karmala, District Solapur (M.S.) India. In total, 21 species of zooplanktons belonging to families and 4 classes viz., Rotifera, Cladocera, Copepoda and Ostracoda were recorded from the Bhima River near Ramwadi village. The class Rotifera represents 9 species, Cladocera 5 species, Copepoda 5 species and Ostracoda 2 species.

Ghosh and Biswas (2015) conducted a survey of the zooplankton communities of a water body in the Chhari ganga oxbow lake located in Nakashipara block of Nadia district, India and an analysis of zooplankton with using diversity indices like Shannon-weaver and Simpson diversity index, species richness and evenness, composition trends with total abundance was also carried out to assess the water quality and aquatic health of the oxbow lake ecosystem for its sustainable management. In this lake three major groups of zooplanktons Rotifera, Copepoda and Cladocera were identified, among the three group rotifers are dominant species in this oxbow lake. Sharma *et al.*, (2015) conducted an ecological study have so as to study diversity of zooplankton and macrobenthic invertebrates in two perennial ponds of Jammu region (Jakh pond and Dilli ponds) in all give number species of zooplankton were identified from Dilli pond whereas 25 species from Jakh pond viz., protozoan, rotifer, cladoceran, copepods and ostracods. Among macrobenthic invertebrates 23 species were indentified from Dilli pond and only 13 were from Jakh pond.

Pawar (2016) studied the zooplankton diversity and seasonal variation in Majalgaon reservoir. A total of 23 species were found in this reservoir.

Among these, rotifers comprise of 8 species (28.92%), Cladocera 6 (19.638%), Copepods 5 (20.09%), Ostracoda 2 (19.317 %) and Protozoa 2 (12.02%). The season wise zooplankton analysis showed that the number of population was highest during summer, followed by monsoon and lowest during winter.

3. MATERIAL METHODS

The present study was carried out during March, 2014 to February, 2015 with a view to investigate the primary and secondary productivity and selected physico-chemical features of lake Pichhola for assessing fisheries production potential of the lake in order to suggest suitable fisheries management policy.

A. CLIMATE OF SOUTHERN RAJASTHAN

Southern Rajasthan experiences a subtropical climate with average rainfall ranging from 64 cm. and relative humidity of 75-95 per cent during the monsoon period. The summers are hot and winters are a bit cool having an average range of maximum temperature between 38-41°C and minimum between 1-5°C. The elevation of study zone is 598 m above mean sea level.

B. STUDY AREA

Lake Pichhola is situated in Udaipur district of Rajasthan at Latitude 24°58'N and Longitude 73°68'E. The water spread of the lake is 6.96 km² with the length of 4 km and the maximum depth of 8.5 m. towards the central western part. The maximum width of the lake is 3 km. Lake Pichhola commands a total catchment area of about 12,700 sq kms (Fig. 3.1).

C. MORPHOLOGY OF LAKE PICHHOLA

The details of morpho metric features of lake Pichhola are given in Table 3.1.

Table 3.1 Morpho metric features of lake Pichhola, Udaipur (Raj.)

1	Location Latitude Longitude Altitude	Udaipur, Rajasthan 24°58'N 73°68'E 598 m (MSL)
2	Average rainfall	640 mm
3	Water spread area	6.96 km ²
4	Maximum length(L)	4 km (2.5 mil)
5	Maximum width (bx)	3 km (1.9 mil)
6	Average depth	3 m (8.2 ft.)

7	Maximum depth	8.5 m (28 ft.)
8	Catchment area	12,700 sq kms
9	Surface area	696 ha.
10	Water volume	13.08 million m ³
11	Lake Type	Freshwater Lake
12	District	Udaipur
13	Year of construction	1362 A.D.

Source: Irrigation Department, Udaipur (Raj.)

D. SAMPLING STATIONS

For the proposed study, four sampling stations were selected in the lake Pichhola for collection of surface water samples, as well as phytoplankton and zooplankton samples (Fig.3.1 and 3.2). Station **A** was located on the South Eastern shore, station **B** was located near the dam on Eastern shore. Sampling station **C** was located at the Northern end of the lake and station **D** was selected near the Western end of the lake. However, sites where direct sewage is released, were avoided while selecting the sampling station.

E. COLLECTION OF WATER SAMPLE

During the study period, quadruplicate surface water samples from adjoining area within a vicinity of 5 meters of four selected sampling stations were collected using a plastic bucket. The water sample were stored in one litre plastic sample collection bottles with air tight cap for analysis of certain parameters in the laboratory of the Department of Aquatic Environment, College of Fisheries. Whereas, some of the parameters were assessed in the field itself, as mentioned under the “Water quality analyses”.

F. DURATION OF STUDY

The study was carried out for duration of one year. The productivity, plankton and water quality analyses of the lake Pichhola was conducted every month.

G. RESEARCH ANALYSIS

(i) Water Quality Analyses (Physico-chemical Parameters)

Water quality parameters such as temperature of air and water, depth of visibility (cm), electrical conductivity-EC (mS cm^{-1}), total dissolved solids (mg l^{-1}), pH, carbonates, bicarbonates and Total alkalinity (mg l^{-1}), dissolved oxygen (mg l^{-1}), free carbon di-oxide (mg l^{-1}), were determined in the field itself, while for the analysis of nitrate-nitrogen (mg l^{-1}) and orthophosphate (mg l^{-1}) the samples were brought to the laboratory in plastic bottles of one litre capacity and analysed as soon as possible using standard methods of Trivedy *et al.*, (1987) and APHA (1989).

1. Air and water temperature

A centigrade thermometer of 0 to 50°C range and graduated to 0.1°C was used to measure air and water temperature. Air temperature around the sampling station was measured in shade. The water temperature was observed by immersing the thermometer in water samples immediately after collection.

2. Depth of visibility:

The transparency of water was determined using a standard Secchi disc of 20 cm diameter. Two readings, one for disappearance and other for reappearance were recorded and then the depth of visibility was calculated as under:

$$\text{Depth of visibility (cm)} = \frac{D_1 + D_2}{2}$$

Where,

D_1 = Depth of disappearance in cm

D_2 = Depth of reappearance in cm

3. Electrical conductivity (EC)

Electrical conductivity was measured with the help of a pen type electronic conductivity meter (make Milwaukee - CD600) having a range of 1990 ppm/10 ppm and an accuracy of $\pm 2\%$ at 20°C and results were expressed as mS cm^{-1} .

4. Total dissolved solids (TDS)

For the estimation of total dissolved solids in every sample, a factor value of 640 is multiplied with the respective value of EC.

5. Hydrogen ion concentration (pH)

The pH of the water sample was measured using a electronic digital pH meter (make Milwaukee - pH600) with an accuracy of ± 0.1 pH at 20°C.

6. Dissolved oxygen (DO)

The concentration of dissolved oxygen in water was estimated following the modified Winkler's method.

In this procedure, oxygen combines with manganous hydroxide to form higher hydroxides which on acidification liberate iodine equivalent to that of oxygen fixed. This iodine is titrated with standard sodium thiosulphate solution using starch as an indicator.

Following steps were adopted for oxygen estimation:

- (i) Water sample was collected in 250 ml glass bottle without bubbling.
- (ii) Two ml of each manganous sulphate (Winkler A) and alkaline-iodide solutions (Winkler B) were dispensed one after the other right at the bottom of the bottle with separate pipettes. Then stopper was replaced.
- (iii) The bottle was shaken upside down at least 6 times and allowed the brown precipitate to settle.
- (iv) The precipitates were dissolved by adding 2 ml of concentrated sulphuric acid and the stoppered bottle was again shaken.
- (v) 50 ml of aliquot was taken in a flask and then titrated with sodium thiosulphate (0.025 N) till the colour changed to pale straw.
- (vi) After that, two drops of starch indicator were added and titrated further till the blue colour disappeared for the first time.
- (vii) The total amount of titrant used was noted and then dissolved oxygen content was calculated using following formula:

$$\text{Dissolved oxygen}(mg\ l^{-1}) = \left[\frac{8 \times 1000 \times N}{V_1} \right] \times V_2$$

Where,

N = Normality of the titrant (0.025 N)

V₁ = Volume of sample (ml)

V₂ = Volume of titrant used (ml)

7. Free carbon dioxide (free CO₂)

For the estimation of free CO₂, 100 ml of water sample was taken in a conical flask and a few drops of phenolphthalein indicator were added. In case the colour turned pink, free CO₂ was considered as absent. If sample remained colourless, the same was titrated against NaOH (0.05 N) till the appearance of pink colour and free carbon dioxide was calculated using following formulae:

$$\text{Free CO}_2 (\text{ml l}^{-1}) = \frac{\text{ml of NaOH} \times N \times 1000 \times 44}{\text{ml of sample}}$$

Where,

N= Normality of the titrant NaOH (0.05 N)

8. Alkalinity

For determining carbonates alkalinity, 100 ml of water sample was taken in conical flask and a few drops of phenolphthalein indicator were added. If sample remained colourless, then carbonate alkalinity was taken as absent and pink colour developed, then water sample was titrated to a colourless end point using it 0.01 N HCL. The same water sample, after determining carbonate alkalinity, was used for the estimation of bicarbonate alkalinity by continuation of the titration with methyl orange as indicator. Calculation was performed using following formulae:

$$(i) \quad \text{Carbonate alkalinity} (\text{mg l}^{-1}) = \frac{A \times N \times 1000 \times 50}{\text{ml of sample}}$$

$$(ii) \quad \text{Bicarbonate alkalinity} (\text{mg l}^{-1}) = \frac{B \times N \times 1000 \times 50}{\text{ml of sample}}$$

$$(iii) \quad \text{Total alkalinity} (\text{mg l}^{-1}) = \text{Carbonate alkalinity} + \text{Bicarbonate alkalinity}$$

Where,

A = ml of HCL used only with phenolphthalein

B = ml of HCL used only with methyl orange

N = Normality of hydrochloric acid

9. Orthophosphate

This was measured following the stannous chloride method of APHA (1989). Orthophosphate ($\text{PO}_4\text{-P}$) in an acidified ammonium molybdate solution produces blue colour when stannous chloride is added. This colour is measured with spectrophotometer at 690 nm. The estimation was made using following procedure:

- (i) 50 ml of water sample was taken in an Erlenmeyer flask. Distilled water blank was also prepared simultaneously.
- (ii) 2 ml of ammonium molybdate solution and 0.25 ml (5-6 drops) of stannous chloride solution were added.
- (iii) Blue colour appeared gradually.
- (iv) After 10 minutes, colour (Blue) intensity was estimated at 690 nm using spectrophotometer.
- (v) Concentration of HPO_4 was calculated with the help of standard curve and orthophosphate was expressed as $\text{PO}_4\text{-P}$ in mg l^{-1} .

10. Nitrate-nitrogen

This was analysed using phenoldisulphonic acid (PDA) method of APHA (1989). For this purpose, 50 ml of filtered sample was taken in a conical flask. To remove the interferences of chlorides, 5 ml silver sulphate solution was added. This was heated slightly and the precipitate obtained was removed by filtration. The filtrate was evaporated in a porcelain dish to complete dryness. The residue was cooled and dissolved in 2 ml phenoldisulphonic acid. The content was diluted to 50 ml with double distilled water. To this, 6 ml of liquid ammonia was added for developing yellow colour.

The yellow colour developed due to presence of nitrate was measured using a Systronics 108 UV spectrophotometer at 410 nm. Using standard nitrate solution, a

standard curve was plotted to estimate the amount of nitrate in the sample which was expressed as $\text{NO}_3 - \text{N}$ in mg l^{-1} .

(ii) Biological Parameters

1. Primary Productivity

Primary productivity was measured at all four stations following light and dark bottle 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 surface. The incubation period was kept three hours. Oxygen (O_2) estimation in the BOD bottles were made following usual Winkler's method. The calculation was done as under:

$$(i) \quad \text{Gross Oxygen Production (GOP) } \text{mg l}^{-1} = \text{LB-DB/h}$$

$$(ii) \quad \text{Net Oxygen Production (NOP) } \text{mg l}^{-1} = \text{LB-IB/h}$$

$$(iii) \quad \text{Community Respiration (CR) } \text{mg l}^{-1} = \text{IB-DB/h}$$

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

$$(i) \quad \text{Gross Primary Productivity (GPP) } \text{g C m}^{-3} \text{ h}^{-1} = \text{GOP}/1.2 \times 0.375 \times h$$

$$(ii) \quad \text{Net Primary Productivity (NPP) } \text{g C m}^{-3} \text{ h}^{-1} = \text{NOP}/1.2 \times 0.375 \times h$$

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 (the photosynthetic quotient for the phytoplankton)

0.375 = A factor value (1 g of oxygen is equal to 0.375 g carbon)

2. Plankton analysis

The phytoplankton and zooplankton samples were collected along with the sampling of water. For the sample collection, an appropriate quantity of water sample (*i.e.* 50 liters) was filtered through bolting silk (mesh size 55 μ) and plankton thus

obtained were preserved in 4% neutralized formaline for further quantitative and qualitative analysis.

For quantitative analysis of plankton, 1 ml subsample was taken in Sedgwick Rafter plankton counting cell with the help of plankton pipette and counted under microscope. The total number of plankton counted in each sample was multiplied with dilution factor and results were expressed as Cell ml⁻¹ and No l⁻¹ respectively for phytoplankton and zooplankton, APHA (1989).

The qualitative analysis of phytoplankton and zooplankton was done following the standard methods of Edmondson (1965), Needham and Needham (1962) and Adoni (1985). The identification of phytoplankton was restricted only upto major groups viz., Cynophyceae, Chlorophyceae, Bacillariophyceae and Desmidiaceae. Similarly, the zooplankton was also identified upto major groups such as Cladocera, Rotifera, Copepoda and Protozoa.

3. Community Structure Analysis:

To calculate heterogeneity of plankton at each sampling site suitable plankton diversity indices viz., Odum's diversity index was applied. This index takes into account the total number of species present as well as their respective abundance thus providing a more convenient means of comparing differences between ecological communities. Similarly to assess the trophic status of the sampling site the Palmer's Algal Pollution Index was calculated following Trivedy *et al.*, (1987)

H. STATISTICAL ANALYSIS:

The data collected on water quality parameters, plankton and primary productivity were processed using suitable statistical tools and techniques viz. Standard deviation, Correlation coefficient between important parameters, and one way analysis of variance to arrive at meaningful conclusions. Mean value of Water quality parameters, Primary productivity and Plankton analysis for all four stations *i.e.* St1 (Station A), St2 (Station B), St3 (Station C) and St4 (Station D) and three seasons *i.e.* S1 (January-April), S2 (May-August), S3 (September-December) have been used for one way analysis of variance.

4. RESULTS

The results pertaining to the water quality, primary productivity and quantitative and qualitative analyses of phytoplankton and zooplankton of lake Pichhola during the study time *i.e.* March, 2014 to February, 2015 are presented hereunder in this chapter. The data regarding water quality parameters, primary productivity and lake plankton are depicted with monthly variations at different stations as well as an overall average values of the same are also given with their mean values, minimum and maximum value. The seasonal variations of these values are also provided at relevant places for easy comparison. The statistical analysis with variables of season, station and their interactions has also been attempted by ANOVA and presented hereunder. Similarly the relationship of various water quality parameters, plankton and productivity has also been analysed to draw the significance.

PHYSICO-CHEMICAL PARAMETERS

The monthly fluctuation in selected water quality parameters of lake Pichhola are presented in Tables 4.1 to 4.6 and Fig. 4.1 to Fig. 4.4. Monthly variations in water quality of lake Pichhola are clearly evident from the results of this study.

Air and water temperature

The monthly variations in air and water temperature are depicted in Tables 4.1 to 4.6. It is evident that the highest air temperature 37.80°C at station **C** was during June with the lowest 21.30°C in January at station **D**. The average temperature of 28.03, 28.53, 28.31 and 28.29°C was observed at the four stations **A**, **B**, **C** and **D** respectively.

The monthly average values of all four stations of air temperature are shown in Table 4.5 and Fig. 4.1. The highest air temperature 37.40°C was observed in June and lowest 22.03°C in January. The average air temperature of all four stations was 28.30°C during the study period.

The surface water temperature fluctuated between 18.70°C to 32.60°C. The average water temperature of 25.38, 24.55, 25.33 and 25.02°C at stations **A**, **B**, **C** and **D** respectively (Tables 4.1 to 4.6).

The monthly average values of all four stations of water temperature are shown in Table 4.5 and Fig 4.1. The highest water temperature 30.33°C was observed in June and lowest 20.23°C in January. The annual average water temperature of all four stations was 25.07°C during the study period.

The statistical analysis of the result pertaining to air and water temperature as given with significant mean values in Table 4.8, 4.9 and ANOVA in Appendix I and II indicates significant difference in three seasons. However, the analysis of variance indicated a non significant difference between stations and the interaction between seasons and stations.

The statistical correlations of both the air and water temperature with other water quality parameters are presented in Table 4.7 which indicated that during the study period, air temperature has a highly significant positive relationship ($P < 0.01$) with water temperature ($r = 0.970$) and total phytoplankton -TPP ($r = 0.733$). Whereas, positive relationship was also established with pH, free CO₂, carbonates, bicarbonates, total alkalinity, orthophosphates, GPP, NPP, and total zooplankton (TZP). However, a significant negative relationship ($P < 0.05$) with depth of visibility, and dissolved oxygen was noted with negative relationship with electrical conductivity, total dissolved solids, nitrate-nitrogen and CR.

Water temperature had relationship pattern similar to that of air temperature. Where a highly positive significant correlation ($P < 0.01$) was seen with air temperature and TPP. However, negative significant relationship ($P < 0.05$) of water temperature was seen with depth of visibility and dissolved oxygen.

Depth of visibility

The values of depth of visibility also referred as transparency at stations **A**, **B**, **C** and **D** of lake Pichhola fluctuated between 75 to 105 cm, 76 to 97 cm, 72 to 87 cm and 77.00 to 90.20 cm respectively. The mean value of depth of visibility was highest at station **A** and lowest at station **C** (Tables 4.1 to 4.6).

The monthly average values of all four stations of depth of visibility as depicted in Table 4.5 indicates highest values among all the stations was 94.00 cm, observed in January. However, it was lowest i.e. 75.00 cm in August during the monsoon. The average depth of visibility of all four stations was 85.56 cm during the study period.

The statistical analysis of the result pertaining to depth of visibility as given with significant mean values in Table 4.10 and ANOVA in Appendix III indicate significant difference between all stations and all the seasons. However, the analysis of variance indicated a non significant difference between the interaction of seasons and stations.

Measuring the correlation coefficient between depth of visibility and other parameters indicated a highly significant positive relationship ($P < 0.01$) with electrical conductivity ($r = 0.861$), total dissolved solids ($r = 0.815$) and nitrate-nitrogen ($r = 0.841$). However, a significant positive relationship ($P < 0.05$) with carbonates, bicarbonates, orthophosphates, TSP was noted. A positive relationship was also established with pH, total alkalinity and CR. However, a significant negative relationship ($P < 0.05$) with air and water temperature was noted with negative relationship with dissolved oxygen, free CO_2 , GPP, NPP and TPP (Table 4.7).

Hydrogen ion concentration (pH)

In general, the water of lake Pichhola remained slight alkaline throughout the study period. The values of pH oscillated from 7.2 to 8.2, 7.1 to 7.9, 7.6 to 8.5 and 7.4 to 8.3 at all four stations viz. **A**, **B**, **C** and **D** respectively. Further, the respective mean values of pH at stations **A**, **B**, **C** and **D** were 7.67, 7.49, 7.84 and 7.72 (Tables 4.1 to 4.6). From these observations it is further evident that station **B** maintained lower average pH as compared to other three stations and the highest average pH was found at station **C**.

The monthly average values of all four stations of pH are shown in Table 4.5. The highest pH 8.23 was observed in June and lowest 7.38 in September. The average pH of all four stations was 7.68 during the study period.

The statistical analysis of the results pertaining to pH as given with significant mean values in Table 4.11 and ANOVA in Appendix IV indicate significant difference in three seasons. However, the analysis of variance indicated a non significant difference between stations and the interaction between seasons and stations.

The statistical correlation results shows that pH had a highly significant positive relationship ($P < 0.01$) with electrical conductivity ($r = 0.698$), total dissolved solids ($r = 0.713$), carbonates ($r = 0.716$), bicarbonates ($r = 0.820$), total alkalinity

($r=0.714$), orthophosphates ($r=0.785$), nitrate-nitrogen ($r=0.698$) and TZP ($r=0.700$). Whereas, a positive relationship was also established with air and water temperature, depth of visibility, free CO_2 and TPP. However, a highly significant negative relationship ($P<0.01$) of pH was seen with dissolved oxygen ($r=0.880$) and a negative relationship with GPP, NPP and CR (Table 4.7).

Electrical conductivity (EC)

The values of electrical conductivity fluctuated from 0.35 to 0.47, 0.34 to 0.42, 0.43 to 0.55 and 0.42 to 0.53 mS cm^{-1} at stations **A**, **B**, **C** and **D** respectively. The average values of EC were 0.42, 0.39, 0.50 and 0.48 mS cm^{-1} at stations **A**, **B**, **C** and **D** respectively. The mean value of electrical conductivity was highest at station **C** and lowest at station **B**. (Tables 4.1 to 4.6).

The monthly average values of all four stations of electrical conductivity are shown in Table 4.5. The highest electrical conductivity of all stations was 0.49 was observed in May and lowest 0.39 in August. The average electrical conductivity of all four stations was 0.45 during the study period.

The statistical analysis of the result pertaining to electrical conductivity as given with significant mean values in Table 4.12 and ANOVA in Appendix V indicate highly significant difference between all stations, all the seasons. However, the analysis of variance indicated as non significant difference between the interaction of seasons and stations.

The statistical correlation of electrical conductivity with selected water quality parameters are shown in Table 4.7. The Electrical conductivity has highly significant positive relationship ($P<0.01$) with depth of visibility ($r=0.861$), pH ($r=0.698$), total dissolved solids ($r=0.980$), carbonates ($r=0.838$), bicarbonates ($r=0.902$), orthophosphates ($r=0.816$), nitrate-nitrogen ($r=0.910$) and TZP ($r=0.786$). However, a significant positive relationship ($P<0.05$) with total alkalinity. A positive relationship with CR and TPP was also noted. However, a significant negative relationship ($P<0.05$) of EC with NPP was noted and a negative relationship with air and water temperature dissolved oxygen, free CO_2 , GPP.

Dissolved oxygen (DO)

During the study period, the concentration of dissolved oxygen in surface water of lake Pichhola ranged from 5.4 to 6.8, 5.6 to 6.7, 4.8 to 6.4 and 5.2 to 6.7 mg

l^{-1} at stations **A**, **B**, **C** and **D** respectively. The average values of dissolved oxygen were 6.00, 6.08, 5.71 and 6.02 at stations **A**, **B**, **C** and **D** respectively. Station **A** had the highest dissolved oxygen (6.8 mg l^{-1}) and station **C** showed the lowest dissolved oxygen (4.8 mg l^{-1}) contents (Tables 4.1 to 4.6).

The highest dissolved oxygen of all stations was 6.63 mg l^{-1} was observed in October and lowest 5.28 in June. The average dissolved oxygen of all four stations was 5.95 mg l^{-1} during the study period (Table 4.5).

The statistical analysis of the result pertaining to dissolved oxygen as given with significant mean values in Table 4.13 and ANOVA in Appendix VI indicate highly significant difference between all stations, all the seasons. However, the analysis of variance indicated as non significant difference between the interaction of seasons and stations.

The statistical correlation of dissolved oxygen had positive relationship with GPP, NPP and CR. Whereas, a highly significant negative correlation ($P < 0.01$) with pH ($r = 0.880$) was noted. However, a significant negative relationship ($P < 0.05$) with air and water temperature, total dissolved solids, bicarbonates and TZP. Whereas, a negative relationship was also established with depth of visibility, electrical conductivity, free CO_2 , carbonates, total alkalinity, orthophosphates, nitrate-nitrogen and TPP (Table 4.7).

Free carbon dioxide (Free CO_2)

The free carbon dioxide fluctuated from 13.00 to 16.00, 14.00 to 22.00 and 13.00 to 16.00 mg l^{-1} at stations **B**, **C** and **D** respectively. The average values of free CO_2 were 14.33, 17.92 and 14.60 at stations **B**, **C** and **D** respectively. Station **C** had the highest free CO_2 (22.00 mg l^{-1}) and station **B** showed the lowest free CO_2 (13.00 mg l^{-1}). The free carbon dioxide was absent at station **A** throughout the study period. (Tables 4.1 to 4.6).

The monthly average values of all four stations of free CO_2 are shown in Table 4.5. The highest free CO_2 of all four stations was 22.00 mg l^{-1} was observed in September and lowest 14.00 mg l^{-1} in August. The average dissolved oxygen of four stations was 17.08 mg l^{-1} during the study period.

The statistical analysis of the result pertaining to free CO_2 as given with significant mean values in Table 4.14 and ANOVA in Appendix VII indicate highly

significant difference between all stations, all the seasons as well as the interaction between all stations and seasons.

The statistical correlation of free CO₂ with selected water quality parameters are shown in Table 4.7. The free CO₂ has significant positive relationship ($P<0.05$) with GPP. Whereas, a positive relationship with air and water temperature, pH, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, NPP, CR and TPP. However, a negative relationship with depth of visibility, electrical conductivity, dissolved oxygen, total dissolved solids and TZP.

Total dissolved solids (TDS)

The Total dissolved solids fluctuated from 235.50 to 311.80, 178.20 to 280.30, 286.00 to 366.50 and 280.20 to 354.10 mg l⁻¹ at stations A, B, C and D respectively. The average values of total dissolved solids were 277.38, 252.62, 334.51 and 322.80 mg l⁻¹ at stations A, B, C and D respectively. The mean value of total dissolved solids was highest at station C and lowest at station B. (Tables 4.1 to 4.6).

The monthly average values of all four stations of total dissolved solids are shown in Table 4.5. The highest total dissolved solids of all stations was 327.95 mg l⁻¹ was observed in May and lowest 257.63 mg l⁻¹ in August. The average total dissolved solids of all four stations was 296.83 mg l⁻¹ during the study period.

The statistical analysis of the result pertaining to total dissolved solids as given with significant mean values in Table 4.15 and ANOVA in Appendix VIII indicate highly significant difference between all stations, all the seasons. However, the analysis of variance indicated as non significant difference between the interaction of seasons and stations.

The statistical correlation of total dissolved solids with selected water quality parameters are shown in Table 4.37. The total dissolved solids had highly significant positive relationship ($P<0.01$) with depth of visibility ($r=0.815$), pH ($r=0.713$), electrical conductivity ($r=0.980$), carbonates ($r=0.808$), bicarbonates ($r=0.883$), total alkalinity ($r=0.599$), orthophosphates ($r=0.770$), nitrate-nitrogen ($r=0.870$) and TZP (0.779). Whereas, a positive relationship with CR and TPP. However, a significant negative relationship ($P<0.05$) with dissolved oxygen and NPP. Whereas, a negative relationship was also established with air and water temperature, free CO₂, GPP.

Carbonate alkalinity

In Lake Pichhola, the carbonate alkalinity ranged between 19.00 to 38.00, 26.20 to 49.00 and 33 to 42 mg l⁻¹ at stations **A**, **B** and **D** respectively. The carbonate alkalinity was absent at station **C** throughout the study period. The average values of carbonates were recorded as 28.58, 36.47, and 37.86 mg l⁻¹ at stations **A**, **B** and **D** respectively. (Tables 4.1 to 4.6).

The monthly average values of all four stations of carbonate alkalinity are shown in Table 4.5 and Fig.4.2. The highest carbonate alkalinity of four stations was 43.50 mg l⁻¹ was observed in May and lowest 26.07 mg l⁻¹ in August. The average carbonate alkalinity of three stations was 33.74 mg l⁻¹ during the study period.

The statistical analysis of the result pertaining to carbonate alkalinity as given with significant mean values in Table 4.16 and ANOVA in Appendix IX indicate highly significant difference between all stations, all the seasons as well as the interaction between all the stations and seasons.

The statistical correlation of carbonate alkalinity with selected water quality parameters are shown in Table 4.7. The carbonate alkalinity has highly significant positive relationship ($P < 0.01$) with pH ($r = 0.716$), electrical conductivity ($r = 0.838$), total dissolved solids ($r = 0.808$), bicarbonates ($r = 0.944$), total alkalinity ($r = 0.824$), orthophosphates ($r = 0.728$), nitrate-nitrogen ($r = 0.732$) and TZP ($r = 0.777$). While, a significant positive relationship ($P < 0.05$) with depth of visibility. Whereas, a positive relationship with air and water temperature, free CO₂, GPP, CR and TPP. However, a negative relationship with dissolved oxygen and NPP.

Bicarbonate alkalinity

The values of bicarbonate alkalinity ranged from 113 to 154, 130 to 167, 120 to 148 and 131 to 144 mg l⁻¹ at stations **A**, **B**, **C** and **D** respectively. The average values of bicarbonate alkalinity were 130.50, 140.67, 137.17 and 138.33 mg l⁻¹ at stations **A**, **B**, **C** and **D** respectively. The mean value of bicarbonate alkalinity was highest at station **B** and lowest at station **A**. (Tables 4.1 to 4.6).

The monthly average values of all four stations of bicarbonate alkalinity are shown in Table 4.5 and Fig 4.2. The highest bicarbonate alkalinity of all four stations was 150.50 mg l⁻¹ was observed in May and lowest 123.75 mg l⁻¹ in August. The

average bicarbonate alkalinity of all four stations was 136.67 mg l⁻¹ during the study period.

The statistical analysis of the result pertaining to bicarbonate alkalinity as given with significant mean values in Table 4.17 and ANOVA in Appendix X indicate highly significant difference between all the stations, all the seasons as well as significant difference between the interaction of all the stations and seasons.

The statistical correlation of bicarbonate alkalinity with selected water quality parameters are shown in Table 4.7. The bicarbonate alkalinity has highly significant positive relationship ($P < 0.01$) with pH ($r = 0.820$), electrical conductivity ($r = 0.902$), total dissolved solids ($r = 0.883$), carbonate alkalinity ($r = 0.944$), total alkalinity ($r = 0.868$), orthophosphates ($r = 0.861$), nitrate-nitrogen ($r = 0.874$) and TZP ($r = 0.784$). While, a significant positive relationship ($P < 0.05$) with depth of visibility. Whereas, a positive relationship with air and water temperature, free CO₂, CR and TPP. However, a significant negative relationship ($P < 0.05$) with dissolved oxygen was noted and a negative relationship with GPP and NPP.

Total alkalinity

In general, the total alkalinity in the present study varied between 132 to 186, 130 to 216 and 120 to 148, 137 to 186 mg l⁻¹ at stations **A**, **B**, **C** and **D** respectively. The average values were 159.08, 168.02, 137.17 and 160.42 mg l⁻¹ at stations **A**, **B**, **C** and **D** respectively (Tables 4.1 to 4.6). The minimum value (120 mg l⁻¹) was found in August at station **C**, while the maximum (216 mg l⁻¹) was recorded at station **B** on May.

The monthly average values of all four stations of total alkalinity are shown in Table 4.5 and Fig.4.2. The highest total alkalinity of all stations was 172.25 mg l⁻¹ was observed in May and lowest 141.25 mg l⁻¹ in July. The average total alkalinity of all stations was 156.13 mg l⁻¹ during the study period.

The statistical analysis of the result pertaining to bicarbonate alkalinity as given with significant mean values in Table 4.18 and ANOVA in Appendix XI indicate highly significant difference between all the stations, all the seasons as well as the interaction between all stations and seasons.

The statistical correlation of total alkalinity with selected water quality parameters are shown in Table 4.7. The total alkalinity has highly significant positive

relationship ($P < 0.01$) with pH ($r = 0.714$), carbonate alkalinity ($r = 0.824$), bicarbonate alkalinity ($r = 0.868$), orthophosphates ($r = 0.788$) and nitrate-nitrogen ($r = 0.733$). While, a significant positive relationship ($P < 0.05$) with electrical conductivity, total dissolved solids and TZP. Whereas, a positive relationship with air and water temperature, depth of visibility, free CO_2 , GPP, CR and TPP. However, a negative relationship with dissolved oxygen and NPP.

Orthophosphates ($\text{HPO}_4\text{-P}$)

The orthophosphates in the lake Pichhola during the study period ranged from 0.04 to 0.08, 0.04 to 0.09, 0.16 to 0.31 and 0.11 to 0.22 mg l^{-1} at stations **A**, **B**, **C** and **D** respectively. The average values were 0.06, 0.06, 0.25 and 0.18 mg l^{-1} at stations **A**, **B**, **C** and **D** respectively (Tables 4.1 to 4.6).

The monthly average values of all four stations of orthophosphates are shown in Table 4.5 and Fig. 4.3. The highest orthophosphates of all stations was 0.16 mg l^{-1} was observed in May, June and lowest 0.11 mg l^{-1} in July. The average orthophosphates of all stations was 0.14 mg l^{-1} during the study period.

The statistical analysis of the result pertaining to orthophosphates as given with significant mean values in Table 4.19 and ANOVA in Appendix XII indicate highly significant difference between all the stations, all the seasons as well as the interaction between all stations and seasons.

The statistical correlation of orthophosphates with selected water quality parameters are shown in Table 4.7. The orthophosphates has highly significant positive relationship ($P < 0.01$) with pH ($r = 0.785$), electrical conductivity ($r = 0.816$), total dissolved solids ($r = 0.770$), carbonate alkalinity ($r = 0.728$), bicarbonate alkalinity ($r = 0.861$), total alkalinity ($r = 0.788$) and nitrate-nitrogen ($r = 0.943$). While, a significant positive relationship ($P < 0.05$) with depth of visibility and TZP. Whereas, a positive relationship with air and water temperature, free CO_2 , GPP, CR and TPP. However, a negative relationship with dissolved oxygen and NPP.

Nitrate-nitrogen ($\text{NO}_3\text{-N}$)

The nitrate-nitrogen in lake Pichhola during the study period ranged from 0.38 to 0.61, 0.34 to 0.62, 0.66 to 0.95 and 0.39 to 0.64 mg l^{-1} at stations **A**, **B**, **C** and **D** respectively. The average nitrate-nitrogen values were 0.53, 0.52, 0.83 and 0.54

(Tables 4.1 to 4.6). The minimum value (0.34 mg l^{-1}) was found in July at station **B**, while the maximum (0.95 mg l^{-1}) was recorded at station **C** in June.

The monthly average values of all four stations of nitrate-nitrogen are shown in Table 4.5 and Fig. 4.3. The highest nitrate-nitrogen of all stations was 0.71 mg l^{-1} was observed in June and lowest 0.44 mg l^{-1} in July. The average nitrate-nitrogen of all stations was 0.60 mg l^{-1} during the study period.

The statistical analysis of the result pertaining to nitrate-nitrogen as given with significant mean values in Table 4.20 and ANOVA in Appendix XIII indicate highly significant difference between all the stations, all the seasons. However, the analysis of variance indicated a non significant difference between the interaction of all the seasons and stations.

The statistical correlation of nitrate-nitrogen with selected water quality parameters are shown in Table 4.7. The nitrate-nitrogen has highly significant positive relationship ($P < 0.01$) with depth of visibility, pH, electrical conductivity, total dissolved solids, carbonate alkalinity, bicarbonate alkalinity, total alkalinity and orthophosphates. While, a significant positive relationship ($P < 0.05$) with TZP. Whereas, a positive relationship with, free CO_2 , CR and TPP. However, a negative relationship with air and water temperature, dissolved oxygen, GPP and NPP.

Primary productivity

The results pertaining to gross, net primary productivity and Community respiration of lake Pichhola during the study period are presented in Tables 4.1 to 4.6. In general, the GPP ranged between 0.30 to 0.44 , 0.28 to 0.44 , 0.36 to 0.50 and 0.38 to $0.47 \text{ g C m}^{-3} \text{ h}^{-1}$ at stations **A**, **B**, **C** and **D** respectively. The average values of GPP were 0.37 , 0.36 , 0.43 and $0.40 \text{ g C m}^{-3} \text{ h}^{-1}$. The minimum value ($0.28 \text{ g C m}^{-3} \text{ h}^{-1}$) was found in January at station **B**, while the maximum ($0.50 \text{ g C m}^{-3} \text{ h}^{-1}$) was recorded at station **C** in October.

The monthly average values of all four stations of GPP are shown in Table 4.5 and Fig. 4.4. The highest GPP of all stations was $0.45 \text{ g C m}^{-3} \text{ h}^{-1}$ was observed in October and lowest $0.36 \text{ g C m}^{-3} \text{ h}^{-1}$ in February. The average GPP of all stations was $0.39 \text{ g C m}^{-3} \text{ h}^{-1}$ during the study period.

The statistical analysis of the result pertaining to GPP as given with significant mean values in Table 4.21 and ANOVA in Appendix XIV indicate highly significant

difference between all the stations, all the seasons as well as the interaction between all the stations and seasons.

The statistical correlation of GPP with selected water quality parameters are shown in Table 4.7. The GPP has a significant positive relationship ($P < 0.05$) with free CO_2 . Whereas, a positive relationship with air and water temperature, dissolved oxygen, carbonate alkalinity, total alkalinity, orthophosphates, NPP, CR and TPP. However, a negative relationship with depth of visibility, pH, electrical conductivity, total dissolved solids, bicarbonate alkalinity, nitrate-nitrogen and TZP.

The respective values of net primary productivity (NPP) at stations **A**, **B**, **C** and **D** ranged from 0.18 to 0.26, 0.15 to 0.30, 0.22 to 0.33 and 0.19 to 0.30 $\text{g C m}^{-3} \text{ h}^{-1}$. The average values of NPP were 0.23, 0.23, 0.24 and 0.26. The minimum value ($0.15 \text{ g C m}^{-3} \text{ h}^{-1}$) was found in January at station **B**, while the maximum ($0.33 \text{ g C m}^{-3} \text{ h}^{-1}$) was recorded at station **C** in October (Tables 4.1 - 4.6).

The monthly average values of all four stations of NPP are shown in Table 4.5 and Fig. 4.4. The highest NPP of all stations was $0.27 \text{ g C m}^{-3} \text{ h}^{-1}$ was observed in June, October and lowest $0.20 \text{ g C m}^{-3} \text{ h}^{-1}$ in March. The average NPP of all stations was $0.24 \text{ g C m}^{-3} \text{ h}^{-1}$ during the study period.

The statistical analysis of the result pertaining to NPP as given with significant mean values in Table 4.22 and ANOVA in Appendix XV indicate highly significant difference between all the stations, all the seasons as well as the interaction between all the stations and seasons.

The statistical correlation of NPP with selected water quality parameters are shown in Table 4.7. The NPP has positive relationship with air and water temperature, dissolved oxygen, free CO_2 , GPP and TPP. However, a significant negative relationship ($P < 0.05$) with electrical conductivity, total dissolved solids was noted and a negative relationship with depth of visibility, pH, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, orthophosphates, nitrate-nitrogen CR and TZP.

The respective values of community respiration (CR) at stations **A**, **B**, **C** and **D** ranged from 0.11 to 0.18, 0.10 to 0.17, 0.14 to 0.19 and 0.10 to 0.19 $\text{g C m}^{-3} \text{ h}^{-1}$. The average values of CR were 0.14, 0.13, 0.17 and 0.14 $\text{g C m}^{-3} \text{ h}^{-1}$ (Tables 4.1 - 4.6).

The monthly average values of all four stations of CR are shown in Table 4.5 and Fig. 4.4. The highest CR of all stations was $0.17 \text{ g C m}^{-3} \text{ h}^{-1}$ was observed in October and lowest $0.12 \text{ g C m}^{-3} \text{ h}^{-1}$ in July. The average CR of all stations was $0.15 \text{ g C m}^{-3} \text{ h}^{-1}$ during the study period.

The statistical analysis of the result pertaining to CR as given with significant mean values in Table 4.23 and ANOVA in Appendix XVI indicate highly significant difference between all the stations, significant difference between all the seasons as well as the interaction between all the stations and seasons.

The statistical correlation of CR was found positive with depth of visibility, electrical conductivity, dissolved oxygen, free CO_2 , total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen GPP and TZP. However, there was a negative relationship with air and water temperature, pH, NPP and TPP (Table 4.7).

LAKE PLANKTON

Phytoplankton

The quantitative enumeration of phytoplankton of lake Pichhola are presented in Tables 4.27 to 4.35, Fig. 4.5 and Plate-1.

The algal flora of the lake Pichhola was contributed by four major groups of phytoplankton viz., Cyanophyceae, Bacillariophyceae, Chlorophyceae and Desmidiaceae. Overall 36 genera of algae were recorded in lake Pichhola during the present study (Table 4.26). Out of the total 36 genera, 12 were from Cyanophyceae, 9 from Bacillariophyceae, 12 from Chlorophyceae, and 3 belongs to Desmidiaceae. The monthly average values of all four stations of overall mean phytoplankton density was more at station **C** i.e. ($148.00 \text{ Cells ml}^{-1}$) followed by station **B** ($146.91 \text{ Cells ml}^{-1}$), station **D** ($145.00 \text{ Cells ml}^{-1}$) and Station **A** ($142.50 \text{ Cells ml}^{-1}$) contents (Tables 4.31-4.34). The trend of dominance among the four 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** and **D** the relative dominance of four algal groups was Cyanophyceae > Bacillariophyceae > Chlorophyceae > Desmidiaceae (Tables 4.31-4.34, Fig. 4.5 and Plate-1). The overall dominance of phytoplankton is similar to the trend found at station **A** (Table 4.35).

The trends of seasonal variations in phytoplankton population at four stations studied are more or less same, both species wise and in abundance. The phytoplankton population was maximum in month of summer followed by in winter at station **A** and **B**. However, this trend was little bit different at station **C** and **D**, where maximum phytoplankton population was noted during summers followed by in the months of monsoons (Tables 4.31-4.34).

The relative dominance of species among the categories at station **A** and **B** in group Cyanophyceae was dominated by *Nostoc* sp. under the group Bacillariophyceae dominated by *Cyclotella* sp., in group Chlorophyceae - *Chlorella* sp. was dominating. Whereas, *Closterium* sp. dominated in the group Desmidiaceae at station **A** and **B**. (Table 4.27 and 4.28).

The relative dominance of species among the categories at station **C** in group Cyanophyceae was dominated by *Spirulina* sp., under the group Bacillariophyceae dominated by *Nitzschia* sp., in group Chlorophyceae - *Chlorella* sp. was dominating. Whereas, *Closterium* sp. dominated in the group Desmidiaceae at station **C**. (Table 4.29).

The relative dominance of species among the categories at station **D** in group Cyanophyceae was dominated by *Oscillatoria* sp., under the group Bacillariophyceae dominated by *Nitzschia* sp., in group Chlorophyceae - *Spirogyra* sp. was dominating. Whereas, *Closterium* sp. dominated in the group Desmidiaceae at station **D** (Table 4.30).

The Odum's species diversity index as shown in Table 4.45 and Fig.4.7 indicate greater species diversity at station **A** (136.39) followed by (128.69) at station **B**, 116.53 at station **D** and lowest at station **C** i.e. 100.17. This index also indicate the pollution level at different stations which can be ascertained that at station **C**, the pollution level was maximum followed by station **D** then station **B** and minimum at station **A**.

Twenty Two (22) pollution tolerant algal genera were found in lake Pichhola (Table 4.47). The Palmer's algal genus index was calculated for the algal genera mentioned for their pollution index as per Palmer (1969). The index as depicted in Table 4.48 shows that the Palmer's score at station **A** and **B** was 16 each. Whereas, at station **C** and **D** the score was 24. This indicates probable evidence of organic

pollution at station **A** and **B**. Whereas, the higher scores at station **C** and **D** confirms high organic pollution at these stations.

The statistical analysis of the result pertaining to total phytoplankton as given with significant mean values in Table 4.24 and ANOVA in Appendix XVII indicate highly significant difference between all the stations, all the seasons. However, the analysis of variance indicated a non significant difference between the interaction of seasons and stations.

The statistical correlation of TPP with selected water quality parameters are shown in Table 4.7. The TPP has highly significant positive relationship ($P < 0.01$) with air and water temperature ($r = 0.733$) ($r = 0.707$). While a positive relationship with pH, electrical conductivity, free CO_2 , total dissolved solids, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, orthophosphates, nitrate-nitrogen, GPP, NPP, TZP, and TPP. However, a negative relationship with depth of visibility, dissolved oxygen and CR.

Zooplankton

The quantitative enumeration of phytoplankton of lake Pichhola are presented in Tables 4.36 to 4.44, Fig. 4.6 and Plate-2.

The zooplankton of the lake Pichhola was contributed by four major groups of zooplankton viz., Rotifera, Cladocera, Copepoda and Protozoa. Overall 32 species of zooplankton were recorded in lake Pichhola during the present study (Table 4.24). Out of the total 32 species, 11 were from Rotifera, 9 from Cladocera, 7 from Copepoda, and 5 belongs to Protozoa. The overall mean zooplankton density was more at station **C** i.e. (38.58 No l^{-1}) followed by station **B** (37.50 No l^{-1}), station **D** (37.00 No l^{-1}) and Station **A** (33.50 No l^{-1}) (Tables 4.40-4.43). The trend of dominance among the four zooplankton groups at station **A** was Copepoda > Rotifera > Cladocera > Protozoa. At station **B** and **D** the trend of dominance was Rotifera > Cladocera > Copepoda > Protozoa. However, at station **C** the relative dominance of zooplankton groups was Cladocera > Rotifera > Copepoda > Protozoa (Tables 4.40-4.43, Fig. 4.6 and Plate-2). The overall dominance of zooplankton is similar to the trend found at station **B** and **D** (Table 4.44).

The trends of seasonal variations in zooplankton population at four stations studied are more or less same, both species wise and in abundance. The zooplankton

population was maximum in month of summer followed by in winter at station **D** and **C**. However, this trend was little bit different at station **A** and **B**, where maximum zooplankton population was noted during summers followed by in the months of monsoons (Tables 4.40-4.43).

The relative dominance of species among the categories at station **A** and **B** in group Rotifera was dominated by *Brachionus* sp., under the group Cladocera dominated by *Daphnia* sp., in group Copepoda - *Cyclops* sp. was dominating. Whereas, *Amoeba* sp. dominated in the group Protozoa at station **A** and **B** (Tables 4.36 and 4.37).

The relative dominance of species among the categories at station **C** in group Rotifera was dominated by *Filinia longiseta*, under the group Cladocera dominated by *Daphnia* sp., in group Copepoda - *Cyclops* sp. was dominating. Whereas, *Amoeba* sp. and *Paramecium* sp. dominated in the group Protozoa at station **C** (Table 4.38).

The relative dominance of species among the categories at station **D** in group Rotifers was dominated by *Keratella* sp., under the group Cladocerans dominated by *Daphnia* sp., in group Copepods - *Cyclops* sp. was dominating. Whereas, *Vorticella* sp. dominated in the group Protozoa at station **C** (Table 4.39).

The Odum's diversity index as such do not match the trends shown by phytoplankton for the obvious reason that zooplanktons are motile to a limited extent move horizontally as well as vertically.

The Odum's diversity index as shown in Table 4.46 and Fig. 4.8 indicate greater species diversity at station **A** (676.22) followed by (655.14) at station **C**, (642.86) at station **D** and lowest at station **B** i.e. (528.03). Zooplankton indicates following order from maximum to minimum is **B > D > C > A**.

The statistical analysis of the result pertaining to total phytoplankton as given with significant mean values in Table 4.25 and ANOVA in Appendix XVIII indicate highly significant difference between all the stations, all the seasons as well as the interaction between all the seasons and stations.

The statistical correlation of TZP with selected water quality parameters are shown in Table 4.7. The TZP has highly significant positive relationship ($P < 0.01$) with pH ($r = 0.700$), electrical conductivity ($r = 0.786$), total dissolved solids ($r = 0.779$), carbonate alkalinity ($r = 0.777$) and bicarbonate alkalinity ($r = 0.784$). While, a

significant positive relationship ($P < 0.05$) with, depth of visibility, total alkalinity, orthophosphates and nitrate-nitrogen. Whereas, a positive relationship with air and water temperature, CR, and TPP. However, a significant negative relationship ($P < 0.01$) with dissolved oxygen was noted and a negative relationship with free CO_2 , GPP, NPP.

During the present investigation 34 fish species belonging to 11 family were reported in lake Pichhola (Table 4.49). Among these three major carps namely *Catla catla*, *Labeo rohita* were the dominant fish species among the Cyprinidae. Besides this three exotic carps namely *Cyprinus carpio*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix* and a few specimen of mahseer (*Tor tor*) were also found in the lake. Four minor species of *Labeo* and six species of *Puntius* were also present prominently in the other Cyprinids. Specimens of Siluridae, Notopteridae, Bagridae, Mastacembelidae, Opheocephalus, Centropomidae, Belonidae, Cobitidae, Osphronemidae and Loricariidae were also found in the lake.

5. DISCUSSION

The results of present study are depicted in (Tables 4.1 to 4.49, Fig. 3.1 to 3.2 and Figs. 4.1 to 4.9) regarding water quality, primary productivity, phytoplankton and zooplankton.

The morphometric features of the lake Pichhola as depicted in (Table 3.1) indicates that it is a large perennial lake with a maximum depth of 8.5 meter (28 ft.) which is located at central Western part of the lake. The lake is spread in an area of 696 ha. Some amount of urban waste and urban sewage were also found to be drained in the lake on the North-West and North-Eastern part of the lake where station **C** and **D** are located.

PHYSICO-CHEMICAL PARAMETERS:

The physico-chemical conditions of water as a substance and its mechanical action as a medium have their own importance for the living complex. Reid (1961) pointed out that whole of the aquatic life in the river, tank, pond and reservoir is governed by the interaction of a number of physical and chemical conditions.

During the present study the air and water temperature were comparable and ranged between 22.03°C to 37.40°C - air temperature and 20.23°C to 30.33°C - water temperature at all four stations. Similar range of air and water temperature is commonly found prevailing in and around water bodies of arid and semi-arid regions of Rajasthan (Gupta, 1988; Sarang, 2001; Rajkumar, 2005; and Balai, 2007). However, in typical settings of arid and semi-arid regions the surface water temperature showed a wide annual fluctuation in investigations conducted by Bohra (1976), Rawat (2002) and Balai (2007). Sharma *et al.* (2011) observed water temperature of lake Pichhola in range of 18.20 to 33.90°C during 2005-07. Mishra *et al.* (2016) observed an average water temperature of 28.57°C of Goverdhan Sagar lake in Udaipur. These findings are very much in consonance with the findings of present research.

Physico-chemical parameters of lake Pichhola were found to be congenial to sustain the divers flora and fauna throughout the study period. The relationship between air and water temperature was clearly seen in the present study where a positive relationship was established between air and water temperature. Shekhawat

(1991) reported close association of air and water temperature in small sized water body. Similar relationship was reported by Ganpati (1962), Verma (1967), Gupta (1991), Solomon (1994), Sharma and Gupta (1994) and Sarang (2001). However, Michael (1964) and Timms (1970) did not find such a relationship between air and water temperature.

In the present study air and water temperature was found to show a highly significant positive relationship with total phytoplankton (TPP) and positive with pH, free CO₂, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, orthophosphates, GPP, NPP, and total zooplankton (TZP). On the other hand air and water temperature showed negative relationship with depth of visibility, electrical conductivity, dissolved oxygen, total dissolved solids, nitrate-nitrogen and CR.

The secchi disc is still one of the valuable tools in the study of limnology. Sharma and Durve (1990) classified lakes on the basis of water clarity and found moderately eutrophic nature of lake Jaisamand with average water clarity values between 88.75 to 101.33 cm. Gupta and Sharma (1994) reported depth of visibility values of 66.00 to 336.00 cm indicating comparatively clear water status of Amarchand reservoir and accordingly placed it under mild eutrophic category.

In the present investigation the water clarity values were found within this range (75.00 to 94.00 cm.) throughout the study period. The observed values of water clarity might be mainly influenced by the suspended particulate matter, plankton and variations in water level during the study period. The present results of visibility points out relatively moderate levels of nutrients in the lake Pichhola and thus can be acclaimed in the category “Moderately eutrophic nature of water” as described by Sharma and Durve (1990). However, Sharma *et al.* (2011) observed water clarity of 98.00 to 149.60 cm. in lake Pichhola and reported the lake of eutrophic nature. It seems that water clarity has not altered much despite increasing human interferences during the last few decades. The lake was also found to possess a fairly good biomass of aquatic vegetation. This may be explained for the excellent nutrient absorption capacity of macrophytes thus, leaving feeble amount of nutrients for growth of phytoplankton. This further finds support from negative correlation between phytoplankton number and water clarity.

During the present study, correlation matrix between water clarity and other parameters indicates that water clarity had a positive relationship with electrical conductivity, pH, alkalinity, nitrate nitrogen, orthophosphate, community respiration and TZP whereas, a negative relationship was seen with air and water temperature, dissolved oxygen, free CO₂, GPP, NPP and TPP. Solomon (1994) reported the positive relationship of total plankton counts with the clarity values for Udaipur lakes. Similar to our findings Sharma *et al.* (2012) also found positive relationship of water clarity with various parameters as stated above.

pH is an important factor of freshwater bodies deciding fish health as well as the productivity of water. Factors like exposure to air temperature, free CO₂ and disposal of industrial wastes *etc.* bring about changes in pH. The moderate to slightly alkaline pH has been considered as most suitable for fish culture while pH above 9 is unsuitable (Ellis *et al.*, 1948, Swingle, 1967, Jhingran, 1977).

In the present study, the average pH ranged from 7.38 to 8.23 at all the four stations. The monthly variations in pH were not large during the study period.

The pH of lake Pichhola was found to be moderately alkaline which is suitable for supporting fairly good aquatic productivity. Such alkaline pH has also been reported earlier by Misra *et al.* (1978), Sharma, 1980 (7.7-8.7), Gupta (1991), Gupta and Sharma (1994), Sarang (2001), Rawat and Jakher (2002). Ujjania (2003) also found alkaline water in the three water bodies of southern Rajasthan. Rajkumar (2005) and Balai (2007) found alkaline water in the Daya reservoir and Jaisamand lake of Udaipur (Raj.) respectively. Sumitra *et al.* (2007) reported a pH of 8.3-9.3 in lake Pichhola which is fairly inclined towards an alkaline nature of water.

In the present study pH showed a positive relationship with air and water temperature, depth of visibility, electrical conductivity, free CO₂, total dissolved solids, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, orthophosphates, nitrate nitrogen, TPP and TZP. On the other hand pH had showed negative relationship with dissolved oxygen, GPP, NPP and CR. Rajkumar (2005) and Balai (2007) also found a positive relationship between pH and water temperature. A positive relationship of pH as seen in the present study was also seen by Sharma *et al.* (2012) with EC, TDS, visibility, phosphate and temperature. Similarly Malik and Bharti (2012) noticed a positive relationship with total zooplankton.

The electrical conductance (EC) represents total ionic load in water due to dissolved substances and sometimes considered as an index of productivity. In present study the electrical conductance of lake Pichhola was found to be ranged from 0.39 to 0.49 mS cm⁻¹ (average EC 0.45 mS cm⁻¹) during the study period. Higher electrical conductance during monsoon may be due to influence of dissolved solids coming from catchment area through runoff water. Similar to the findings in the present study with higher EC values in summer Sharma *et al.* (2011) also reported high electrical conductance during summer season (0.463 μ S cm⁻¹) indicating a eutrophic condition of water body in lake Pichhola. Sharma (1980) recorded average electrical conductance of 0.426 μ S cm⁻¹ from Fateh Sagar lake.

The positive relationship of electrical conductivity observed in the present investigation with depth of visibility, pH, total dissolved solids, carbonates, bicarbonates, orthophosphates, nitrate-nitrogen, total alkalinity, CR, TPP and TZP. Alike the present findings, Balai (2007) observed positive significant relationship of electrical conductance with carbonates, bicarbonates, total alkalinity and silicates. Meena *et al.* (2007) reported significant correlation ship of electrical conductance with primary production, TDS, BOD and total alkalinity of lake Pichhola, Udaipur (Raj.). Similar positive relationship was also seen in Udaipur lakes by Sharma *et al.* (2012) and Mishra *et al.* (2012).

Dissolved oxygen is the most critical water quality variable in aquatic ecosystem. It is of primary importance both as regulator of metabolism of plant and animal communities and as an indicator of water condition. According to Hutchinson (1967) dissolved oxygen is the most significant chemical abiotic component which is essential for smooth running of metabolic activities for all organisms in the aquatic ecosystem and is one of the best indicators to show the nature of the water body. Wetzel (1975) opined that oxygen content is important for direct requirement of many organisms and affects the solubility and availability of many nutrients and therefore the productivity of aquatic ecosystem.

During present study dissolved oxygen concentration of lake Pichhola ranged from 5.28 to 6.63 mg l⁻¹ with average value of 5.95 mg l⁻¹. Similar values of dissolved oxygen were also noted by Gupta and Sharma (1994), Bharadwaj and Sharma (1999), Sarang *et al.* (2002), Nandan and Magar (2007), Tamot *et al.* (2007) and Mishra *et al.* (2016) in different water bodies of the India.

The dissolved oxygen indicated positive correlation with GPP, NPP and CR. However, a negative correlation of dissolved oxygen with air and water temperature, pH, depth of visibility, electrical conductivity, free CO₂, total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, TPP and TZP was found during the present study. Bhardwaj and Sharma (1999) also found inverse correlation ship of dissolved oxygen with water temperature at sewage fertilized seasonal pond of Udaipur (Raj.). The negative correlation of dissolved oxygen with water temperature ($r = -0.589$) is in agreement with Das (2000), Sumitra *et al.* (2007), Sharma (2007) and Rajasekhar *et al.* (2007). Besides this similar to our study Kaparapu and Geddada (2015) also found negative correlation of dissolved oxygen with total phytoplankton abundance. In concurrence to present study Sharma *et al.* (2011) also found a significant negative relation of dissolved oxygen with temperature, alkalinity, electrical conductivity, nitrate, phosphates and community respiration.

The peak values of higher dissolved oxygen in winter as found in lake Pichhola has also been reported by Kolekar (2006), Negi *et al.* (2006), Upadhyay and Dwivedi (2006), Sharma (2007) and Malara (2008). Similar to the present study, Sharma *et al.* (2011) also found higher values of dissolved oxygen in winters and the authors justified it due to high solubility of oxygen at low temperature and slower degradation of organic matter. Comparable positive relationship of dissolved oxygen with NPP values as found in lake Pichhola has also been reported earlier in Goverdhan Sagar by Mishra *et al.* (2012).

Carbon di-oxide is highly soluble in water. The main source of free CO₂ is mainly decomposition of organic matter and respiration of plants and animals (Dwivedi and Pandey, 2002).

In the present study free CO₂ was absent at station A throughout the study period. However, free CO₂ was found frequently at station C (14.00 - 22.00 mg l⁻¹). Similar results for absence of free CO₂ were also reported by Gupta and Sharma (1994), Das (2000), Rajkumar (2005), Dasgupta *et al.* (2007), Parihar *et al.* (2007) and Paulose and Maheshwari (2007). Ujjania *et al.* (2007) and Balai (2007) in different water bodies of southern Rajasthan. The absence or low values of free CO₂ during winters can be attributed due to its complete utilization by the macrophytic vegetation and by phytoplankton (Rawson, 1939). The presence of free CO₂ at some

stations in earlier study of fresh water lakes in Udaipur (Mishra *et al.*, 2012) can be attributed to the flush of nutrient rich organic matter through urban sewage.

The free CO₂ has indicated positive correlation with air and water temperature pH, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, GPP, NPP, CR and TPP. However, a negative correlation of free CO₂ with depth of visibility, electrical conductivity, dissolved oxygen, total dissolved solids and TZP was found during the present study.

Mishra *et al.* (2012) also found similar results of free CO₂ have positive relationship with orthophosphates, CR and negative with depth of visibility in the lake Goverdhan Sagar, Udaipur. An inverse relationship between dissolved oxygen and free CO₂ has also been reported by Khan and Siddiqui (1971).

The higher values of total dissolved solids in natural waters are generally due to increased anthropogenic activity, stagnation and concentration of water, which hampers water quality (Manickam *et al.*, 2014). However, Narayan *et al.* (2007) opined that in summer most of the vegetation gets decayed and thus gives rise in TDS.

During present study total dissolved solids (TDS) ranged from 257.63 to 327.95 mg l⁻¹ with an average value of 296.83 mg l⁻¹. Sharma (2007) noted a range of TDS between 243-424 mg l⁻¹ during monsoon and winter respectively, in lake Pichhola. Sharma *et al.* (2011) found TDS 210-278 mg l⁻¹ with lowest during winter and highest during summer of 2005-06 respectively. However, Sharma *et al.* (2012) found TDS ranged from 178-728 mg l⁻¹ with an average value of 476.61 mg l⁻¹ in Bada madar Tank, Udaipur. Higher concentration of TDS in lake Pichhola coincided with higher discharge of urban sewage and organic matter by the interference of human being (Sharma, 2007).

In the present study total dissolved solids (TDS) has indicated positive correlation with depth of visibility, pH, electrical conductivity, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, CR, TPP and TZP. However, a negative correlation of TDS with air and water temperature, dissolved oxygen, free CO₂, GPP and NPP was also noted. The positive relationship of TDS as seen in the present study was also noted earlier by Sharma *et al.* (2012) with depth of visibility, pH, electrical conductivity, total alkalinity, orthophosphates and nitrate-nitrogen in the Madar Tank, Udaipur.

Carbonates are bound form of carbon dioxide. A change in alkalinity thus indicates either an addition or precipitation of carbonates. The regular presence of carbonates in the water bodies of arid and semi-arid regions was also reported by Khatri (1980), Saxena (1982), Gupta and Sharma (1994), Sharma and Gupta (1994) and Sarang *et al.* (2002).

During present study carbonate alkalinity ranged from 26.07 to 43.50 mg l⁻¹. Such observations with carbonate alkalinity within this range were also reported earlier by Gupta and Sharma (1994). Sarang *et al.* (2002) and Balai (2007) observed similar results in the Jaisamand reservoir of Udaipur (Rajasthan).

The carbonate alkalinity indicated positive relationship with air and water temperature, depth of visibility, pH, electrical conductivity, free CO₂, total dissolved solids, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, GPP, CR, TPP and TZP. On the other hand it showed negative relationship with, dissolved oxygen and NPP.

Bicarbonates form a major source of carbon for aquatic flora, particularly for the phytoplankton in the absence of free CO₂. Presence of bicarbonates, carbon dioxide and hydrogen alkalinity implied that CO₃-HCO₃ and free CO₂ were responsible for alkalinity (Jhingran, 1992). During the present study bicarbonate alkalinity showed fairly good presence which varied from 123.75 to 150.50 mg l⁻¹ in lake Pichhola.

Goldman and Wetzel (1963) and Sreenivasan (1966) found maximum alkalinity during summer which declined subsequently in the monsoon period. Vijayaraghavan (1970), Sharma and Gupta (1994), Bhardwaj and Sharma (1999), Das (2000), Dwivedi *et al.* (2000), Rajkumar (2005), Balai (2007) and Nandan and Magar (2007) also found similar trend in the bicarbonate alkalinity.

Correlation matrix indicates that bicarbonate alkalinity had positive relationship with air and water temperature, depth of visibility, pH, electrical conductivity, free CO₂, total dissolved solids, carbonate alkalinity, total alkalinity, orthophosphates, nitrate-nitrogen, CR, TPP and TZP. On the other hand negative relationship with, dissolved oxygen, GPP, and NPP was seen. Parihar *et al.* (2007) while studying waters of Udaipur (Raj.) also reported highly significant correlation between bicarbonate and total alkalinity.

Natural bodies of water in the tropics usually show a wide range of fluctuation in total alkalinity values depending upon the location, seasons, plankton population and nature of bottom deposits. Stagnant waters in tropical plains in low rainfall areas during the summer season are likely to have high total alkalinity values. A range of 4 to over 1000 ppm alkalinity has been encountered in natural bodies of water (Jhingran, 1992). The increase in total alkalinity may be related with increase in pH (Wetzel, 1983).

In the present study, total alkalinity ranged from 141.25 to 172.25 mg l⁻¹. Rao (1984), Mwachiro (1993) and Solomon (1994) have studied selected lakes of Udaipur and reported the alkalinity above 60 mg l⁻¹ in all the water bodies. Ujjania (2003) observed total alkalinity of 65 to 199 mg l⁻¹ in three water bodies of southern Rajasthan. Rajkumar (2005), Parihar *et al.* (2007) and Balai (2007) also reported higher range of alkalinity in different water bodies of Udaipur region. Sharma *et al.* (2012) found total alkalinity between 103 to 142 ppm while the recorded average value of total alkalinity was 124 ppm in Bada Madar Tank.

Total alkalinity depicted positive correlation with air and water temperature, depth of visibility, pH, electrical conductivity, free CO₂, total dissolved solids, carbonates, bicarbonates, orthophosphates, nitrate-nitrogen, GPP, CR, TPP and TZP. Similar relationships were also found by Sharma *et al.* (2011) and Sharma *et al.* (2012) who found positive correlation of total alkalinity with TDS, electrical conductivity and nitrate-nitrogen. The values of total alkalinity above 60 mg l⁻¹ can be considered as an indication of nutrient rich condition (Spence, 1964). Alikunhi (1957) stated that in highly productive waters, the alkalinity ought to be over 100 ppm. Swingle (1967) adjudged such waters suitable for fish culture. As such the Pichhola lake water can be considered productive in nature and suitable for fish culture.

Phosphorus is generally recognized as a key nutrient in deciding the fertility of a water body. Frequently limits plant production and ultimately influences fish production. Too much phosphorus is sometimes responsible for excessive production of blue-green algae or other nuisance plant species in an aquatic body. The source of phosphorus in water body is principally from dead plankton by the microbial actions. This plankton is broken down by autolysis. According to Cole (1979) phosphorus is very meager in terms of abundance on the earth surface and ecologically it is often

considered as the most critical single element in the maintenance of the aquatic productivity.

Phytoplankton absorbs phosphorus very rapidly and most of its uptake take place probably occurs within a few hours or even a few minutes, following fertilization (Coffin *et al.*, 1949). The results (Tables 4.1 to 4.7) on inorganic phosphate obtained in the present study thus justify non-polluted status of lake Pichhola owing to the availability of primary producers (mainly macrophytes) to utilize phosphorus efficiently.

Here the dissolved phosphate concentrations ranged between 0.11 to 0.16 mg l⁻¹ during the study period. Rao (1987) recorded orthophosphates variations between 0.065 to 0.525 mg l⁻¹ in Rangasagar which relatively eutrophic water and bears connections with lake Pichhola. Dwivedi *et al.* (2000) observed phosphate from 0.20 to 0.55 ppm in Naktara reservoir, (M.P.) India. Sultan *et al.* (2003) found nutrients in the form of orthophosphate ranging between 0.07 to 0.50 mg l⁻¹ at Pahunj reservoir, Uttar Pradesh. Whereas, Chouhan and Sharma (2007) reported quite higher concentration of phosphate between 2.58 to 2.66 ppm at lake Budha Pushkar near Ajmer, Rajasthan. In the present study dominance of nitrate-nitrogen over phosphate is noticed. Rajkumar (2005) also found the same results in Daya reservoir. Sharma *et al.* (2012) found phosphate ranged between 1.25 mg l⁻¹ to 4.95 mg l⁻¹ with average value of 2.68 mg l⁻¹ in the water body of southern Rajasthan. The comparative low level of phosphate indicated that water free from effluent contamination (Ruttner, 1953).

In the present study orthophosphate showed positive relationship with air and water temperature, depth of visibility, pH, electrical conductivity, free CO₂, total dissolved solids, carbonates, bicarbonates, total alkalinity, nitrate-nitrogen, GPP, CR, TPP and TZP. Whereas, a negative relationship with dissolved oxygen and NPP was seen. Sharma *et al.* (2012) found similar positive relationship with pH, depth of visibility, temperature, and nitrate-nitrogen.

In the lake ecosystem the major input of nitrate-nitrogen is allochthonous *i.e.* through run off or edition of urban sewage but this may also be contributed from the decomposition of aquatic plants, fishes and other nitrogenous matter and its further oxidation (Goldman and Horne, 1983). Nitrate generally occurs in the trace quantities

which is essential for many photosynthetic autotrophs and in some cases has also been identified as the growth limiting nutrient.

In the present study in lake Pichhola, the value of nitrate-nitrogen varied from 0.44 to 0.71 mg l⁻¹ with an average value of 0.60 mg l⁻¹. These values of nitrate were comparable to those reported by Sharma (1980), Nasar and Kaur (1982), Sharma and Gupta (1994), Bharadwaj and Sharma (1999), Das (2000), Dwivedi *et al.* (2000), Sultan *et al.* (2003).

Relatively higher value of nitrate in the present investigation were recorded during summers in June at station C which may be due to addition of urban sewage and human influence. Further, high value of nitrate in summer was found possibly due to its release from decomposition of organic matter. Similar trend of nitrate concentration was found by Dwivedi and Pandey (2002). This may also be assigned to higher microbial activities and higher excretory products of aquatic animals (Dwivedi and Pandey, 2002).

The statistical computation indicated a positive correlation of nitrates with, depth of visibility, pH, electrical conductivity, free CO₂, total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, CR, TPP and TZP. Whereas, negative relationship with air and water temperature, dissolved oxygen, GPP and NPP. Such relationships were also noticed in various Udaipur waters by Sharma *et al.* (2011) in lake Pichhola, Sharma *et al.* (2012) in Bada Madar Tank and Mishra *et al.* (2012) in Goverdhan Sagar.

PRIMARY PRODUCTIVITY:

Primary production is the biological process by which the inorganic materials of the environment are converted into the organic matter. In natural waters, the primary production almost entirely depends on photosynthesis particularly by macrophytes, phytoplankton and periphyton.

The primary productivity values from certain water bodies of Udaipur are presented here below for comparison:

S.No.	Water body	Gross primary productivity
1	Fateh Sagar	0.16 g C/m ³ /hr
2	Badi Tank	0.17 g C/m ³ /hr
3	Pichhola	0.20 g C/m ³ /hr
4	Dudh Talai	0.20 g C/m ³ /hr
5	Goverdhan Sagar	0.43 g C/m ³ /hr
6	Daya reservoir	0.45 g C/m ³ /hr

Source: Rajkumar (2005)

From the above comparison, it is clear that primary productivity of lake Pichhola at all stations during the present investigation were alike the values reported by earlier workers which indicate the productive nature of the lake Pichhola.

It is evident that GPP at all stations ranged between 0.36 to 0.45 g C m⁻³ h⁻¹ with an average value of 0.39 g C m⁻³ h⁻¹.

The higher primary productivity found in the present study may be assigned to high concentration of nutrients, higher temperature and higher photosynthesis during the pre-summer and late monsoon months. Rajkumar (2005) also reported higher average GPP (0.45 g C m³ h⁻¹) in Daya reservoir which was acclaimed for adequate influx of water. However, quite earlier Gupta (1991) found only 0.19 g C m³ h⁻¹ GPP in the Daya reservoir. Similar to the current study Sultan *et al.* (2003) and Rajkumar (2005) found higher primary productivity in tropical waters, congenial for biological production.

The statistical relationship of GPP was found positive with air and water temperature, free CO₂, dissolved oxygen, carbonates, total alkalinity, orthophosphates, NPP, CR and TPP. While, negative relationship with depth of visibility, pH, electrical conductivity, total dissolved solids, bicarbonates, nitrate-nitrogen and TZP. Mishra *et al.* (2012) and Sharma *et al.* (2011) also found positive relationship with dissolved oxygen and orthophosphates. The significantly positive relationship of GPP with temperature and nitrate-nitrogen is also supported by Paulose and Maheshwari (2007) while conducting a comparative study of Jal Mahal and Ramgarh lake of Jaipur. Further, in contrast to the present study the GPP has

established a negative correlation with orthophosphates as reported by Rajkumar (2005) shows effective use of phosphorus in primary production. However, this rationality is noticed with negative relationship of GPP with nitrate-nitrogen in the present study.

The Net primary productivity (NPP) in the present study is found between 0.20 to 0.27 g C m³ h⁻¹ with an average value of 0.24 g C m³ h⁻¹. Rajkumar (2005) found an average NPP of 0.31 g C m³ h⁻¹ in the surface waters of Daya reservoir.

The statistical relationship of NPP was found positive with air and water temperature, dissolved oxygen, free CO₂, GPP and TPP. While, negative relationship with depth of visibility, pH, electrical conductivity, total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, CR and TZP.

The average CR found in the present study 0.12 to 0.17 g C m³ h⁻¹ is also comparable with that of Goverdhan Sagar 0.17 g C m³ h⁻¹ Mishra *et al.* (2016) and Daya reservoir 0.14 g C m³ h⁻¹ as reported by Rajkumar (2005). The statistical relationship of CR was found positive with depth of visibility, electrical conductivity, dissolved oxygen, free CO₂, total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, GPP and TZP. However, negative correlation with air and water temperature, pH, NPP and TPP.

LAKE PLANKTON:

Plankton in inland water bodies holds a key position in the energy transformation in a water body by maintaining trophic level, food chains and energy flow. As producers and consumers they play an important role in the transformation of energy from one trophic level to the higher trophic levels and ultimately leading to fish production which is the final product of an aquatic environment. Phytoplankton of freshwater habitat as green algae, blue green algae, diatoms, desmids etc. are important among aquatic flora. They are ecologically significant as they form the primary link in food chain for all aquatic animals (Misra *et al.*, 2001). During the present investigation, 36 genera of phytoplankton were noticed in lake Pichhola (Table-4.26). Out of which 12 were from Cyanophyceae (33.33%), 9 from Bacillariophyceae (25.00%), 12 from Chlorophyceae (33.33%) and 3 belongs to Desmidiaceae (8.33%). However, Rao and Durve (1987) have reported 52 genera out of which 25 belong to Chlorophyceae, 12 from Bacillariophyceae, 2 from

Euglenophyceae, 1 from Xanthophyceae and 12 from Myxophyceae in Jaisamand reservoir. Jain (1978) reported 35 genera of phytoplankton in Goverdhan Sagar. Mishra *et al.* (2016) found 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 significant decline in the biodiversity of phytoplankton.

Willen (1990), Yusuff and Patimah (1994) considered eutrophic lakes on the basis of blue-green algae. Sharma *et al.* (2011) 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 lake Pichhola. As evident from her 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. Baghela (2006) observed the dominance of Chlorophyceae in Oligotrophic Lake Jawai Dam.

The observed scenario of phytoplankton dominance at four stations studied in lake Pichhola is as under:

Station A: Chlorophyceae > Cyanophyceae > Bacillariophyceae > Desmidiaceae.

Station B: Cyanophyceae > Chlorophyceae > Bacillariophyceae > Desmidiaceae.

Station C&D: Cyanophyceae > Bacillariophyceae > Chlorophyceae > Desmidiaceae.

From this point of view, lake Pichhola with dominance of Cyanophyceae and Chlorophyceae in the present study may be assigned moderately eutrophic status of the lake on the basis of observed planktonic densities. However, at these stations 22 pollution indicating algal genera were observed for which the pollution tolerance in decreasing order has been depicted in Table 4.47 with *Oscillatoria* at the top and *Cosmarium* sp. at the bottom.

The statistical correlation of phytoplankton was found positive with air and water temperature, pH, electrical conductivity, free CO₂, total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, GPP,

NPP, TZP and TPP. However, there was a negative relationship with depth of visibility, dissolved oxygen and CR.

Palmer (1969) has published a composite rating of algae tolerant of organic pollution, assembled from the 165 authors and developed a pollution-tolerant algal index. One of his lists includes 60 most pollution-tolerant algal genera. Among these, 22 algal genera were found in lake Pichhola (Table 4.47). The phytoplankton are listed by species in this Table, the number after the species listed for a genus indicates the placement of the genus in Palmer's list. The lowest numbers are for the most pollution-tolerant genera. Palmer also published 5 tables that list the most pollution-tolerant species of 5 genera: *Euglena*, *Oscillatoria*, *Nitzschia*, *Scenedesmus*, and *Navicula*. The flora of lake Pichhola contains 3 genera out of these 5. In the same report, Palmer constructs algal pollution indices which he developed for use in rating water samples for high or low organic pollution. Two indices are given, one for algal genera and the other for species. Palmer assigned each genus or species a pollution index value from 1 to 6. This value is determined by the relative number of total points credited to the listed algae based upon their points. A score greater than 20 for a water sample signifies high organic pollution, while a score of 15-19 suggests probable evidence of high organic pollution. Values less than 15 indicate low organic pollution. The values from the application of Palmer's pollution index to the planktonic algae of these were obtained from the data for all four stations selected in Pichhola.

In the present study the Palmer's algal genus index (Palmer, 1969) as calculated for the algal genera and depicted in Table 4.48 shows that the Palmer's score at station **A** and **B** was 16 each. Whereas, at station **C** and **D** the score was 24. This indicates probable evidence of organic pollution at station **A** and **B**. Whereas, the higher scores at station **C** and **D** confirms high organic pollution at these stations.

Staker *et al.* (1974) collected Phytoplankton samples and calculated Palmer's pollution-tolerant algae indices. These indices suggested eutrophic conditions in Lake Mead. Somani and Pejaver (2007) evaluated the pollution in the lake Masunda in Thane (Maharashtra) and found presence of 11 pollution tolerant genera using Palmer's algal genus index. Bordoloi and Baruah (2014) assessed phytoplankton in a historical pond of Tinsusukia district (Assam) for water quality and the pollution

tolerant phytoplankton genera. A total of 12 Palmer's genera were been reported from the pond having Palmer's score of 28.

The pollution index value as well as the water quality parameters along with the presence of some algal indicators indicated highly organically polluted status of the pond and recommended management interventions. Kotadia and Mulia (2014) studied phytoplankton diversity and investigated Palmer pollution index for Ghuma Lake in rural area of Ahmedabad (Gujarat) and found 20 algal genus including 7 pollution indicators genus.

Odum's diversity index is another mathematical tool which helps in analyzing the constituent diversity of algal species and monitoring water quality. It is considered an excellent index to determine the level of pollution in both flowing and standing water bodies (Odum, 1960). Lower values of Odum's index revealed higher pollution with low species diversity, whereas, higher values of Odum's index indicates more species diversity and lower pollution level in an aquatic ecosystem.

The Odum's species index as shown in the Table 4.45 indicates greater species diversity at station **A** (136.39) followed by (128.69) at station **B**, 116.53 at station **D** and lowest at station **C** i.e. 100.17. This index also indicate the pollution level at different stations which can be ascertained that at station **C**, the pollution level was maximum followed by station **D** then station **B** and minimum at station **A**.

Somani and Pejaver (2007) evaluate the pollution status in the lake Masunda in Thane (Maharashtra) using Odum's index and found variations of species. Except for two months the author's found that the lake always exhibited lower values of this index, (0.03-0.438) indicating higher pollution status.

Malhotra *et al.*, (2014) studied phytoplankton diversity of western Yamuna canal and River Yamuna in Yamunanagar, Haryana, India. Odum's diversity index used for analyzing the constituent diversity of algal species and monitoring the water quality. Sixteen taxa from western Yamuna canal and thirty five taxa from River Yamuna have been observed belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae and Dinophyceae. The abundance, distribution, total population, group percentage and species diversity were studied and correlated with pollution indicating water quality characteristics. Species diversity values indicated a decrease from pre effluent point to effluent discharge channel and post effluent discharge point.

Maximum value of Odum's species diversity index was observed for *Cladophora* sp. at western Yamuna canal and at River Yamuna indicating them as less polluted.

Zooplankton invariably forms an integral component of freshwater communities and contributes significantly to secondary productivity. These fish-food organisms have been studied from various inland ecosystems of this country but information on their ecology in the Indian floodplain lakes in particular is yet limited (Sharma and Sharma, 2008).

The observed scenario of zooplankton was as already given in Chapter 4. The minute variation in the zooplankton may be associated with prevailing water quality conditions of this lake.

Among the zooplankton, total 32 species belonging to four major groups *i.e.* Rotifera, Cladocera, Copepoda and Protozoa, were recorded during study period in lake Pichhola (Table-4.26). Out of these 32 genera, 11 were from Rotifera (34.37%), 9 from Cladocera (28.12%), 7 from Copepoda (21.87%) and 5 belonged to Protozoa (15.62%). Sharma *et al.*, (2011) found the diverse taxonomic groups of zooplankton in lake Pichhola out of which 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 Copepods are enlisted. Besides these, 5 species of Ostracods were also recorded. 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. Sharma *et al.*, (2012) reported different groups of zooplankton in Bada Madar Tank, Udaipur out of which 10 species of Protozoans belonging to 9 genera and 31 species of Rotifers belonging to 14 genera were reported to represent these Phyla among Zooplankton. Along with these 17 species of Cladocerans belonging to 10 genera, 6 species of 3 genera belonging to Copepods and 2 forms of Ostracods were also enlisted. After including occasional zooplankters like insects and their larvae, crustacean larvae, spiders and mites (2) total 68 forms of zooplanktons were recorded. Balai *et al.* (2014) was observed various zooplanktonic fauna in Jaisamand lake, Udaipur comprised mainly protozoans, rotifers, cladocerans, ostracods and copepods. All these groups were represented by 51 species in which Rotifera 17, Cladocera 18, protozoa 7, Ostracoda 5 and Copepoda 4 species. The pooled data showed that zooplankton community was

contributed primarily by Rotifera (51.44%) > Cladocera (45.48%) > Copepoda (5.17%) > Protozoa (4.58%) > Ostracoda (2.02%) in order of dominance in Jaisamand lake.

The Odum's diversity index as such do not match the trends shown by phytoplankton for the obvious reason that zooplanktons are motile to a limited extent move horizontally as well as vertically.

Mukherjee (2011) had done a statistical psychiatry of the biodiversity of zooplankton population and their seasonal fluctuation in the Gangasagar pond, Jabalpur and found the miscellany of zooplankton in correlation with the physico-chemical as well as the biological environment of the fish pond. Species diversity of zooplanktons was calculated as per the formula given by Shannon and Wiener (1949) & Odum (1971).

The observed scenario of zooplankton dominance at four stations studied in lake Pichhola is as under:

Station A: Copepoda > Rotifera > Cladocera > Protozoa.

Station B & D: Rotifera > Cladocera > Copepoda > Protozoa.

Station C: Cladocera > Rotifera > Copepoda > Protozoa.

The statistical correlation of zooplankton was found positive with air temperature, depth of visibility, pH, electrical conductivity, total dissolved solids, carbonates, bicarbonates, total alkalinity, orthophosphates, nitrate-nitrogen, CR and TPP. However, there was a negative relationship with dissolved oxygen, free CO₂, GPP and NPP.

ASSESSMENT OF YIELD POTENTIAL:

Several methods are in vogue to assess the fishery potential of small reservoirs by deriving equations based on area, depth, catchment area and the chemical parameters of soil and water. Later, morpho-edaphic index (MEI) was evolved in an attempt to combine the morphometric as well as chemical parameters (Sugunan, 1997). Relationships between MEI and catch were based on the assumed characteristics for some sets of reservoirs possessing a certain number of limnological conditions, *i.e.* (i) that the ionic composition is dominated by the carbonate-

bicarbonate system, (ii) that the water body is not dystrophic, (iii) that the volume does not fluctuate noticeably and (iii) that the temperature regime is similar.

From the above discussion it would be obvious that fish production (secondary production) in natural and tended waters should be related to primary production of water bodies concerned. As indicated, already several attempts have been made to correlate these fish yield with primary productivity.

The dissolved solids measurable as conductivity of the water concerned have also been well correlated with the production of fish (fish yield-FY). The Morpho-Edaphic Index (MEI) referred to above (the productivity of the water bodies is directly correlated with conductivity and inversely correlated with depth of the water body), has been found to be correlating well with fish yield in African lakes (Henderson and Wellcome, 1974; Melack, 1976). Melack compared fish yields of 8 African lakes with corresponding fish production (P_G) and obtained a relation:

$$\text{Log. FY} = 0.113 P_G + 0.91; r = 0.57$$

where, FY = fish yield in $\text{kg ha}^{-1}/\text{yr}^{-1}$

P_G = Gross photosynthesis in $\text{g O}_2 \text{ m}^{-2} \text{ D}^{-1}$

He found even a better correlation between FY and P_G for a group of tropical lakes in Madras, India.

$$\text{FY} = 0.122 P_G + 0.95; r = 0.82.$$

It would appear that this relationship could be more obvious when production of lakes stocked with herbivores fishes are considered, as in the case of Madras lakes (Srinivasan, 1972). The MEI was poorly correlated ($r = 0.004$) for African lakes, but the correlation was better for the Madras lakes:

$$\text{FY} = 4.1 (k/z)^{0.80}; r = 0.60$$

where 'k' is conductivity and 'z' is depth

However, in the present study the correlation regression calculated between the present fish production of lake Pichhola (y) kg.m^{-1} and the gross oxygen produced (GOP) $\text{g O}_2 \text{ m}^3 \text{ h}^{-1}$ can be explained as:

$$\text{Fish production (y)} = 20533 \text{ GOP} - 14975; r = 0.664 \text{ (Fig.4.9)}$$

Whereas, the relationship between the fish production in lake Pichhola and gross primary productivity (GPP) during the study period can be explained as

$$\text{Fish production (y)} = 65771 \text{ GPP} - 1562; r = 0.636 \text{ (Fig.4.9)}$$

Fish yields in fish ponds have also been correlated with primary productivity in manured fish ponds in Israel by Noreiga-Curtis (1979). In manured ponds, where polyculture, was done he found an efficiency of conversion (FY/G_G) of 4.2 -5.9, while compared to the value of 1.5 for monoculture (carp only) ponds (Hepher, 1962). But in all cases the observed fish yields were higher than those theoretically expected from plankton crop.

Boyd (1979) correlated P_G with fish yield (FY) (*Tilapia aurea*) in ponds at Anbury, Alabama, and fitted a P_G equation to the data namely:

$$Y = 0.166.64 + 354.60x - 18.06 x^2, r = 0.89$$

Where, Y = fish production in kg/ha and x = P_G in g C/m²/day

Boyd (1979) also tested fish for FY with these other parameters, namely Phytoplankton counts, Secchi disc and Chlorophyll 'a' concentration and found the best fit, again indicating a curvilinear relation, for FY and chlorophyll, indicating an 'r' value of 0.94. A comprehensive study of secondary production is also given by Morgan *et al.* (1980). Potential yield of herbivorous fish especially plankton eating fish such as tilapias, has been estimated for water bodies from the values of primary production (P_G), assuming an efficiency of conversion in tilapia to be 10% (Beveridge, 1984). Such estimations would be of value in predicting yields in aquaculture.

The morpho-edaphic index given by Welcomme (1972) is:

$$\text{MEI} = \frac{\text{Specific conductivity } (\mu \text{ mhos/cm})}{\text{Mean depth (m)}}$$

For African lakes (Henderson and Welcomme, 1974) calculated fish yield potential using following formulae where, MEI was: $c = 14.3136 \text{ MEI}^{0.4681}$.

Asian reservoirs are known to have a lower yield potential than their African counterparts. However, Henderson and Welcomme (1974) expressed that till an Indian formula is derived, this formula can be applied to obtain a rough indication of

the productivity of any reservoir within the limits of between one half to twice the estimate. Such equations are sufficiently precise to give an idea of the scale of investment whether in research or developmental infrastructure is appropriate to any water body. More precision can be achieved after separate equations have been derived for different classes of reservoirs. Based on these assumptions the MEI for lake Pichhola is $0.45 \times 1000/3 \text{ m} = 150$.

When this value of MEI is put into the formula C (Potential fish yield Kg /ha/yr) = $14.3136 \times 150^{0.4681}$

i.e. 14.3136×10.438

= $149.41 \text{ kg/yr.} \times 696 \text{ ha}$ (Area of lake Pichhola)

= $103,988 \text{ kg/yr.}$ or 8665.73 kg/month

Based on scientific management practices applied for small reservoirs by Ayyappan *et al.* (2006) the fish productivity of different waters without scientific management was estimated to 03 to 35 kg/ha/year. This production could be raised to 70 to 275 kg/ha/year with scientific management practices applied for small reservoirs. Considering the morphometric features of lake Pichhola (696 ha.) this water body should give total annual fish production of 1,91,400 kg. @ 275 kg/ha/year.

The present production of entire lake Pichhola as reported by fisheries department and contractor is about 109320 kg/yr. *i.e.* 9110 kg/month. However, the potential fish production calculated on the basis of (Odum, 1971) using GPP ($0.39 \text{ g C m}^{-3} \text{ h}^{-1}$) is 1,83552.63 kg/yr. or 1,5296.05 kg/month. This can be calculated by multiplying Odum's conversion factor that is 1.2% of [GPP (0.392) x average Sunshine hrs (8.00) x days (365) x area (696) x Euphotic zone (1.92m) x 10000 (m per ha)/1000 (to convert in kg)]. Thus, the present annual fish production of lake Pichhola nearby touches the maximum production from small reservoirs as stated by Ayyappan *et al.* (2006).

However, the Odum's conversion does not take into account the macrophyte production. In view of this it is suggested that for weed infested wetlands more reliable method for fish production estimation should be worked out in future researches.

Comparing the present fish production of lake Pichhola with the potential fish yield there is a gap of 40.45 per cent as per the Odum's (1971) estimate.

However, compared to the estimates of Welcomme (1972) using MEI the present fish production of lake Pichhola *i.e.* 109320 kg/yr. is comparable to the estimated potential yield of 113254 kg /yr. which is showing a gap of only 3.47 per cent.

Considering this from fish production point of view lake Pichhola is highly productive. During the present investigation 34 fish species belonging to 11 family were reported in lake Pichhola. Major carps and exotic carps were the dominant fish species. Whereas, minor carps and cat fishes were also present but recessive (Table 4.49).

CONCLUSION:

From the present limnological study of lake Pichhola it can be concluded that:

- The lake Pichhola is a perennial water body of historic importance and a highly productive reservoir with an average estimated water depth of 3 m and having a maximum water spread area of 696 ha during the study period *i.e.* March 2014 to March 2015.
- The physico-chemical parameters of lake Pichhola were fairly moderate. The average water quality parameters of the lake during the study period were: air temperature-28.30°C, water temperature-25.07°C, Depth of visibility-85.56 cm., pH-7.68, EC-0.45 mS/cm⁻¹, dissolved oxygen-5.95 mg l⁻¹, free CO₂-17.08 mg l⁻¹, Total dissolved solids-296.83 mg l⁻¹, carbonates-33.74 mg l⁻¹, bicarbonates-136.67 mg l⁻¹, total alkalinity-156.13 mg l⁻¹, orthophosphates-0.14 mg l⁻¹, nitrate-nitrogen-0.60 mg l⁻¹, GPP-0.39 g C m³ h⁻¹, NPP-0.24 g C m³ h⁻¹ and CR-0.15 g C m³ h⁻¹. On the basis of relatively moderate levels of nutrients in the lake Pichhola can be considered in the category of moderately eutrophic nature of water.
- Air and water temperature were found to have a highly significant positive relationship with total phytoplankton.

- The visibility points out relatively moderate levels of nutrients in the lake Pichhola and thus can be acclaimed in the category “Moderately eutrophic nature of water”
- The pH of lake Pichhola was found to be slightly alkaline which is suitable for supporting fairly good aquatic productivity.
- The peak values of higher dissolved oxygen in winter as found in lake Pichhola have shown a positive relationship with lake productivity is justified by high solubility of oxygen at low temperature and indicates slower degradation of organic matter.
- Free CO₂ was absent at station **A** throughout the study period. The presence of free CO₂ at station **C** in lake Pichhola was attributed to the flush of nutrient rich organic matter through urban sewage.
- Higher concentration of TDS at stations **C** and **D** in lake Pichhola indicates discharge of urban sewage and organic matter by human interference.
- Bicarbonate alkalinity formed a major source of carbon for the production of aquatic flora in lake Pichhola particularly for the phytoplankton in the absence of free CO₂.
- The fairly good values of total alkalinity indicate nutrient rich conditions adjudged the Pichhola lake water to be considered productive in nature and suitable for fish culture.
- Inorganic phosphate obtained in the present study indicates rapid use of this nutrient owing to the utilization by primary producers to utilize phosphorus efficiently.
- Relatively higher value of nitrate during summers at station **C** is attributed due to its principal allochthonous source *i.e.* addition of urban sewage and human influence.
- The higher primary productivity during the pre-summer and late monsoon months found in the present study may be accredited to high concentration of available nutrients, high temperature and higher rate of photosynthesis.

- The GPP has established a negative correlation with orthophosphates showing effective use of phosphorus through primary production.
- During the present investigation, 36 genera of phytoplankton were noticed in lake Pichhola out of which 12 genera represented Cyanophyceae (33.33%), 9 to Bacillariophyceae (25.00%), 12 to Chlorophyceae (33.33%) and 3 genera belongs to Desmidiaceae (8.33%).
- The observed scenario of phytoplankton dominance at four stations of lake Pichhola was as under:

Station A: Chlorophyceae > Cyanophyceae > Bacillariophyceae > Desmidiaceae.

Station B: Cyanophyceae > Chlorophyceae > Bacillariophyceae > Desmidiaceae.

Station C&D: Cyanophyceae > Bacillariophyceae > Chlorophyceae > Desmidiaceae.

- From this point of view, lake Pichhola with dominance of Cyanophyceae and Chlorophyceae may be assigned moderately eutrophic status of the lake with 22 pollution indicating algal genera.
- In the present study the Palmer's algal genus index at station A and B was 16 each. Whereas, at station C and D the score was 24. This indicates probable evidence of low organic pollution at station A and B. Whereas, the higher scores at station C and D confirms high organic pollution at these stations.
- The Odum's diversity index indicates greater species diversity at station A (136.39) followed by (128.69) at station B, 116.53 at station D and lowest at station C *i.e.* 100.17. This index also indicate the pollution level at different stations in the order from maximum to minimum is **C > D > B > A**.
- Among the zooplankton, total 32 genera belonging to four major groups *i.e.* Rotifera, Cladocera, Copepoda, and Protozoa, were recorded. Out of these, 11 genera were from Rotifera (34.37%), 9 from Cladocera (28.12%), 7 from Copepoda (21.87%) and 5 belonged to Protozoa (15.62%). Zooplankton indicate following order from maximum to minimum is **B > D > C > A**.

- The observed scenario of zooplankton dominance at four stations studied in lake Pichhola is as under:

Station A: Copepoda > Rotifera > Cladocera > Protozoa.

Station B & D: Rotifera > Cladocera > Copepoda > Protozoa.

Station C: Cladocera > Rotifera > Copepoda > Protozoa.

- The MEI for lake Pichhola is $14.3136 \times 150\Lambda^{0.4681}$ summing up to a potential fish yield of 103988 Kg/yr. or 8665.73 kg/month.
- The potential fish production as calculated on the basis of (Odum, 1971) using GPP ($0.39 \text{ g C m}^3 \text{ h}^{-1}$) is 183552.63 kg/yr. or 15296.05 kg/month.
- Comparing the present fish production of lake Pichhola and the potential fish yield there is a gap of 40.45 per cent as per the Odum's (1971) estimate and a gap of 3.47 per cent as per the MEI estimate (Welcomme, 1972).
- During the present investigation 34 fish species belonging to 11 family were reported in lake Pichhola.

From the above discussion it is clear that on the basis of water quality parameters, observations on productivity and lake plankton it is appropriate to place this water body somewhere between “mild eutrophic-to-eutrophic water”. Indeed, much of the available nutrient resources are gainfully utilized by the primary producers and thus this is the good example of effective channelization of nutrients into higher producers *i.e.* fish production. In view of this it is appropriate to further channelize this energy trapped in the form of primary producers (macrophytes and phytoplankton) and available secondary producers *i.e.* zooplankton for the production of suitable fish species.

SUGGESTIONS:

The study also suggest appropriate measures for management of such an important aquatic environment by reducing anthropogenic pressure, checking of urban sewage, intrusion and culture of suitable fish species for converting the available primary productivity and nutrients into a valuable fish crop.

To fulfill the considerable gap in fish production suitable measures for the development of aquaculture practices such as selection of fast growing planktophagus

fishes such as Grass carp feeding on aquatic macrophytes should be increased. Likewise, modified aquaculture techniques such as cage culture and strict regulation on gear selectivity and observation of closed season should be followed to promote auto stocking in the lake to maintain its serene beauty by biocontrolling the algae and macrophytes.

6. SUMMARY

The current research work was conducted to find out the production potential of lake Pichhola, a highly productive water body of Udaipur in Southern Rajasthan. The study aims for the assessment of its phytoplankton and zooplankton productivity. Attempt has also been made to assess the current water quality status of lake Pichhola and to establish its relation with biotic resources to suggest proper management practices for getting the optimum fish production.

The first chapter of the thesis gives details of the introduction and genesis of the research work. The second chapter of the thesis illustrates the reviews of the research conducted earlier on the different waters. This chapter also includes the results and major findings of some limnological studies conducted in Udaipur district. The third chapter gives the materials and methodology followed in carrying the present research work. The location map of lake Pichhola along with the location of four sampling stations mentioned as stations **A**, **B**, **C** and **D** and morphometric features are also depicted in this chapter.

The results of the present study are depicted in Tables 4.1 to 4.49, Fig.3.1 to 3.2 and Figs. 4.1 to 4.9 regarding water quality, phytoplankton, zooplankton and primary productivity.

The morphometric features of the lake Pichhola indicates that it is a moderately shallow lake with a maximum depth of 8.5 meter (28 ft.) which is located at central western part of the lake. The lake is spread in an area of 696 ha. Some amount of urban waste and urban sewage were also found to be drained in the lake on the North-west and North-Eastern part of the lake where station **C** and **D** are located.

Physico-chemical parameters of lake Pichhola were found to be congenial throughout the study period. The overall average water quality parameters of the lake during the study period were: air temperature-28.30°C, water temperature-25.07°C, Depth of visibility-85.56 cm., pH-7.68, EC-0.45 mS cm⁻¹, dissolved oxygen-5.95 mg l⁻¹, free CO₂-17.08 mg l⁻¹, Total dissolved solids-296.83 mg l⁻¹, carbonates-33.74 mg l⁻¹, bicarbonates-136.67 mg l⁻¹, total alkalinity-156.13 mg l⁻¹, orthophosphates-0.14 mg l⁻¹, nitrate-nitrogen-0.60 mg l⁻¹, GPP-0.39 g C m³ h⁻¹, NPP-0.24 g C m³ h⁻¹, CR-0.15 g C m³ h⁻¹. Average water quality parameters indicate that this lake has relatively moderate level of nutrients with addition of certain urban wastes, thus coming under a category of “mild eutrophic to eutrophic water”.

The GPP (Average 0.39 g C/m³/ha) indicated positive relationship with air and water temperature, free CO₂, dissolved oxygen, carbonates, total alkalinity, orthophosphates, NPP, CR and TPP.

The biological analysis of lake Pichhola indicated availability of phytoplankton comprising 36 genera of the classes based on their dominance at four stations as under:

Station A: Chlorophyceae > Cyanophyceae > Bacillariophyceae > Desmidiaceae.

Station B: Cyanophyceae > Chlorophyceae > Bacillariophyceae > Desmidiaceae.

Station C&D: Cyanophyceae > Bacillariophyceae > Chlorophyceae > Desmidiaceae.

According to Palmer Index 22 pollution indicating algal genera were observed in lake Pichhola. The Palmer's algal genus index at station **A** and **B** was 16 each. Whereas, at station **C** and **D** the score was 24. This indicates probable evidence of low organic pollution at station **A** and **B**. Whereas, the higher scores at station **C** and **D** confirms high organic pollution at these stations.

The Odum's species index indicate greater species diversity at station **A** (136.39) followed by (128.69) at station **B**, 116.53 at station **D** and lowest at station **C** i.e. 100.17. This index also indicate the pollution level at different stations in the order from maximum to minimum is **C > D > B > A**.

The observed scenario of zooplankton dominance at four stations studied in lake Pichhola is as under: 32 genera

Station A: Copepoda > Rotifera > Cladocera > Protozoa.

Station B& D: Rotifera > Cladocera > Copepoda > Protozoa.

Station C: Cladocera > Rotifera > Copepoda > Protozoa.

According to Odum's species index zooplankton indicates following order from maximum to minimum is **B > D > C > A**.

The MEI for lake Pichhola is $14.3136 \times 150\Lambda^{0.4681}$ summing upto a potential fish yield of 1,03988 kg/yr or 8665.73 kg/month.

The potential fish production as calculated on the basis of Odum (1971) using GPP (0.39 g C m³ h⁻¹) is 1,83552.63 kg/yr or 1,5296.05 kg/month.

Comparing the present fish production of lake Pichhola and the potential fish yield there is a gap of 40.45 per cent as per the Odum's (1971) estimate and a gap of 3.47 per cent as per the MEI estimate (Welcomme, 1972). The present fish production is fairly satisfactory as stated for small reservoirs by Ayyappan *et al.* (2006).

During the present investigation 34 fish species belonging to 11 family were reported in lake Pichhola.

From the above discussion it is clear that on the basis of water quality parameters, observations on productivity and lake plankton it is appropriate to place this water body somewhere between "mild eutrophic-to-eutrophic water". Indeed, much of the available nutrient resources are gainfully utilized by the primary producers and thus this is the good example of effective channelization of nutrients into secondary and tertiary producers *i.e.* zooplankton and fish production. In view of this, it is appropriate to further channelize this energy trapped in the form of primary producers (macrophytes and phytoplankton) and available secondary producers *i.e.* zooplankton for the production of suitable fish species.

The study also suggest appropriate measures for management of such an important aquatic environment by reducing anthropogenic pressure, checking of urban sewage, intrusion and culture of suitable fish species for converting the available primary productivity and nutrients into a valuable fish crop.

vcvc **Table 4.1: Physico-chemical characteristics and Primary productivity at station A of lake Pichhola, Udaipur**

Parameters	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max	SD
Air temperature $^{\circ}\text{C}$	25.30	28.20	35.60	37.00	32.50	30.30	28.00	27.20	24.00	22.00	22.30	24.00	28.03	22.00	37.00	4.98
Water temperature $^{\circ}\text{C}$	24.10	27.60	28.20	29.00	28.60	27.50	24.50	24.40	22.70	22.40	22.50	23.00	25.38	22.40	29.00	2.60
Depth of visibility (cm)	93.00	92.00	85.00	84.00	78.00	75.00	80.00	86.00	88.00	90.50	105.00	98.00	87.88	75.00	105.00	8.52
pH	7.90	8.10	8.10	8.20	7.60	7.50	7.20	7.30	7.40	7.40	7.60	7.70	7.67	7.20	8.20	0.34
EC (mS cm^{-1})	0.44	0.45	0.47	0.46	0.37	0.35	0.36	0.39	0.41	0.42	0.43	0.44	0.42	0.35	0.47	0.04
Dissolved oxygen (mg l^{-1})	5.80	5.70	5.60	5.40	5.80	6.00	6.40	6.80	6.60	6.20	5.80	5.90	6.00	5.40	6.80	0.42
Free CO_2 (mg l^{-1})	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total dissolved Solid (mg l^{-1})	293.30	300.40	311.80	306.20	249.00	235.50	240.20	260.20	273.40	279.40	286.00	293.10	277.38	235.50	311.80	25.90
Carbonates (mg l^{-1})	29.00	35.00	38.00	32.00	23.00	19.00	24.00	25.00	28.00	26.00	32.00	32.00	28.58	19.00	38.00	5.47
Bicarbonates (mg l^{-1})	138.00	142.00	145.00	154.00	116.00	113.00	118.00	120.00	126.00	130.00	131.00	133.00	130.50	113.00	154.00	12.65
Total alkalinity (mg l^{-1})	167.00	177.00	183.00	186.00	139.00	132.00	142.00	145.00	154.00	156.00	163.00	165.00	159.08	132.00	186.00	17.56
Orthophosphates (mg l^{-1})	0.05	0.05	0.06	0.06	0.07	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.06	0.04	0.08	0.01
Nitrate-nitrogen (mg l^{-1})	0.56	0.58	0.56	0.61	0.38	0.40	0.48	0.52	0.56	0.58	0.56	0.58	0.53	0.38	0.61	0.07
Primary productivity ($\text{g C m}^{-3} \text{ h}^{-1}$)																
Gross primary productivity	0.37	0.35	0.34	0.31	0.30	0.31	0.38	0.41	0.44	0.42	0.42	0.40	0.37	0.30	0.44	0.05
Net primary productivity	0.22	0.21	0.21	0.20	0.18	0.18	0.24	0.26	0.26	0.25	0.26	0.24	0.23	0.18	0.26	0.03
Community respiration	0.15	0.14	0.13	0.11	0.12	0.13	0.14	0.15	0.18	0.17	0.16	0.16	0.15	0.11	0.18	0.02

Table 4.2: Physico-chemical characteristics and Primary productivity at station B of lake Pichhola, Udaipur

Parameters	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max	SD
Air temperature $^{\circ}\text{C}$	25.70	28.70	35.90	37.40	33.00	31.00	28.50	27.80	24.50	22.50	22.90	24.50	28.53	22.50	37.40	4.94
Water temperature $^{\circ}\text{C}$	23.50	27.00	28.20	28.60	27.80	26.80	24.30	24.10	21.80	20.80	20.20	21.50	24.55	20.20	28.60	3.05
Depth of visibility (cm)	85.00	87.00	88.00	90.00	77.00	76.00	81.50	87.00	89.00	92.00	97.00	91.50	86.75	76.00	97.00	6.13
pH	7.60	7.70	7.80	7.90	7.40	7.20	7.10	7.30	7.40	7.40	7.50	7.60	7.49	7.10	7.90	0.24
EC (mS cm^{-1})	0.39	0.40	0.42	0.41	0.35	0.34	0.35	0.37	0.39	0.41	0.42	0.42	0.39	0.34	0.42	0.03
Dissolved oxygen (mg l^{-1})	6.00	5.80	5.60	5.70	5.90	6.20	6.40	6.70	6.50	6.20	5.90	6.10	6.08	5.60	6.70	0.33
Free CO_2 (mg l^{-1})	-	-	-	-	16.00	-	-	-	14.00	-	-	13.00	14.33	13.00	16.00	1.53
Total dissolved solids (mg l^{-1})	259.30	266.10	279.40	272.70	233.50	228.80	233.40	178.20	246.70	273.60	279.40	280.30	252.62	178.20	280.30	30.37
Carbonates (mg l^{-1})	38.00	42.00	49.00	35.00	-	26.20	30.20	34.00	-	37.00	36.80	-	36.47	26.20	49.00	6.55
Bicarbonates (mg l^{-1})	140.00	160.00	167.00	137.00	130.00	131.00	134.00	135.00	136.00	138.00	138.00	142.00	140.67	130.00	167.00	11.29
Total alkalinity (mg l^{-1})	178.00	202.00	216.00	172.00	130.00	157.20	164.20	169.00	136.00	175.00	174.80	142.00	168.02	130.00	216.00	25.13
Orthophosphates (mg l^{-1})	0.04	0.05	0.05	0.06	0.08	0.09	0.08	0.08	0.07	0.05	0.05	0.04	0.06	0.04	0.09	0.02
Nitrate-nitrogen (mg l^{-1})	0.58	0.58	0.62	0.62	0.34	0.36	0.42	0.48	0.52	0.54	0.56	0.58	0.52	0.34	0.62	0.10
Primary productivity ($\text{g C m}^{-3} \text{ h}^{-1}$)																
Gross primary productivity	0.33	0.39	0.38	0.40	0.39	0.42	0.44	0.43	0.32	0.29	0.28	0.29	0.36	0.28	0.44	0.06
Net primary productivity	0.18	0.25	0.22	0.30	0.27	0.28	0.27	0.28	0.22	0.16	0.15	0.17	0.23	0.15	0.30	0.05
Community respiration	0.15	0.14	0.16	0.10	0.12	0.14	0.17	0.15	0.10	0.13	0.13	0.12	0.13	0.10	0.17	0.02

Table 4.3: Physico-chemical characteristics and Primary productivity at station C of lake Pichhola, Udaipur

Parameters	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max	SD
Air temperature $^{\circ}\text{C}$	26.00	28.90	35.50	37.80	33.10	30.20	28.70	27.50	24.50	22.30	21.60	23.60	28.31	21.60	37.80	5.16
Water temperature $^{\circ}\text{C}$	24.50	27.40	30.70	31.10	30.00	26.10	24.20	25.80	22.30	21.10	19.50	21.20	25.33	19.50	31.10	3.92
Depth of visibility (cm)	87.00	86.00	83.00	82.00	74.00	72.00	78.00	81.00	83.00	85.00	85.00	87.00	81.92	72.00	87.00	4.93
pH	7.86	7.90	8.30	8.50	7.60	7.65	7.70	7.70	7.65	7.75	7.70	7.80	7.84	7.60	8.50	0.28
EC (mS cm^{-1})	0.53	0.54	0.55	0.50	0.45	0.43	0.45	0.48	0.51	0.52	0.52	0.53	0.50	0.43	0.55	0.04
Dissolved oxygen (mg l^{-1})	5.40	5.20	5.00	4.80	5.70	5.90	6.20	6.40	6.40	6.00	5.70	5.80	5.71	4.80	6.40	0.52
Free CO_2 (mg l^{-1})	18.00	20.00	22.00	21.00	14.00	14.00	22.00	20.00	15.00	17.00	16.00	16.00	17.92	14.00	22.00	3.00
Total dissolved Solid (mg l^{-1})	353.10	359.70	366.50	335.00	299.00	286.00	300.00	319.50	350.00	346.30	346.00	353.00	334.51	286.00	366.50	26.78
Carbonates (mg l^{-1})	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonates (mg l^{-1})	134.00	138.00	146.00	148.00	124.00	120.00	136.00	138.00	142.00	146.00	138.00	136.00	137.17	120.00	148.00	8.42
Total alkalinity (mg l^{-1})	134.00	138.00	146.00	148.00	124.00	120.00	136.00	138.00	142.00	146.00	138.00	136.00	137.17	120.00	148.00	8.42
Orthophosphates (mg l^{-1})	0.29	0.29	0.30	0.31	0.16	0.18	0.20	0.24	0.26	0.26	0.28	0.28	0.25	0.16	0.31	0.05
Nitrate-nitrogen (mg l^{-1})	0.84	0.86	0.88	0.95	0.66	0.68	0.76	0.82	0.87	0.87	0.88	0.87	0.83	0.66	0.95	0.09
Primary productivity ($\text{g C m}^{-3} \text{ h}^{-1}$)																
Gross primary productivity	0.42	0.44	0.47	0.45	0.41	0.36	0.40	0.50	0.46	0.42	0.41	0.38	0.43	0.36	0.50	0.04
Net primary productivity	0.25	0.26	0.28	0.27	0.26	0.22	0.26	0.33	0.28	0.25	0.26	0.22	0.24	0.22	0.33	0.03
Community respiration	0.17	0.18	0.19	0.18	0.15	0.14	0.14	0.17	0.18	0.17	0.15	0.16	0.17	0.14	0.19	0.02

Table 4.4: Physico-chemical characteristics and Primary productivity at station D of lake Pichhola, Udaipur

Parameters	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max	SD
Air temperature $^{\circ}\text{C}$	25.90	28.70	35.90	37.40	33.00	31.00	28.50	27.80	24.20	23.10	21.30	22.70	28.29	21.30	37.40	5.23
Water temperature $^{\circ}\text{C}$	24.10	27.00	31.50	32.60	29.60	26.80	23.60	24.70	22.10	20.20	18.70	19.30	25.02	18.70	32.60	4.62
Depth of visibility (cm)	89.00	88.50	87.30	86.10	79.00	77.00	82.00	85.00	86.50	88.50	89.00	90.20	85.68	77.00	90.20	4.22
pH	7.76	7.84	8.10	8.30	7.40	7.45	7.50	7.55	7.50	7.65	7.95	7.60	7.72	7.40	8.30	0.28
EC (mS cm^{-1})	0.50	0.52	0.53	0.48	0.43	0.42	0.44	0.46	0.49	0.51	0.51	0.52	0.48	0.42	0.53	0.04
Dissolved oxygen (mg l^{-1})	5.80	5.60	5.40	5.20	6.00	6.10	6.40	6.60	6.70	6.30	6.00	6.10	6.02	5.20	6.70	0.46
Free CO_2 (mg l^{-1})	15.00	13.00	14.00	-	-	-	-	-	-	-	15.00	16.00	14.60	13.00	16.00	1.14
Total dissolved Solid (mg l^{-1})	334.00	347.40	354.10	319.60	287.10	280.20	293.60	306.00	326.20	339.90	339.20	346.30	322.80	280.20	354.10	25.35
Carbonates (mg l^{-1})	-	-	-	39.00	37.00	33.00	35.00	38.00	41.00	42.00	-	-	37.86	33.00	42.00	3.18
Bicarbonates (mg l^{-1})	137.00	141.00	144.00	138.00	135.00	131.00	134.00	137.00	142.00	144.00	138.00	139.00	138.33	131.00	144.00	3.96
Total alkalinity (mg l^{-1})	137.00	141.00	144.00	177.00	172.00	164.00	169.00	175.00	183.00	186.00	138.00	139.00	160.42	137.00	186.00	19.14
Orthophosphates (mg l^{-1})	0.21	0.19	0.21	0.22	0.11	0.13	0.15	0.17	0.18	0.19	0.19	0.20	0.18	0.11	0.22	0.03
Nitrate-nitrogen (mg l^{-1})	0.55	0.57	0.59	0.64	0.39	0.41	0.48	0.51	0.56	0.57	0.58	0.59	0.54	0.39	0.64	0.08
Primary productivity ($\text{g C m}^{-3} \text{ h}^{-1}$)																
Gross primary productivity	0.40	0.38	0.39	0.40	0.42	0.42	0.44	0.47	0.38	0.39	0.38	0.38	0.40	0.38	0.47	0.03
Net primary productivity	0.19	0.24	0.22	0.30	0.28	0.30	0.28	0.28	0.22	0.24	0.28	0.23	0.26	0.19	0.30	0.04
Community respiration	0.16	0.15	0.16	0.12	0.10	0.13	0.14	0.19	0.16	0.14	0.12	0.15	0.14	0.10	0.19	0.02

Table 4.5: Monthly average values of physico-chemical characteristics and primary productivity all four stations of lake Pichhola, Udaipur

Parameters	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max	SD
Air temperature $^{\circ}\text{C}$	25.73	28.63	35.73	37.40	32.90	30.63	28.43	27.58	24.30	22.48	22.03	23.70	28.30	22.03	37.40	5.07
Water temperature $^{\circ}\text{C}$	24.05	27.25	29.65	30.33	29.00	26.80	24.15	24.75	22.23	21.13	20.23	21.25	25.07	20.23	30.33	3.51
Depth of visibility (cm)	88.50	88.38	85.83	85.53	77.00	75.00	80.38	84.75	86.63	89.00	94.00	91.68	85.56	75.00	94.00	5.65
pH	7.78	7.89	8.08	8.23	7.50	7.45	7.38	7.46	7.49	7.55	7.69	7.68	7.68	7.38	8.23	0.27
EC (mS cm^{-1})	0.47	0.48	0.49	0.46	0.40	0.39	0.40	0.43	0.45	0.47	0.47	0.48	0.45	0.39	0.49	0.04
Dissolved oxygen (mg l^{-1})	5.75	5.58	5.40	5.28	5.85	6.05	6.35	6.63	6.55	6.18	5.85	5.98	5.95	5.28	6.63	0.43
Free CO_2 (mg l^{-1})	16.50	16.50	18.00	21.00	15.00	14.00	22.00	20.00	14.50	17.00	15.50	15.00	17.08	14.00	22.00	2.64
Total dissolved Solid (mg l^{-1})	309.93	318.40	327.95	308.38	267.15	257.63	266.80	265.98	299.08	309.80	312.65	318.18	296.83	257.63	327.95	25.03
Carbonates (mg l^{-1})	33.50	38.50	43.50	35.33	30.00	26.07	29.73	32.33	34.50	35.00	34.40	32.00	33.74	26.07	43.50	4.44
Bicarbonates (mg l^{-1})	137.25	145.25	150.50	144.25	126.25	123.75	130.50	132.50	136.50	139.50	136.25	137.50	136.67	123.75	150.50	7.76
Total alkalinity (mg l^{-1})	154.00	164.50	172.25	170.75	141.25	143.30	152.80	156.75	153.75	165.25	153.45	145.50	156.13	141.25	172.25	10.25
Orthophosphates (mg l^{-1})	0.15	0.15	0.16	0.16	0.11	0.12	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.11	0.16	0.01
Nitrate-nitrogen (mg l^{-1})	0.63	0.65	0.66	0.71	0.44	0.46	0.54	0.58	0.63	0.64	0.65	0.66	0.60	0.44	0.71	0.08
Primary productivity ($\text{g C m}^{-3} \text{ h}^{-1}$)																
Gross primary productivity	0.38	0.39	0.40	0.39	0.38	0.38	0.42	0.45	0.40	0.38	0.37	0.36	0.39	0.36	0.45	0.02
Net primary productivity	0.20	0.23	0.22	0.27	0.24	0.25	0.26	0.27	0.23	0.22	0.24	0.22	0.24	0.20	0.27	0.02
Community respiration	0.16	0.15	0.16	0.13	0.12	0.14	0.15	0.17	0.16	0.15	0.14	0.15	0.15	0.12	0.17	0.01

Table 4.6: Annual average values of physico-chemical characteristics and primary productivity at four stations of lake Pichhola, Udaipur

Parameters	Station A	Station B	Station C	Station D	Overall Avg.
Air temperature $^{\circ}\text{C}$	28.03	28.53	28.31	28.29	28.29
Water temperature $^{\circ}\text{C}$	25.38	24.55	25.33	25.02	25.07
Depth of visibility (cm)	87.88	86.75	81.92	85.68	85.56
pH	7.67	7.49	7.84	7.72	7.68
EC (mS cm^{-1})	0.42	0.39	0.50	0.48	0.45
Dissolved oxygen (mg l^{-1})	6.00	6.08	5.71	6.02	5.95
Free CO_2 (mg l^{-1})	-	14.33	17.92	14.60	15.62
Total dissolved Solid (mg l^{-1})	277.38	252.62	334.51	322.80	296.83
Carbonates (mg l^{-1})	28.58	36.47	-	37.86	34.30
Bicarbonates (mg l^{-1})	130.50	140.67	137.17	138.33	136.67
Total alkalinity (mg l^{-1})	159.08	168.02	137.17	160.42	156.17
Orthophosphates (mg l^{-1})	0.06	0.06	0.25	0.18	0.14
Nitrate-nitrogen (mg l^{-1})	0.53	0.52	0.83	0.54	0.61
Primary productivity ($\text{g C m}^{-3} \text{ h}^{-1}$)					
Gross primary productivity	0.37	0.36	0.43	0.40	0.39
Net primary productivity	0.23	0.23	0.24	0.26	0.24
Community respiration	0.15	0.13	0.17	0.14	0.15

Table 4.7 Statistical correlation matrix amongst physico-chemical, primary productivity and plankton of lake Pichhola, Udaipur

Parameters	Air temp.	Water temp.	DOV	pH	EC	DO	Free CO ₂	TDS	Carbo.	Bicarbo.	Total Alk.	Orthophos.	NO ₃ -N	GPP	NPP	CR	TPP	TZP
Air Temp.	1.000																	
Water temp.	0.970**	1.000																
DOV	-0.554*	-0.567*	1.000															
pH	0.534	0.514	0.365	1.000														
EC	-0.155	-0.152	0.861**	0.698**	1.000													
Dissolved oxygen	-0.577*	-0.589*	-0.146	-0.880**	-0.485	1.000												
Free CO ₂	0.379	0.278	-0.060	0.228	-0.039	-0.035	1.000											
TDS	-0.130	-0.130	0.815**	0.713**	0.980**	-0.564*	-0.106	1.000										
Carbonates	0.194	0.210	0.544*	0.716**	0.838**	-0.504	0.160	0.808**	1.000									
Bicarbonates	0.185	0.177	0.625*	0.820**	0.902**	-0.577*	0.244	0.883**	0.944**	1.000								
Total alkalinity	0.315	0.291	0.381	0.714**	0.640**	-0.444	0.521	0.599*	0.824**	0.868**	1.000							
Orthophosphates	0.091	0.038	0.668*	0.785**	0.816**	-0.443	0.305	0.770**	0.728**	0.861**	0.788**	1.000						
NO ₃ -N	-0.124	-0.173	0.841**	0.698**	0.910**	-0.372	0.228	0.870**	0.732**	0.874**	0.733**	0.943**	1.000					
GPP	0.152	0.142	-0.224	-0.232	-0.285	0.505	0.632*	-0.435	0.024	-0.065	0.218	0.024	-0.089	1.000				
NPP	0.376	0.312	-0.498	-0.201	-0.610*	0.264	0.510	-0.670*	-0.392	-0.384	-0.060	-0.232	-0.344	0.603*	1.000			
CR	-0.385	-0.349	0.417	-0.065	0.405	0.360	0.152	0.290	0.441	0.387	0.351	0.397	0.395	0.475	-0.328	1.000		
TPP	0.733**	0.707**	-0.237	0.478	0.037	-0.489	0.202	0.054	0.280	0.266	0.271	0.052	0.028	0.014	0.412	-0.523	1.000	
TZP	0.148	0.206	0.558*	0.700**	0.786**	-0.576*	-0.103	0.779**	0.777**	0.784**	0.562*	0.542*	0.652*	-0.261	-0.337	0.023	0.540	1.000

* Significant at 5%level of significance

* Significant at 1%level of significance

Table 4.8: Mean values of air temperature and their statistical significance

ST		Season		S×St	
St1	NS	S1	31.86	S1×St1	NS
St2	NS	S2	29.88	S2×St1	NS
St3	NS	S3	23.12	S3×St1	NS
St4	NS			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	NS		0.36		NS
C.D.(P=0.05)	NS		1.04		NS

Table 4.9: Mean values of water temperature and their statistical significance

ST		Season		S×St	
St1	NS	S1	31.86	S1×St1	NS
St2	NS	S2	29.88	S2×St1	NS
St3	NS	S3	23.12	S3×St1	NS
St4	NS			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	NS		0.32		NS
C.D.(P=0.05)	NS		0.92		NS

NS – Non Significant

S – Season

St. – Station

Table 4.10: Mean values of depth of visibility and their statistical significance

ST		Season		S×St	
St1	87.87	S1	87.06	S1×St1	NS
St2	86.75	S2	79.28	S2×St1	NS
St3	81.92	S3	90.33	S3×St1	NS
St4	85.68			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	1.31		1.14		NS
C.D.(P=0.05)	3.77		3.27		NS

Table 4.11: Mean values of pH and their statistical significance

ST		Season		S×St	
St1	NS	S1	7.99	S1×St1	NS
St2	NS	S2	7.45	S2×St1	NS
St3	NS	S3	7.60	S3×St1	NS
St4	NS			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	NS		0.10		NS
C.D.(P=0.05)	NS		0.28		NS

NS – Non Significant

S – Season

St. – Station

Table 4.12: Mean values of EC and their statistical significance

ST		Season		S×St	
St1	0.42	S1	0.47	S1×St1	NS
St2	0.39	S2	0.40	S2×St1	NS
St3	0.50	S3	0.47	S3×St1	NS
St4	0.48			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	0.006		0.005		NS
C.D.(P=0.05)	0.017		0.015		NS

Table 4.13: Mean values of dissolved oxygen and their statistical significance

ST		Season		S×St	
St1	6.00	S1	5.50	S1×St1	NS
St2	6.08	S2	6.22	S2×St1	NS
St3	5.71	S3	6.14	S3×St1	NS
St4	6.02			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	0.07		0.06		NS
C.D.(P=0.05)	0.22		0.19		NS

NS – Non Significant

S – Season

St. – Station

Table 4.14: Mean values of free CO₂ and their statistical significance

Station		Season		S×St	
St1	0.00	S1	7.69	S1×St1	0.00
St2	3.58	S2	5.38	S2×St1	0.00
St3	17.92	S3	7.63	S3×St1	0.00
St4	6.08			S1×St2	0.00
				S2×St2	4.00
				S3×St2	6.75
				S1×St3	20.25
				S2×St3	17.50
				S3×St3	16.00
				S1×St4	10.50
				S2×St4	0.00
				S3×St4	7.75
SEM±	0.12		0.10		0.21
C.D.(P=0.05)	0.34		0.30		0.60

Table 4.15: Mean values of TDS and their statistical significance

Station		Season		S×St	
St1	277.38	S1	316.16	S1×St1	NS
St2	252.62	S2	264.39	S2×St1	NS
St3	334.51	S3	309.93	S3×St1	NS
St4	322.80			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	3.903		3.38		NS
C.D.(P=0.05)	11.19		9.69		NS

NS – Non Significant

S – Season

St. – Station

Table 4.16: Mean values of carbonate alkalinity and their statistical significance

Station		Season		S×St	
St1	28.58	S1	21.06	S1×St1	33.50
St2	27.35	S2	20.28	S2×St1	22.75
St3	0.00	S3	17.18	S3×St1	29.50
St4	22.08			S1×St2	41.00
				S2×St2	22.60
				S3×St2	18.45
				S1×St3	0.00
				S2×St3	0.00
				S3×St3	0.00
				S1×St4	9.75
				S2×St4	35.75
				S3×St4	20.75
SEM±	0.31		0.27		0.54
C.D.(P=0.05)	0.90		0.78		1.56

Table 4.17: Mean values of bicarbonate alkalinity and their statistical significance

Station		Season		S×St	
St1	130.50	S1	144.31	S1×St1	144.75
St2	140.67	S2	128.25	S2×St1	116.75
St3	137.17	S3	137.44	S3×St1	130.00
St4	138.33			S1×St2	151.00
				S2×St2	132.50
				S3×St2	138.50
				S1×St3	141.50
				S2×St3	129.50
				S3×St3	140.50
				S1×St4	140.00
				S2×St4	134.25
				S3×St4	140.75
SEM±	1.78		1.54		3.09
C.D.(P=0.05)	5.12		4.44		8.88

NS – Non Significant

S – Season

St. – Station

Table 4.18: Mean values of total alkalinity and their statistical significance

Station		Season		S×St	
St1	159.08	S1	165.38	S1×St1	178.25
St2	168.02	S2	148.53	S2×St1	139.50
St3	137.17	S3	154.61	S3×St1	159.50
St4	160.42			S1×St2	192.00
				S2×St2	155.10
				S3×St2	156.95
				S1×St3	141.50
				S2×St3	129.50
				S3×St3	140.50
				S1×St4	149.75
				S2×St4	170.00
				S3×St4	161.50
SEM±	2.06		1.78		3.56
C.D.(P=0.05)	5.90		5.11		10.23

Table 4.19: Mean values of orthophosphates and their statistical significance

Station		Season		S×St	
St1	0.06	S1	0.15	S1×St1	0.06
St2	0.06	S2	0.12	S2×St1	0.07
St3	0.25	S3	0.14	S3×St1	0.05
St4	0.18			S1×St2	0.05
				S2×St2	0.08
				S3×St2	0.05
				S1×St3	0.29
				S2×St3	0.19
				S3×St3	0.27
				S1×St4	0.20
				S2×St4	0.14
				S3×St4	0.19
SEM±	0.002		0.002		0.003
C.D.(P=0.05)	0.006		0.005		0.010

NS – Non Significant

S – Season

St. – Station

Table 4.20: Mean values of Nitrate-Nitrogen and their statistical significance

Station		Season		S×St	
St1	0.53	S1	0.66	S1×St1	NS
St2	0.52	S2	0.51	S2×St1	NS
St3	0.83	S3	0.64	S3×St1	NS
St4	0.54			S1×St2	NS
				S2×St2	NS
				S3×St2	NS
				S1×St3	NS
				S2×St3	NS
				S3×St3	NS
				S1×St4	NS
				S2×St4	NS
				S3×St4	NS
SEM±	0.008		0.007		NS
C.D.(P=0.05)	0.023		0.020		NS

Table 4.21: Mean values of GPP and their statistical significance

Station		Season		S×St	
St1	0.37	S1	0.39	S1×St1	0.34
St2	0.36	S2	0.40	S2×St1	0.35
St3	0.43	S3	0.38	S3×St1	0.42
St4	0.40			S1×St2	0.37
				S2×St2	0.42
				S3×St2	0.29
				S1×St3	0.46
				S2×St3	0.41
				S3×St3	0.40
				S1×St4	0.39
				S2×St4	0.42
				S3×St4	0.39
SEM±	0.008		0.005		0.010
C.D.(P=0.05)	0.023		0.014		0.029

NS – Non Significant

S – Season

St. – Station

Table 4.22: Mean values of NPP and their statistical significance

Station		Season		S×St	
St1	0.23	S1	0.24	S1×St1	0.21
St2	0.23	S2	0.26	S2×St1	0.22
St3	0.26	S3	0.23	S3×St1	0.26
St4	0.26			S1×St2	0.24
				S2×St2	0.28
				S3×St2	0.17
				S1×St3	0.28
				S2×St3	0.26
				S3×St3	0.24
				S1×St4	0.23
				S2×St4	0.28
				S3×St4	0.24
SEM±	0.004		0.003		0.006
C.D.(P=0.05)	0.010		0.009		0.018

Table 4.23: Mean values of CR and their statistical significance

Station		Season		S×St	
St1	0.15	S1	0.15	S1×St1	0.13
St2	0.13	S2	0.14	S2×St1	0.14
St3	0.17	S3	0.15	S3×St1	0.17
St4	0.14			S1×St2	0.14
				S2×St2	0.15
				S3×St2	0.12
				S1×St3	0.18
				S2×St3	0.15
				S3×St3	0.17
				S1×St4	0.15
				S2×St4	0.14
				S3×St4	0.14
SEM±	0.002		0.002		0.004
C.D.(P=0.05)	0.006		0.005		0.011

NS – Non Significant

S – Season

St. – Station

Table 4.24: Mean values of total phytoplankton (TPP) and their statistical significance

Station		Season		S×St	
St1	NS	S1	175.13	S1×St1	171.75
St2	NS	S2	125.56	S2×St1	108.00
St3	NS	S3	135.56	S3×St1	147.75
St4	NS			S1×St2	186.75
				S2×St2	109.50
				S3×St2	144.50
				S1×St3	170.25
				S2×St3	146.75
				S3×St3	126.50
				S1×St4	171.75
				S2×St4	138.00
				S3×St4	123.50
SEM±	NS		1.90		3.805
C.D.(P=0.05)	NS		5.45		10.91

Table 4.25: Mean values of total zooplankton (TZP) and their statistical significance

Station		Season		S×St	
St1	33.50	S1	44.88	S1×St1	37.75
St2	37.50	S2	24.88	S2×St1	25.75
St3	38.58	S3	40.19	S3×St1	37.00
St4	37.00			S1×St2	47.50
				S2×St2	24.75
				S3×St2	40.25
				S1×St3	49.75
				S2×St3	25.25
				S3×St3	40.75
				S1×St4	44.50
				S2×St4	23.75
				S3×St4	42.75
SEM±	0.57		0.49		0.99
C.D.(P=0.05)	1.64		1.42		2.84

NS – Non Significant

S – Season

St. – Station

Table 4.26: Check list of plankton found in lake Pichhola, Udaipur

Phytoplankton	Zooplankton
CYANOPHYCEAE	ROTIFERA
<i>Anabaena</i>	<i>Filinia longiseta</i>
<i>Nostoc</i>	<i>Keratella</i> sp.
<i>Polycystis</i>	<i>Trichocera</i> sp.
<i>Oscillatoria</i>	<i>Testudinella</i> sp.
<i>Agmenellum</i>	<i>Hexarthra</i> sp.
<i>Coelospharium</i>	<i>Rotaria</i> sp.
<i>Microcystis</i>	<i>Polyarthra</i> sp.
<i>Merismopedia</i>	<i>Brachionus</i> sp.
<i>Spirulina</i>	<i>Monostyla</i> sp.
<i>Aphanocapsa</i>	<i>Platylas</i> sp.
<i>Synechocystis</i>	<i>Notholca</i> sp.
<i>Arthrospira</i>	
BACILLARIOPHYCEAE	CLADOCERA
<i>Synedra</i>	<i>Daphnia</i> sp.
<i>Nitzschia</i>	<i>Moina</i> sp.
<i>Fragilaria</i>	<i>Bosmina</i> sp.
<i>Navicula</i>	<i>Sida</i> sp.
<i>Diatoma</i>	<i>Macrothrix</i> sp.
<i>Tabellaria</i>	<i>Diaphanosoma</i> sp.
<i>Cyclotella</i>	<i>Simocephalus</i> sp.
<i>Asterionella</i>	<i>Chydorus</i> sp.
<i>Pinnularia</i>	<i>Alonella</i> sp.
CHLOROPHYCEAE	COPEPODA
<i>Pediastrum</i>	<i>Diaptomus</i> sp.
<i>Protococcus</i>	<i>Cyclops</i> sp.
<i>Ulothrix</i>	<i>Canthocampus</i> sp.
<i>Chlamydomonas</i>	<i>Nauplius</i> larvae
<i>Spirogyra</i>	<i>Mesocyclops</i> sp.
<i>Tetraspora cylindrica</i>	<i>Halicyclops</i> sp.
<i>Ankistrodesmus</i>	<i>Eucyclops</i> sp.
<i>Hydrodictyon</i>	PROTOZOA
<i>Volvox</i>	<i>Amoeba</i> sp.
<i>Chlorella</i>	<i>Arcella</i> sp.
<i>Coelastrum</i>	<i>Didinium</i> sp.
<i>Zygnema</i>	<i>Paramecium</i> sp.
	<i>Vorticella</i> sp.
DESMIDIACEAE	
<i>Cosmarium</i>	
<i>Ganatozygon</i>	
<i>Closterium</i>	

Table: 4.27 Quantitative enumeration of phytoplankton (Cell ml⁻¹) at station A of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	Sd
CYANOPHYCEAE																
<i>Anabaena</i>	-	-	-	12.00	11.00	11.00	10.00	8.00	9.00	9.00	10.00	9.00	9.89	8.00	12.00	1.27
<i>Nostoc</i>	10.00	11.00	10.00	12.00	-	-	-	-	-	11.00	13.00	12.00	11.29	10.00	13.00	1.11
<i>Polycystis</i>	10.00	11.00	11.00	13.00	4.00	5.00	-	6.00	5.00	7.00	8.00	8.00	8.00	4.00	13.00	2.93
<i>Oscillatoria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Agmenellums</i>	6.00	8.00	7.00	9.00	-	-	-	-	-	5.00	4.00	3.00	6.00	3.00	9.00	2.16
<i>Coelospharium</i>	5.00	6.00	4.00	5.00	-	-	-	-	-	4.00	5.00	4.00	4.71	4.00	6.00	0.76
<i>Microcystis</i>	6.00	8.00	10.00	11.00	5.00	4.00			6.00	6.00	7.00	6.00	6.90	4.00	11.00	2.18
<i>Meriosmopedia</i>	-	-	-	-	-	-	-	7.00	9.00	9.00	11.00	12.00	9.60	7.00	12.00	1.95
<i>Spirulina</i>	8.00	9.00	9.00	7.00	6.00	-	-	-	-	-	-	-	7.80	6.00	9.00	1.30
<i>Aphanocapsa</i>	4.00	3.00	3.00	5.00	-	-	-	-	-	-	-	-	3.75	3.00	5.00	0.96
<i>Synechocystis</i>	3.00	2.00	2.00	3.00	-	-	-	-	-	-	2.00	2.00	2.33	2.00	3.00	0.52
<i>Arthrospira</i>			7.00	8.00	10.00	9.00	8.00	-	-	-	-	-	8.40	7.00	10.00	1.14
TOTAL	52.00	58.00	63.00	85.00	36.00	29.00	18.00	21.00	29.00	51.00	60.00	56.00	78.67	58.00	103.00	16.28
BACILLARIOPHYCEAE																
<i>Synedra</i>	4.00	4.00	-	-	-	-	-	6.00	7.00	6.00	5.00	5.00	5.29	4.00	7.00	1.11
<i>Nitzschia</i>	8.00	10.00	10.00	9.00	-	-	-	8.00	9.00	8.00	5.00	6.00	8.11	5.00	10.00	1.69
<i>Fragilaria</i>	7.00	8.00	9.00	8.00	6.00	5.00	-	-	-	-	5.00	6.00	6.75	5.00	9.00	1.49
<i>Navicula</i>	9.00	8.00	8.00	9.00	-	-	-	-	-	-	4.00	5.00	7.17	4.00	9.00	2.14
<i>Diatoma</i>	7.00	7.00	8.00	9.00	4.00	3.00	5.00	-	6.00	7.00	8.00	7.00	6.45	3.00	9.00	1.81
<i>Tabellaria</i>	5.00	7.00	6.00	8.00	3.00	3.00	-	-	-	-	-	-	5.33	3.00	8.00	2.07
<i>Cyclotella</i>	-	-	7.00	9.00	9.00	8.00	10.00	7.00	-	-	-	-	8.33	7.00	10.00	1.21
<i>Asterionella</i>	-	-	6.00	8.00	6.00	5.00	-	-	-	-	-	-	6.25	5.00	8.00	1.26
<i>Pinnularia</i>	5.00	6.00	7.00	7.00	-	-	-	-	-	-	-	-	6.25	5.00	7.00	0.96
TOTAL	45.00	50.00	61.00	67.00	28.00	24.00	15.00	21.00	22.00	21.00	27.00	29.00	59.93	41.00	77.00	13.73

CHLOROPHYCEAE																
<i>Pediastrum</i>	10.00	8.00	6.00	6.00	5.00	3.00	-	-	6.00	6.00	8.00	7.00	6.50	3.00	10.00	1.90
<i>Protococcus</i>	10.00	8.00	8.00	9.00	4.00	3.00	-	-	-	-	-	-	7.00	3.00	10.00	2.83
<i>Ulothrix</i>	6.00	8.00	7.00	7.00	-	-	7.00	10.00	12.00	9.00	6.00	9.00	8.10	6.00	12.00	1.91
<i>Chlamydomonas</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Spirogyra</i>	-	-	-	-	-	-	-	12.00	11.00	10.00	12.00	14.00	11.80	10.00	14.00	1.48
<i>Tetraspora cylindrica</i>	6.00	5.00	4.00	5.00	2.00	2.00	-	-	-	-	3.00	4.00	3.88	2.00	6.00	1.46
<i>Ankistrodesmus</i>	-	-	-	-	10.00	11.00	13.00	9.00	-	-	-	-	10.75	9.00	13.00	1.71
<i>Hydrodictyon</i>	6.00	-	-	-	-	-	-	-	6.00	7.00	7.00	8.00	6.80	6.00	8.00	0.84
<i>Volvox</i>	-	-	9.00	12.00	10.00	8.00	15.00	12.00	-	-	2.00	3.00	8.88	2.00	15.00	4.49
<i>Chlorella</i>	-	-	-	-	7.00	8.00	12.00	15.00	14.00	15.00	16.00	13.00	12.50	7.00	16.00	3.34
<i>Coelastrum</i>	-	-	-	-	-	-	7.00	10.00	11.00	7.00	-	-	8.75	7.00	11.00	2.06
<i>Zygnema</i>	5.00	-	-	-	-	-	-	-	7.00	8.00	8.00	10.00	7.60	5.00	10.00	1.82
TOTAL	43.00	29.00	34.00	39.00	38.00	35.00	54.00	68.00	67.00	62.00	62.00	68.00	92.55	60.00	125.00	23.83
DESMIDIACEAE																
<i>Cosmarium</i>	5.00	5.00	4.00	5.00	3.00	2.00	-	-	-	-	4.00	5.00	4.13	2.00	5.00	1.13
<i>Ganatozygon</i>	4.00	5.00	-	-	-	-	-	-	7.00	8.00	7.00	6.00	6.17	4.00	8.00	1.47
<i>Closterium</i>	6.00	7.00	8.00	12.00	11.00	9.00	12.00	8.00	-	-	-	-	9.13	6.00	12.00	2.30
TOTAL	15.00	17.00	12.00	17.00	14.00	11.00	12.00	8.00	7.00	8.00	11.00	11.00	19.42	12.00	25.00	4.89

Table 4.28: Quantitative enumeration of phytoplankton (Cell ml⁻¹) at station B of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE																
<i>Anabaena</i>	-	-	-	10.00	9.00	8.00	9.00	6.00	7.00	7.00	10.00	10.00	8.44	6.00	10.00	1.51
<i>Nostoc</i>	11.00	11.00	9.00	9.00	-	-	-	-	-	10.00	11.00	12.00	10.43	9.00	12.00	1.13
<i>Polycystis</i>	11.00	11.00	12.00	13.00	6.00	7.00	-	8.00	7.00	9.00	9.00	9.00	9.27	6.00	13.00	2.24
<i>Oscillatoria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Agmenellum</i>	8.00	9.00	8.00	10.00	-	-	-	-	-	7.00	6.00	5.00	7.57	5.00	10.00	1.72
<i>Coelospharium</i>	5.00	6.00	4.00	5.00	-	-	-	-	-	4.00	5.00	4.00	4.71	4.00	6.00	0.76
<i>Microcystis</i>	8.00	10.00	9.00	12.00	6.00	4.00	-	5.00	7.00	8.00	10.00	9.00	8.00	4.00	12.00	2.37
<i>Meriosmopedia</i>	-	-	-	-	-	-	7.00	9.00	9.00	10.00	12.00	13.00	10.00	7.00	13.00	2.19
<i>Spirulina</i>	10.00	12.00	11.00	9.00	8.00	6.00	-	-	-	-	-	-	9.33	6.00	12.00	2.16
<i>Aphanocapsa</i>	6.00	6.00	5.00	7.00	3.00	-	-	-	-	-	-	-	5.40	3.00	7.00	1.52
<i>Synechocystis</i>	5.00	4.00	5.00	3.00	2.00	-	-	-	-	-	2.00	2.00	3.29	2.00	5.00	1.38
<i>Arthrospira</i>	-	-	9.00	10.00	11.00	10.00	6.00	-	-	-	-	-	9.20	6.00	11.00	1.92
TOTAL	64.00	69.00	72.00	88.00	45.00	35.00	22.00	28.00	30.00	55.00	65.00	64.00	85.65	58.00	111.00	18.90
BACILLARIOPHYCEAE																
<i>Synedra</i>	6.00	5.00	-	-	-	-	-	7.00	8.00	7.00	6.00	5.00	6.29	5.00	8.00	1.11
<i>Nitzschia</i>	9.00	7.00	9.00	9.00	-	-	-	9.00	8.00	8.00	6.00	6.00	7.89	6.00	9.00	1.27
<i>Fragilaria</i>	9.00	9.00	11.00	9.00	7.00	6.00	-	-	-	-	6.00	6.00	7.88	6.00	11.00	1.89
<i>Navicula</i>	8.00	9.00	8.00	10.00	-	-	-	-	-	-	6.00	8.00	8.17	6.00	10.00	1.33
<i>Diatoma</i>	9.00	9.00	10.00	10.00	6.00	5.00	4.00	-	7.00	7.00	9.00	7.00	7.55	4.00	10.00	2.02
<i>Tabellaria</i>	6.00	8.00	8.00	10.00	5.00	4.00	-	-	-	-	-	-	6.83	4.00	10.00	2.23
<i>Cyclotella</i>	-	-	9.00	10.00	7.00	9.00	10.00	8.00	-	-	-	-	8.83	7.00	10.00	1.17
<i>Asterionella</i>	-	-	8.00	10.00	7.00	6.00	-	-	-	-	-	-	7.75	6.00	10.00	1.71
<i>Pinnularia</i>	7.00	8.00	9.00	9.00	-	-	-	-	-	-	-	-	8.25	7.00	9.00	0.96
TOTAL	54.00	55.00	72.00	77.00	32.00	30.00	14.00	24.00	23.00	22.00	33.00	32.00	69.43	51.00	87.00	13.68

CHLOROPHYCEAE																
<i>Pediastrum</i>	11.00	9.00	7.00	6.00	5.00	3.00	-	-	6.00	6.00	6.00	7.00	6.60	3.00	11.00	2.17
<i>Protococcus</i>	10.00	8.00	9.00	9.00	5.00	3.00	-	-	-	-	-	-	7.33	3.00	10.00	2.73
<i>Ulothrix</i>	7.00	9.00	7.00	8.00	-	-	8.00	9.00	11.00	7.00	5.00	7.00	7.80	5.00	11.00	1.62
<i>Chlamydomonas</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Spirogyra</i>	-	-	-	-	-	-	-	11.00	9.00	9.00	11.00	11.00	10.20	9.00	11.00	1.10
<i>Tetraspora cylindrica</i>	4.00	4.00	5.00	5.00	2.00	2.00	-	-	-	-	3.00	4.00	3.63	2.00	5.00	1.19
<i>Ankistrodesmus</i>	-	-	-	-	9.00	11.00	10.00	9.00	-	-	-	-	9.75	9.00	11.00	0.96
<i>Hydrodictyon</i>	5.00	-	-	-	-	-	-	-	7.00	8.00	7.00	9.00	7.20	5.00	9.00	1.48
<i>Volvox</i>	-	-	9.00	10.00	9.00	9.00	11.00	10.00	-	-	-	-	9.67	9.00	11.00	0.82
<i>Chlorella</i>	-	-	-	-	8.00	9.00	11.00	12.00	14.00	13.00	13.00	15.00	11.88	8.00	15.00	2.42
<i>Coelastrum</i>	-	-	-	-	-	-	9.00	11.00	9.00	8.00			9.25	8.00	11.00	1.26
<i>Zygnema</i>	7.00	-	-	-	-	-	-	-	8.00	9.00	9.00	11.00	8.80	7.00	11.00	1.48
TOTAL	44.00	30.00	37.00	38.00	38.00	37.00	49.00	62.00	64.00	60.00	54.00	64.00	92.10	68.00	116.00	17.22
DESMIDIACEAE																
<i>Cosmarium</i>	7.00	6.00	5.00	5.00	2.00	2.00	-	-	-	-	5.00	5.00	4.63	2.00	7.00	1.77
<i>Ganatozygon</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Closterium</i>	5.00	5.00	7.00	7.00	9.00	9.00	7.00	-	-	-	-	-	7.00	5.00	9.00	1.63
TOTAL	12.00	11.00	12.00	12.00	11.00	11.00	7.00	0.00	0.00	0.00	5.00	5.00	11.63	7.00	16.00	3.40

Table 4.29: Quantitative enumeration of phytoplankton (Cell ml⁻¹) at station C of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE																
<i>Anabaena</i>	-	-	4.00	12.00	10.00	8.00	8.00	7.00	7.00	6.00	6.00	4.00	7.20	4.00	12.00	2.49
<i>Nostoc</i>	9.00	8.00	10.00	8.00	-	-	-	-	-	11.00	12.00	10.00	9.71	8.00	12.00	1.50
<i>Polycystis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Oscillatoria</i>	16.00	17.00	18.00	16.00	11.00	10.00	12.00	10.00	8.00	6.00	7.00	13.00	12.00	6.00	18.00	4.05
<i>Agmenellum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Coelospharium</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Microcystis</i>	12.00	11.00	10.00	8.00	7.00	10.00	12.00	14.00	12.00	11.00	12.00	15.00	11.17	7.00	15.00	2.25
<i>Meriosmopedia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Spirulina</i>	12.00	14.00	15.00	14.00	-	-	-	-	-	-	-	6.00	12.20	6.00	15.00	3.63
<i>Aphanocapsa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Synechocystis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Arthrospira</i>	8.00	12.00	14.00	16.00	8.00	9.00	8.00	-	-	-	-	-	10.71	8.00	16.00	3.30
TOTAL	57.00	62.00	71.00	74.00	36.00	37.00	40.00	31.00	27.00	34.00	37.00	48.00	63.00	39.00	88.00	17.21
BACILLARIOPHYCEAE																
<i>Synedra</i>	10.00	12.00	14.00	16.00	-	-	-	8.00	8.00	9.00	6.00	9.00	10.22	6.00	16.00	3.19
<i>Nitzschia</i>	15.00	16.00	17.00	16.00	-	-	-	12.00	11.00	10.00	7.00	10.00	12.67	7.00	17.00	3.46
<i>Fragilaria</i>	8.00	9.00	10.00	7.00	6.00	6.00	-	-	-	-	8.00	9.00	7.88	6.00	10.00	1.46
<i>Navicula</i>	12.00	12.00	11.00	13.00	-	-	-	-	-	-	-	7.00	11.00	7.00	13.00	2.35
<i>Diatoma</i>	6.00	8.00	8.00	7.00	-	5.00	5.00	-	-	7.00	8.00	7.00	6.78	5.00	8.00	1.20
<i>Tabellaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cyclotella</i>	-	-	10.00	14.00	12.00	11.00	15.00	11.00	-	-	-	-	12.17	10.00	15.00	1.94
<i>Asterionella</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pinnularia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	51.00	57.00	70.00	73.00	18.00	22.00	20.00	31.00	19.00	26.00	29.00	42.00	60.71	41.00	79.00	13.60

CHLOROPHYCEAE																
<i>Pediastrum</i>	11.00	9.00	7.00	7.00	6.00	5.00	-	-	5.00	6.00	7.00	7.00	7.00	5.00	11.00	1.83
<i>Protococcus</i>	8.00	7.00	7.00	5.00	4.00	5.00	-	-	-	-	-	-	6.00	4.00	8.00	1.55
<i>Ulothrix</i>	6.00	-	-	-	-	-	8.00	14.00	18.00	10.00	8.00	12.00	10.86	6.00	18.00	4.14
<i>Chlamydomonas</i>	-	-	-	14.00	15.00	17.00	14.00	11.00	7.00	6.00	5.00	-	11.13	5.00	17.00	4.58
<i>Spirogyra</i>	-	-	-	-	3.00	4.00	6.00	14.00	15.00	14.00	15.00	18.00	11.13	3.00	18.00	5.82
<i>Tetraspora cylindrica</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ankistrodesmus</i>	-	-	-	-	-	12.00	15.00	14.00	-	-	-	-	13.67	12.00	15.00	1.53
<i>Hydrodictyon</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Volvox</i>	-	-	7.00	12.00	11.00	9.00	12.00	10.00	-	-	-	-	10.17	7.00	12.00	1.94
<i>Chlorella</i>	-	-	-	-	9.00	11.00	18.00	22.00	18.00	16.00	14.00	16.00	15.50	9.00	22.00	4.14
<i>Coelastrum</i>	-	-	-	-	-	-	8.00	12.00	10.00	8.00	-	-	9.50	8.00	12.00	1.91
<i>Zygnema</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	25.00	16.00	21.00	38.00	48.00	63.00	81.00	97.00	73.00	60.00	49.00	53.00	94.94	59.00	133.00	27.44
DESMIDIACEAE																
<i>Cosmarium</i>	6.00	6.00	5.00	-	4.00	-	5.00	3.00	-	-	4.00	5.00	4.75	3.00	6.00	1.04
<i>Ganatozygon</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Closterium</i>	9.00	10.00	14.00	16.00	13.00	11.00	15.00	12.00	-	-	-	-	12.50	9.00	16.00	2.45
TOTAL	15.00	16.00	19.00	16.00	17.00	11.00	20.00	15.00	0.00	0.00	4.00	5.00	17.25	12.00	22.00	3.48

Table 4.30: Quantitative enumeration of phytoplankton (Cell ml⁻¹) at station D of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE																
<i>Anabaena</i>	-	-	3.00	10.00	9.00	9.00	7.00	7.00	7.00	6.00	6.00	5.00	6.90	3.00	10.00	2.08
<i>Nostoc</i>	8.00	7.00	8.00	8.00	-	-	-	-	-	9.00	10.00	9.00	8.43	7.00	10.00	0.98
<i>Polycystis</i>	11.00	13.00	14.00	15.00	7.00	6.00	-	7.00	7.00	10.00	12.00	10.00	10.18	6.00	15.00	3.12
<i>Oscillatoria</i>	14.00	13.00	15.00	13.00	9.00	9.00	10.00	9.00	7.00	6.00	7.00	11.00	10.25	6.00	15.00	2.96
<i>Agmenellum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Coelospharium</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Microcystis</i>	10.00	9.00	9.00	7.00	6.00	8.00	10.00	11.00	9.00	11.00	12.00	13.00	9.58	6.00	13.00	2.02
<i>Meriosmopedia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Spirulina</i>	10.00	12.00	11.00	10.00	-	-	-	-	-	-	-	7.00	10.00	7.00	12.00	1.87
<i>Aphanocapsa</i>	7.00	8.00	9.00	9.00	5.00	-	-	-	-	-	-	-	7.60	5.00	9.00	1.67
<i>Synechocystis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Arthrospira</i>	6.00	10.00	11.00	12.00	6.00	8.00	6.00	-	-	-	-	-	8.43	6.00	12.00	2.57
TOTAL	66.00	72.00	80.00	84.00	42.00	40.00	33.00	34.00	30.00	42.00	47.00	55.00	71.37	46.00	96.00	17.28
BACILLARIOPHYCEAE																
<i>Synedra</i>	8.00	10.00	12.00	13.00	-	-	-	8.00	7.00	7.00	5.00	7.00	8.56	5.00	13.00	2.60
<i>Nitzschia</i>	13.00	13.00	12.00	13.00	-	-	-	10.00	9.00	9.00	6.00	8.00	10.33	6.00	13.00	2.55
<i>Fragilaria</i>	7.00	7.00	8.00	6.00	5.00	4.00	-	-	-	-	6.00	8.00	6.38	4.00	8.00	1.41
<i>Navicula</i>	10.00	10.00	9.00	11.00	-	-	-	-	-	-	6.00	5.00	8.50	5.00	11.00	2.43
<i>Diatoma</i>	6.00	8.00	8.00	7.00	-	5.00	5.00	-	-	7.00	8.00	7.00	6.78	5.00	8.00	1.20
<i>Tabellaria</i>	8.00	7.00	9.00	9.00	4.00	4.00	-	-	-	-	-	-	6.83	4.00	9.00	2.32
<i>Cyclotella</i>	-	-	9.00	10.00	11.00	9.00	13.00	9.00	-	-	-	-	10.17	9.00	13.00	1.60
<i>Asterionella</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pinnularia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	52.00	55.00	67.00	69.00	20.00	22.00	18.00	27.00	16.00	23.00	31.00	35.00	57.54	38.00	75.00	14.11

CHLOROPHYCEAE																
<i>Pediastrum</i>	9.00	8.00	6.00	6.00	5.00	5.00	-	-	4.00	5.00	6.00	6.00	6.00	4.00	9.00	1.49
<i>Protococcus</i>	5.00	6.00	6.00	4.00	5.00	4.00	-	-	-	-	-	-	5.00	4.00	6.00	0.89
<i>Ulothrix</i>	6.00	-	-	-	-	-	7.00	12.00	14.00	10.00	7.00	11.00	9.57	6.00	14.00	2.99
<i>Chlamydomonas</i>	-	-	-	12.00	11.00	15.00	12.00	9.00	8.00	7.00	6.00	-	10.00	6.00	15.00	3.02
<i>Spirogyra</i>	-	-	-	-	5.00	6.00	8.00	11.00	13.00	12.00	12.00	15.00	10.25	5.00	15.00	3.54
<i>Tetraspora cylindrica</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ankistrodesmus</i>	-	-	7.00	9.00	9.00	10.00	11.00	12.00	-	-	-	-	9.67	7.00	12.00	1.75
<i>Hydrodictyon</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Volvox</i>	-	-	6.00	10.00	10.00	7.00	10.00	8.00	-	-	-	-	8.50	6.00	10.00	1.76
<i>Chlorella</i>	-	-	-	-	7.00	9.00	14.00	17.00	15.00	14.00	13.00	15.00	13.00	7.00	17.00	3.34
<i>Coelastrum</i>	-	-	-	-	-	-	7.00	11.00	9.00	7.00	-	-	8.50	7.00	11.00	1.91
<i>Zygnema</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	20.00	14.00	25.00	41.00	52.00	56.00	69.00	80.00	63.00	55.00	44.00	47.00	80.49	52.00	109.00	20.70
DESMIDIACEAE																
<i>Cosmarium</i>	5.00	5.00	4.00	-	3.00	2.00	3.00	2.00	-	-	3.00	3.00	3.33	2.00	5.00	1.12
<i>Ganatozygon</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Closterium</i>	7.00	8.00	11.00	14.00	12.00	11.00	15.00	10.00	-	-	-	-	11.00	7.00	15.00	2.73
TOTAL	12.00	13.00	15.00	14.00	15.00	13.00	18.00	12.00	0.00	0.00	3.00	3.00	14.33	9.00	20.00	3.84

Table 4.31: Major groups of phytoplankton (Cell ml⁻¹) at station A of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE	52.00	58.00	63.00	85.00	36.00	29.00	18.00	21.00	29.00	51.00	60.00	56.00	46.50	18.00	85.00	2.83
BACILLARIOPHYCEAE	45.00	50.00	61.00	67.00	28.00	24.00	15.00	21.00	22.00	21.00	27.00	29.00	34.17	15.00	67.00	11.31
CHLOROPHYCEAE	43.00	29.00	34.00	39.00	38.00	35.00	54.00	68.00	67.00	62.00	62.00	68.00	49.92	29.00	68.00	17.68
DESMIDIACEAE	15.00	17.00	12.00	17.00	14.00	11.00	12.00	8.00	7.00	8.00	11.00	11.00	11.92	7.00	17.00	2.83
TOTAL	155.00	154.00	170.00	208.00	116.00	99.00	99.00	118.00	125.00	142.00	160.00	164.00	142.50	69.00	237.00	34.65

Table 4.32: Major groups of phytoplankton (Cell ml⁻¹) at station B of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE	64.00	69.00	72.00	88.00	45.00	35.00	15.00	28.00	30.00	56.00	65.00	65.00	52.67	15.00	88.00	0.71
BACILLARIOPHYCEAE	54.00	55.00	72.00	77.00	32.00	30.00	14.00	24.00	23.00	22.00	33.00	32.00	39.00	14.00	77.00	15.56
CHLOROPHYCEAE	44.00	30.00	37.00	38.00	38.00	37.00	49.00	62.00	64.00	60.00	54.00	64.00	48.08	30.00	64.00	14.14
DESMIDIACEAE	12.00	11.00	12.00	12.00	11.00	11.00	7.00	0.00	0.00	0.00	5.00	5.00	7.17	0.00	12.00	4.95
TOTAL	174.00	165.00	193.00	215.00	126.00	113.00	85.00	114.00	117.00	138.00	157.00	166.00	146.92	59.00	241.00	35.36

Table 4.33: Major groups of phytoplankton (Cell ml⁻¹) at station C of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE	57.00	62.00	71.00	74.00	36.00	37.00	40.00	31.00	27.00	34.00	37.00	48.00	52.50	27.00	74.00	6.36
BACILLARIOPHYCEAE	51.00	57.00	70.00	73.00	18.00	22.00	20.00	31.00	19.00	26.00	29.00	42.00	46.50	18.00	73.00	6.36
CHLOROPHYCEAE	25.00	16.00	21.00	38.00	48.00	63.00	81.00	97.00	73.00	60.00	49.00	53.00	39.00	16.00	97.00	19.80
DESMIDIACEAE	15.00	16.00	19.00	16.00	17.00	11.00	20.00	15.00	0.00	0.00	4.00	5.00	10.00	0.00	20.00	7.07
TOTAL	148.00	151.00	181.00	201.00	119.00	133.00	161.00	174.00	119.00	120.00	119.00	148.00	148.00	61.00	264.00	39.60

Table 4.34: Major groups of phytoplankton (Cell ml⁻¹) at station D of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
CYANOPHYCEAE	66.00	72.00	80.00	86.00	42.00	40.00	33.00	34.00	30.00	42.00	47.00	55.00	60.50	30.00	86.00	7.78
BACILLARIOPHYCEAE	52.00	55.00	67.00	71.00	20.00	22.00	18.00	27.00	16.00	23.00	31.00	35.00	43.50	16.00	71.00	12.02
CHLOROPHYCEAE	20.00	14.00	18.00	32.00	52.00	56.00	70.00	80.00	63.00	55.00	44.00	47.00	33.50	14.00	80.00	19.09
DESMIDIACEAE	12.00	13.00	15.00	14.00	15.00	13.00	18.00	12.00	0.00	0.00	3.00	3.00	7.50	0.00	18.00	6.36
TOTAL	150.00	154.00	180.00	203.00	129.00	131.00	139.00	153.00	109.00	120.00	125.00	140.00	145.00	60.00	255.00	45.25

Table 4.35: Annual average values of phytoplankton (Cell ml⁻¹) at four stations of lake Pichhola, Udaipur

Major groups	Station A	Station B	Station C	Station D	Overall Avg.
CYANOPHYCEAE					
<i>Anabaena</i>	9.89	8.44	7.20	6.90	8.11
<i>Nostoc</i>	11.29	10.43	9.71	8.43	9.97
<i>Polycystis</i>	8.00	9.27	-	10.18	9.15
<i>Oscillatoria</i>	-	-	12.00	10.25	11.13
<i>Agmenellum</i>	6.00	7.57	-	-	6.79
<i>Coelospharium</i>	4.71	4.71	-	-	4.71
<i>Microcystis</i>	6.90	8.00	11.17	9.58	8.91
<i>Meriosmopedia</i>	9.60	10.00	-	-	9.80
<i>Spirulina</i>	7.80	9.33	12.20	10.00	9.83
<i>Aphanocapsa</i>	3.75	5.40	-	7.60	5.58
<i>Synechocystis</i>	2.33	3.29	-	-	2.81
<i>Arthrospira</i>	8.40	9.20	10.71	8.43	9.19
TOTAL	78.67	85.65	63.00	71.37	74.67
BACILLARIOPHYCEAE					
<i>Synedra</i>	5.29	6.29	10.22	8.56	7.59
<i>Nitzschia</i>	8.11	7.89	12.67	10.33	9.75
<i>Fragilaria</i>	6.75	7.88	7.88	6.38	7.22
<i>Navicula</i>	7.17	8.17	11.00	8.50	8.71
<i>Diatoma</i>	6.45	7.55	6.78	6.78	6.89
<i>Tabellaria</i>	5.33	6.83	-	6.83	6.33
<i>Cyclotella</i>	8.33	8.83	12.17	10.17	9.88

<i>Asterionella</i>	6.25	7.75	-	-	7.00
<i>Pinnularia</i>	6.25	8.25	-	-	7.25
TOTAL	59.93	69.43	60.71	57.54	61.90
CHLOROPHYCEAE					
<i>Pediastrum</i>	6.50	6.60	7.00	6.00	6.53
<i>Protococcus</i>	7.00	7.33	6.00	5.00	6.33
<i>Ulothrix</i>	8.10	7.80	10.86	9.57	9.08
<i>Chlamydomonas</i>	-	-	11.13	10.00	10.57
<i>Spirogyra</i>	11.80	10.20	11.13	10.25	10.85
<i>Tetrasporacylindrica</i>	3.88	3.63	-	-	3.76
<i>Ankistrodesmus</i>	10.75	9.75	13.67	9.67	10.96
<i>Hydrodictyon</i>	6.80	7.20	-	-	7.00
<i>Volvox</i>	8.88	9.67	10.17	8.50	9.31
<i>Chlorella</i>	12.50	11.88	15.50	13.00	13.22
<i>Coelastrum</i>	8.75	9.25	9.50	8.50	9.00
<i>Zygnema</i>	7.60	8.80	-	-	8.20
TOTAL	92.55	92.10	94.94	80.49	90.02
DESMIDIACEAE					
<i>Cosmarium</i>	4.13	4.63	4.75	3.33	4.21
<i>Ganatozygon</i>	6.17	-	-	-	6.17
<i>Closterium</i>	9.13	7.00	12.50	11.00	9.91
TOTAL	19.42	11.63	17.25	14.33	15.66

Table 4.36: Quantitative enumeration of zooplankton (No l⁻¹) at station A of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA																
<i>Filinia longiseta</i>	2.00	2.00	3.00	1.00	-	1.00	-	-	2.00	1.00	1.00	2.00	1.67	1.00	3.00	0.71
<i>Keratella</i> sp.	3.00	2.00	2.00	-	-	1.00	2.00	2.00	-	-	1.00	1.00	1.75	1.00	3.00	0.71
<i>Trichocera</i> sp.	2.00	2.00	1.00	-	2.00		1.00	1.00	2.00	1.00	2.00	2.00	1.60	1.00	2.00	0.52
<i>Testudinella</i> sp.	-	-	2.00	1.00	1.00	1.00	-	2.00	2.00	-	-	-	1.50	1.00	2.00	0.55
<i>Hexarthra</i> sp.	-	-	1.00	2.00	-	-	-	-	-	1.00	1.00	2.00	1.40	1.00	2.00	0.55
<i>Rotaria</i> sp.	1.00	1.00	-	-	1.00	1.00	2.00	1.00	2.00	2.00	1.00	-	1.33	1.00	2.00	0.50
<i>Polyarthra</i> sp.	-	-	-	-	-	-	-	1.00	1.00	2.00	1.00	2.00	1.40	1.00	2.00	0.55
<i>Brachionus</i> sp.	3.00	3.00	2.00	3.00	1.00	1.00	1.00	-	2.00	2.00	-	2.00	2.00	1.00	3.00	0.82
<i>Monostyla</i> sp.	2.00	-	1.00	1.00	1.00	-	2.00	1.00	1.00	1.00	2.00	-	1.33	1.00	2.00	0.50
<i>Platylas</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Notholca</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	13.00	10.00	12.00	8.00	6.00	5.00	8.00	8.00	12.00	10.00	9.00	11.00	13.98	9.00	21.00	5.39
CLADOCERA																
<i>Daphnia</i> sp.	3.00	3.00	2.00	3.00	1.00	-	2.00	2.00	1.00	2.00	2.00	2.00	2.09	1.00	3.00	0.70
<i>Moina</i> sp.	2.00	2.00	1.00	2.00	1.00	-	2.00	2.00	1.00	-	1.00	1.00	1.50	1.00	2.00	0.53
<i>Bosmina</i> sp.	1.00	-	2.00	2.00	1.00	1.00	2.00	2.00	3.00	1.00	1.00	1.00	1.55	1.00	3.00	0.69
<i>Sida</i> sp.	1.00	2.00	-	2.00	-	1.00	-	-	-	-	2.00	1.00	1.50	1.00	2.00	0.55
<i>Macrothrix</i> sp.	1.00	-	2.00	2.00	1.00	-	1.00	-	2.00	2.00	2.00	1.00	1.56	1.00	2.00	0.53
<i>Diaphanosoma</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Simocephalus</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Chydorus</i> sp.	1.00	2.00	2.00		1.00	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.36	1.00	2.00	0.50
<i>Alonella</i> sp.	2.00	3.00	2.00	1.00	1.00	1.00		2.00	1.00	2.00	1.00	2.00	1.64	1.00	3.00	0.67
TOTAL	11.00	12.00	11.00	12.00	6.00	4.00	8.00	10.00	9.00	9.00	10.00	9.00	11.19	7.00	17.00	4.17

COPEPODA																
<i>Diaptomus</i> sp.	3.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.50	1.00	3.00	0.67
<i>Cyclops</i> sp.	4.00	3.00	2.00	2.00	1.00	1.00	2.00	2.00	3.00	3.00	1.00	-	2.18	1.00	4.00	0.98
<i>Canthocampus</i> sp.	2.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	1.50	1.00	2.00	0.52
<i>Nauplius</i> larvae	-	2.00	2.00	2.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.45	1.00	2.00	0.52
<i>Mesocyclops</i> sp.	1.00	2.00	-	-	1.00	-	2.00	1.00	-	1.00	1.00	1.00	1.25	1.00	2.00	0.46
<i>Halicyclops</i> sp.	1.00	-	1.00	2.00	1.00	1.00	2.00	-	2.00	1.00	2.00	2.00	1.50	1.00	2.00	0.53
<i>Eucyclops</i> sp.	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	-	1.00	2.00	2.00	1.20	1.00	2.00	0.42
TOTAL	12.00	11.00	9.00	10.00	8.00	6.00	9.00	7.00	10.00	12.00	10.00	9.00	10.59	7.00	17.00	4.11
PROTOZOA																
<i>Amoeba</i> sp.	2.00	2.00	1.00	1.00	-	-	1.00	1.00	2.00	2.00	2.00	1.00	1.50	1.00	2.00	0.53
<i>Arcella</i> sp.	1.00	1.00	-	-	-	1.00	1.00	2.00	2.00	2.00	2.00	1.00	1.44	1.00	2.00	0.53
<i>Didinium</i> sp.	2.00	1.00	1.00	1.00	-	-	1.00	2.00	1.00	1.00	2.00	2.00	1.40	1.00	2.00	0.52
<i>Paramecium</i> sp.		2.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	2.00	1.27	1.00	2.00	0.47
<i>Vorticella</i> sp.	2.00	-	1.00	-	2.00	1.00	1.00	-	1.00	-	1.00	1.00	1.25	1.00	2.00	0.46
TOTAL	7.00	6.00	4.00	3.00	3.00	3.00	5.00	7.00	7.00	6.00	8.00	7.00	6.87	5.00	10.00	2.50

Table 4.37: Quantitative enumeration of zooplankton (No l⁻¹) at station B of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA																
<i>Filinia longiseta</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Keratella</i> sp.	4.00	3.00	3.00	2.00	2.00	1.00	2.00	3.00	4.00	3.00	3.00	3.00	2.75	1.00	4.00	0.87
<i>Trichocera</i> sp.	3.00	2.00	2.00	3.00	2.00	1.00	-	-	3.00	3.00	3.00	2.00	2.40	1.00	3.00	0.70
<i>Testudinella</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hexarthra</i> sp.	2.00	2.00	2.00	3.00	1.00	1.00	2.00	2.00	3.00	3.00	3.00	2.00	2.17	1.00	3.00	0.72
<i>Rotaria</i> sp.	3.00	2.00	2.00	3.00	-	1.00	2.00	3.00	3.00	2.00	2.00	3.00	2.36	1.00	3.00	0.67
<i>Polyarthra</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Brachionus</i> sp.	3.00	3.00	4.00	4.00	2.00	2.00	3.00	3.00	2.00	2.00	3.00	3.00	2.83	2.00	4.00	0.72
<i>Monostyla</i> sp.	3.00	2.00	2.00	-	-	1.00	2.00	2.00	2.00	2.00		2.00	2.00	1.00	3.00	0.50
<i>Platylas</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Notholca</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18.00	14.00	15.00	15.00	7.00	7.00	11.00	13.00	17.00	15.00	14.00	15.00	14.51	7.00	20.00	4.17
CLADOCERA																
<i>Daphnia</i> sp.	3.00	3.00	3.00	3.00	1.00	1.00	2.00	3.00	2.00	3.00	3.00	3.00	2.50	1.00	3.00	0.80
<i>Moina</i> sp.	3.00	3.00	2.00	3.00	1.00	2.00	1.00	2.00	2.00	1.00	2.00	3.00	2.08	1.00	3.00	0.79
<i>Bosmina</i> sp.	3.00	3.00	2.00	2.00	1.00	1.00	3.00	2.00	3.00	3.00	2.00	3.00	2.33	1.00	3.00	0.78
<i>Sida</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Macrothrix</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diaphanosoma</i> sp.	2.00	2.00	2.00	2.00	1.00		1.00	1.00	2.00	2.00	1.00	2.00	1.64	1.00	2.00	0.54
<i>Simocephalus</i> sp.	3.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00	1.00	2.00	1.75	1.00	3.00	0.51
<i>Chydorus</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Alonella</i> sp.	2.00	2.00	2.00	1.00	1.00	1.00	1.00	-	-	2.00	2.00	2.00	1.60	1.00	2.00	0.52
TOTAL	16.00	15.00	13.00	13.00	6.00	6.00	9.00	10.00	11.00	13.00	11.00	15.00	11.90	6.00	16.00	2.89

COPEPODA																
<i>Diaptomus</i> sp.	3.00	3.00	3.00	2.00	-	1.00	1.00	2.00	1.00	1.00	2.00	2.00	1.91	1.00	3.00	0.83
<i>Cyclops</i> sp.	3.00	3.00	3.00	3.00	1.00	1.00	2.00	3.00	3.00	2.00	2.00	3.00	2.42	1.00	3.00	0.79
<i>Canthocampus</i> sp.	2.00	2.00	2.00	2.00	-	-	1.00	1.00	1.00	2.00	-	-	1.63	1.00	2.00	0.52
<i>Nauplius</i> larvae	2.00	2.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.42	1.00	2.00	0.51
<i>Mesocyclops</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Halicyclops</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Eucyclops</i> sp.	2.00	1.00	2.00	2.00	-	-	-	1.00	2.00	2.00	1.00	2.00	1.67	1.00	2.00	0.50
TOTAL	12.00	11.00	12.00	11.00	2.00	3.00	5.00	8.00	8.00	9.00	6.00	8.00	9.03	5.00	12.00	3.16
PROTOZOA																
<i>Amoeba</i> sp.	2.00	2.00	2.00	2.00	-	1.00	1.00	2.00	-	2.00	2.00	2.00	1.80	1.00	2.00	0.42
<i>Arcella</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Didinium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Paramecium</i> sp.	2.00	2.00	2.00	1.00	-	-	-	-	1.00	2.00	2.00	2.00	1.75	1.00	2.00	0.46
<i>Vorticella</i> sp.	3.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00	1.00	2.00	1.75	1.00	3.00	0.62
TOTAL	7.00	6.00	6.00	5.00	1.00	2.00	2.00	4.00	3.00	6.00	5.00	6.00	5.30	3.00	7.00	1.51

Table 4.38: Quantitative enumeration of zooplankton (No l⁻¹) at station C of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA																
<i>Filinia longiseta</i>	3.00	4.00	3.00	2.00	1.00	1.00	-	2.00	1.00	1.00	1.00	2.00	1.91	1.00	4.00	1.04
<i>Keratella</i> sp.	2.00	3.00	1.00	2.00	1.00	1.00	2.00	2.00	1.00		1.00	2.00	1.64	1.00	3.00	0.67
<i>Trichocera</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Testudinella</i> sp.	1.00	1.00	2.00	1.00	1.00	1.00	1.00	2.00	2.00		1.00	1.00	1.27	1.00	2.00	0.47
<i>Hexarthra</i> sp.	2.00	1.00	1.00	2.00	1.00	1.00	-	-	-	1.00	1.00	2.00	1.33	1.00	2.00	0.50
<i>Rotaria</i> sp.	2.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	2.00	2.00	1.00	-	1.45	1.00	2.00	0.52
<i>Polyarthra</i> sp.	2.00	1.00	1.00	2.00	1.00	-	-	1.00	1.00	2.00	1.00	2.00	1.40	1.00	2.00	0.52
<i>Brachionus</i> sp.	2.00	3.00	1.00	2.00	1.00	-	-	2.00	2.00	2.00		2.00	1.89	1.00	3.00	0.60
<i>Monostyla</i> sp.	2.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	2.00	2.00	1.33	1.00	2.00	0.49
<i>Platylas</i> sp.	1.00	1.00	2.00	2.00	-	-	-	-	2.00	1.00	2.00	1.00	1.50	1.00	2.00	0.53
<i>Notholca</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	17.00	16.00	13.00	16.00	8.00	6.00	7.00	11.00	12.00	10.00	10.00	14.00	13.73	9.00	22.00	5.35
CLADOCERA																
<i>Daphnia</i> sp.	4.00	3.00	3.00	3.00	2.00	2.00	1.00	3.00	1.00	2.00	2.00	3.00	2.42	1.00	4.00	0.90
<i>Moina</i> sp.	3.00	2.00	1.00	3.00	2.00	2.00	2.00	2.00	2.00	-	2.00	2.00	2.09	1.00	3.00	0.54
<i>Bosmina</i> sp.	2.00	2.00	2.00	2.00	1.00	1.00	2.00	2.00	3.00	2.00	2.00	2.00	1.92	1.00	3.00	0.51
<i>Sida</i> sp.	2.00	1.00	1.00	2.00	1.00	1.00	-	1.00	1.00	-	2.00	1.00	1.30	1.00	2.00	0.48
<i>Macrothrix</i> sp.	1.00	1.00	2.00	2.00	1.00	-	1.00	-	2.00	2.00	2.00	1.00	1.50	1.00	2.00	0.53
<i>Diaphanosoma</i> sp.	2.00	1.00	1.00	2.00	1.00	-	-	1.00	2.00	-	-	1.00	1.38	1.00	2.00	0.52
<i>Simocephalus</i> sp.	2.00	1.00	1.00	2.00	1.00	-	-	-	1.00	1.00	2.00	2.00	1.44	1.00	2.00	0.53
<i>Chydorus</i> sp.	2.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00	1.00	2.00	1.67	1.00	2.00	0.49
<i>Alonella</i> sp.	3.00	3.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	1.67	1.00	3.00	0.78
TOTAL	21.00	16.00	15.00	19.00	11.00	8.00	8.00	12.00	15.00	11.00	15.00	16.00	15.38	9.00	23.00	5.28

COPEPODA																
<i>Diaptomus</i> sp.	4.00	3.00	2.00	2.00	1.00	1.00	-	-	2.00	2.00	2.00	2.00	2.10	1.00	4.00	0.88
<i>Cyclops</i> sp.	4.00	3.00	2.00	2.00	1.00	1.00	2.00	2.00	3.00	3.00	2.00	2.00	2.25	1.00	4.00	0.87
<i>Canthocampus</i> sp.	2.00	2.00	2.00	2.00	1.00	1.00	1.00	-	-	2.00	2.00	2.00	1.70	1.00	2.00	0.48
<i>Nauplius</i> larvae	1.00	2.00	2.00	2.00	-	-	1.00	1.00	2.00	2.00	1.00	2.00	1.60	1.00	2.00	0.52
<i>Mesocyclops</i> sp.	1.00	2.00	1.00	1.00	-	-	1.00	1.00	1.00	1.00	-	2.00	1.22	1.00	2.00	0.44
<i>Halicyclops</i> sp.	1.00	1.00	1.00	1.00	1.00	-	-	-	1.00	1.00	1.00	2.00	1.11	1.00	2.00	0.33
<i>Eucyclops</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	13.00	13.00	10.00	10.00	4.00	3.00	5.00	4.00	9.00	11.00	8.00	12.00	9.98	6.00	16.00	3.52
PROTOZOA																
<i>Amoeba</i> sp.	1.00	1.00	-	-	-	-	2.00	2.00	2.00	2.00	1.00	1.00	1.50	1.00	2.00	0.53
<i>Arcella</i> sp.	1.00	1.00	1.00	-	-	1.00	1.00	1.00	-	-	1.00	1.00	1.00	1.00	1.00	0.00
<i>Didinium</i> sp.	1.00	1.00	1.00	1.00	-	-	1.00	2.00	2.00	2.00	2.00	1.00	1.40	1.00	2.00	0.52
<i>Paramecium</i> sp.	2.00	2.00	1.00	2.00	-	-	1.00	1.00	1.00	-	-	2.00	1.50	1.00	2.00	0.53
<i>Vorticella</i> sp.	2.00	1.00	1.00	-	1.00	1.00	-	-	-	-	1.00	1.00	1.14	1.00	2.00	0.38
TOTAL	7.00	6.00	4.00	3.00	1.00	2.00	5.00	6.00	5.00	4.00	5.00	6.00	6.54	5.00	9.00	1.96

Table 4.39: Quantitative enumeration of zooplankton (No l⁻¹) at station “D” of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA																
<i>Filinia longiseta</i>	2.00	2.00	1.00	2.00	1.00	1.00	-	-	2.00	2.00	1.00	2.00	1.60	1.00	2.00	0.52
<i>Keratella</i> sp.	3.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	3.00	2.00	1.00	2.00	1.83	1.00	3.00	0.72
<i>Trichocera</i> sp.	2.00	-	1.00	2.00	1.00	-	1.00	1.00	2.00	2.00	2.00	2.00	1.60	1.00	2.00	0.52
<i>Testudinella</i> sp.	2.00	2.00	1.00	2.00	1.00	1.00	1.00	2.00		2.00	2.00	2.00	1.64	1.00	2.00	0.50
<i>Hexarthra</i> sp.	2.00	2.00	1.00	2.00	1.00	-	1.00	2.00	2.00	2.00	3.00	1.00	1.73	1.00	3.00	0.65
<i>Rotaria</i> sp.	2.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	-	-	2.00	1.70	1.00	2.00	0.48
<i>Polyarthra</i> sp.	2.00	2.00	2.00	1.00	1.00	1.00	-	2.00	2.00	-	2.00	2.00	1.41	-	-	-
<i>Brachionus</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Monostyla</i> sp.	2.00		1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	-	2.00	1.50	1.00	2.00	0.53
<i>Platylas</i> sp.	1.00	1.00	-	1.00	-	-	-	-	-	-	-	2.00	1.25	1.00	2.00	0.50
<i>Notholca</i> sp.	-	1.00	1.00	-	-	-	1.00	2.00	2.00	-	1.00	1.00	1.29	1.00	2.00	0.49
TOTAL	18.00	14.00	12.00	15.00	8.00	6.00	7.00	15.00	17.00	12.00	12.00	18.00	14.13	9.00	20.00	4.90
CLADOCERA																
<i>Daphnia</i> sp.	2.00	2.00	2.00	2.00	-	1.00	1.00	2.00	1.00	2.00	2.00	2.00	1.73	1.00	2.00	0.47
<i>Moina</i> sp.	2.00	2.00	2.00	2.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	1.67	1.00	2.00	0.49
<i>Bosmina</i> sp.	2.00	2.00	2.00	2.00	1.00	-	1.00	2.00	2.00	1.00	-	2.00	1.70	1.00	2.00	0.48
<i>Sida</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Macrothrix</i> sp.	1.00	1.00	2.00	2.00	-	1.00	-	1.00	2.00		2.00	2.00	1.56	1.00	2.00	0.53
<i>Diaphanosoma</i> sp.	1.00	2.00	2.00	1.00	1.00	-	-	-	2.00	2.00	-	1.00	-	1.00	2.00	0.45
<i>Simocephalus</i> sp.	2.00	2.00	2.00	2.00	1.00	-	-	2.00	2.00	2.00	-	2.00	-	1.00	2.00	0.57
<i>Chydorus</i> sp.	1.00	1.00	-	2.00	1.00	-	-	-	-	-	1.00	1.00	-	-	-	0.32
<i>Alonella</i> sp.	-	-	1.00	1.00	1.00	1.00	-	-	-	1.00	2.00	2.00	1.29	1.00	2.00	0.49
TOTAL	11.00	12.00	13.00	14.00	6.00	4.00	3.00	8.00	11.00	10.00	9.00	14.00	7.94	7.00	14.00	2.46

COPEPODA																
<i>Diaptomus</i> sp.	2.00	2.00	3.00	3.00	-	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.09	1.00	3.00	0.54
<i>Cyclops</i> sp.	3.00	3.00	4.00	4.00	2.00	1.00	2.00	2.00	3.00	2.00	2.00	2.00	2.50	1.00	4.00	0.90
<i>Canthocampus</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nauplius</i> larvae	-	2.00	2.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	1.64	1.00	2.00	0.50
<i>Mesocyclops</i> sp.	2.00	2.00	1.00	2.00	1.00	-	1.00	2.00	2.00	-	1.00	2.00	1.60	-	-	0.64
<i>Halicyclops</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Eucyclops</i> sp.	1.00	1.00	-	2.00	1.00	-	1.00	1.00	2.00	2.00	2.00	2.00	1.50	1.00	2.00	0.53
TOTAL	8.00	10.00	10.00	12.00	5.00	3.00	7.00	9.00	11.00	8.00	9.00	10.00	9.33	4.00	11.00	2.48
PROTOZOA																
<i>Amoeba</i> sp.	1.00	2.00	-	2.00	1.00	1.00	1.00	-	-	2.00	2.00	2.00	1.56	1.00	2.00	0.53
<i>Arcella</i> sp.	2.00	2.00	2.00	2.00	1.00		1.00	1.00	2.00	2.00	2.00	2.00	1.73	1.00	2.00	0.47
<i>Didinium</i> sp.	2.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	1.75	1.00	2.00	0.45
<i>Paramecium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Vorticella</i> sp.	2.00	2.00	2.00	2.00	1.00	-	-	2.00	2.00	2.00	2.00	2.00	1.90	1.00	2.00	0.32
TOTAL	7.00	8.00	6.00	8.00	4.00	2.00	3.00	5.00	6.00	8.00	8.00	8.00	6.93	4.00	8.00	1.76

Table 4.40: Major groups of zooplankton (No l⁻¹) at station A of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA	13.00	10.00	12.00	8.00	6.00	5.00	8.00	8.00	12.00	10.00	9.00	11.00	9.33	5.00	13.00	2.46
CLADOCERA	11.00	12.00	11.00	12.00	6.00	4.00	8.00	10.00	9.00	9.00	10.00	9.00	9.25	4.00	12.00	2.38
COPEPODA	12.00	11.00	9.00	10.00	8.00	6.00	9.00	7.00	10.00	12.00	10.00	9.00	9.42	6.00	12.00	1.83
PROTOZOA	7.00	6.00	4.00	3.00	3.00	3.00	5.00	7.00	7.00	6.00	8.00	7.00	5.50	3.00	8.00	1.83
TOTAL	43.00	39.00	36.00	33.00	23.00	18.00	30.00	32.00	38.00	37.00	37.00	36.00	33.50	18.00	45.00	8.51

Table 4.41: Major groups of zooplankton (No l⁻¹) at station B of lake Pichhola Udaipur

Major groups of zooplankton	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA	18.00	14.00	15.00	15.00	7.00	7.00	11.00	13.00	17.00	15.00	14.00	15.00	13.42	7.00	18.00	3.48
CLADOCERA	16.00	15.00	13.00	13.00	6.00	6.00	9.00	10.00	11.00	13.00	11.00	15.00	11.50	6.00	16.00	3.32
COPEPODA	12.00	11.00	12.00	11.00	2.00	3.00	5.00	8.00	8.00	9.00	6.00	8.00	7.92	2.00	12.00	3.37
PROTOZOA	7.00	6.00	6.00	6.00	1.00	2.00	4.00	5.00	4.00	4.00	5.00	6.00	4.67	1.00	7.00	1.78
TOTAL	53.00	46.00	46.00	45.00	16.00	18.00	29.00	36.00	40.00	41.00	36.00	44.00	37.50	16.00	53.00	11.94

Table 4.42: Major groups of zooplankton (No l⁻¹) at station C of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA	17.00	16.00	13.00	16.00	8.00	6.00	7.00	11.00	12.00	10.00	10.00	14.00	11.67	6.00	17.00	3.65
CLADOCERA	21.00	16.00	15.00	19.00	11.00	8.00	8.00	12.00	15.00	11.00	15.00	16.00	13.92	8.00	21.00	4.03
COPEPODA	13.00	13.00	10.00	10.00	4.00	3.00	5.00	4.00	9.00	11.00	8.00	12.00	8.50	3.00	13.00	3.66
PROTOZOA	7.00	6.00	4.00	3.00	1.00	2.00	5.00	6.00	5.00	4.00	5.00	6.00	4.50	1.00	7.00	1.78
TOTAL	58.00	51.00	42.00	48.00	24.00	19.00	25.00	33.00	41.00	36.00	38.00	48.00	38.58	18.00	58.00	13.12

Table 4.43: Major groups of zooplankton (No l⁻¹) at station D of lake Pichhola Udaipur

Major groups	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Avg	Min	Max	SD
ROTIFERA	18.00	14.00	12.00	15.00	8.00	6.00	7.00	15.00	17.00	12.00	12.00	18.00	12.83	6.00	18.00	4.13
CLADOCERA	11.00	12.00	13.00	14.00	6.00	4.00	3.00	8.00	11.00	10.00	9.00	14.00	9.58	3.00	14.00	3.70
COPEPODA	8.00	10.00	10.00	12.00	5.00	3.00	7.00	9.00	11.00	8.00	9.00	10.00	8.50	3.00	12.00	2.54
PROTOZOA	7.00	8.00	6.00	8.00	4.00	2.00	3.00	5.00	6.00	8.00	8.00	8.00	6.08	2.00	8.00	2.15
TOTAL	44.00	44.00	41.00	49.00	23.00	15.00	20.00	37.00	45.00	38.00	38.00	50.00	37.00	14.00	52.00	12.53

Table 4.44: Annual average values of zooplankton (No l⁻¹) at four stations of lake Pichhola, Udaipur

Major groups	Station A	Station B	Station C	Station D	Overall Avg.
ROTIFERA					
<i>Filinia longiseta</i>	1.67	-	1.91	1.60	1.73
<i>Keratella</i> sp.	1.75	2.75	1.64	1.83	1.99
<i>Trichocera</i> sp.	1.60	2.40	-	1.60	1.87
<i>Testudinella</i> sp.	1.50	-	1.27	1.64	1.47
<i>Hexarthra</i> sp.	1.40	2.17	1.33	1.73	1.66
<i>Rotaria</i> sp.	1.33	2.36	1.45	1.70	1.71
<i>Polyarthra</i> sp.	1.40	-	1.40	1.41	1.40
<i>Brachionus</i> sp.	2.00	2.83	1.89	-	2.24
<i>Monostyla</i> sp.	1.33	2.00	1.33	1.50	1.54
<i>Platyias</i> sp.	-	-	1.50	1.25	1.38
<i>Notholca</i> sp.	-	-	-	1.29	1.29
TOTAL	13.98	14.51	13.73	14.13	14.09
CLADOCERA					
<i>Daphnia</i> sp.	2.09	2.50	2.42	1.73	2.19
<i>Moina</i> sp.	1.50	2.08	2.09	1.67	1.84
<i>Bosmina</i> sp.	1.55	2.33	1.92	1.70	1.88
<i>Sida</i> sp.	1.50	-	1.30	-	1.40
<i>Macrothrix</i> sp.	1.56	-	1.50	1.56	1.54
<i>Diaphanosoma</i> sp.	-	1.64	1.38	-	1.51
<i>Simocephalus</i> sp.	-	1.75	1.44	-	1.60

<i>Chydorus</i> sp.	1.36	-	1.67	-	1.52
<i>Alonella</i> sp.	1.64	1.60	1.67	1.29	1.55
TOTAL	11.19	11.90	15.38	7.94	11.60
COPEPODA					
<i>Diaptomus</i> sp.	1.50	1.91	2.10	2.09	1.90
<i>Cyclops</i> sp.	2.18	2.42	2.25	2.50	2.34
<i>Canthocampus</i> sp.	1.50	1.63	1.70	-	1.61
<i>Nauplius</i> larvae	1.45	1.42	1.60	1.64	1.53
<i>Mesocyclops</i> sp.	1.25	-	1.22	1.60	1.36
<i>Halicyclops</i> sp.	1.50	-	1.11	-	1.31
<i>Eucyclops</i> sp.	1.20	1.67	-	1.50	1.46
TOTAL	10.59	9.03	9.98	9.33	9.73
PROTOZOA					
<i>Amoeba</i> sp.	1.50	1.80	1.50	1.56	1.59
<i>Arcella</i> sp.	1.44	-	1.00	1.73	1.39
<i>Didinium</i> sp.	1.40	-	1.40	1.75	1.52
<i>Paramecium</i> sp.	1.27	1.75	1.50	-	1.51
<i>Vorticella</i> sp.	1.25	1.75	1.14	1.90	1.51
TOTAL	6.87	5.30	6.54	6.93	6.41

Table 4.45 Odum's Diversity Index of phytoplankton at all four stations of lake Pichhola, Udaipur

Station	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max
ST. A	154.84	142.85	141.17	120.19	155.17	171.71	101.01	110.16	128.00	127.65	143.75	140.24	136.40	101.01	171.71
ST. B	132.18	127.27	124.35	116.27	158.73	159.29	117.64	114.03	111.11	123.18	133.75	126.50	128.69	111.11	159.29
ST. C	101.35	92.71	93.92	84.57	117.64	112.78	93.16	86.20	92.43	108.33	117.64	101.35	100.17	84.57	117.64
ST. D	120.00	110.38	111.11	98.52	139.53	137.40	107.91	104.57	110.09	116.66	128.00	114.28	116.54	98.52	139.53

Table 4.46 Odum's Diversity Index of zooplankton at all four stations of lake Pichhola, Udaipur

Station	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Average	Min	Max
ST. A	534.88	512.82	638.88	606.06	869.56	1000.00	700.00	656.25	605.26	621.62	702.70	666.66	676.22	512.82	1000.00
ST. B	377.35	434.78	434.78	422.22	812.50	888.88	620.68	500.00	450.00	463.41	500.00	431.81	528.03	377.35	888.88
ST. C	482.75	568.62	666.66	541.66	916.66	894.73	720.00	636.36	609.75	583.33	657.89	583.33	655.15	482.75	916.66
ST. D	545.45	545.45	560.97	530.61	956.52	1000.00	900.00	567.56	488.88	526.31	552.63	540.00	642.87	488.88	1000.00

Table 4.47: Most pollution tolerant algal genera of lake Pichhola in decreasing order following Palmer (1969)

1	<i>Oscillatoria</i>
2	<i>Chlamydomonas</i>
3	<i>Chlorella</i>
4	<i>Nitzschia</i>
5	<i>Navicula</i>
6	<i>Synedra</i>
7	<i>Ankistrodesmus</i>
8	<i>Cyclotella</i>
9	<i>Closterium</i>
10	<i>Microcystis</i>
11	<i>Spirogyra</i>
12	<i>Anabaena</i>
13	<i>Pediastrum</i>
14	<i>Arthrospira</i>
15	<i>Fragilaria</i>
16	<i>Ulothrix</i>
17	<i>Spirulina</i>
18	<i>Coelastrum</i>
19	<i>Diatoma</i>
20	<i>Pinnularia</i>
21	<i>Asterionella</i>
22	<i>Cosmarium</i>

Table 4.48: Palmer pollution index of algal genera found in lake Pichhola

S.No.	Algal genera considered for Pollution Index with respective score	Score at stations			
		A	B	C	D
1	<i>Ankistrodesmus</i> (2)	2	2	2	2
2	<i>Chlamydomonas</i> (4)	0	0	4	4
3	<i>Chlorella</i> (3)	3	3	3	3
4	<i>Closterium</i> (1)	1	1	1	1
5	<i>Cyclotella</i> (1)	1	1	1	1
6	<i>Microcystis</i> (1)	1	1	1	1
7	<i>Navicula</i> (3)	3	3	3	3
8	<i>Nitzschia</i> (3)	3	3	3	3
9	<i>Oscillatoria</i> (4)	0	0	4	4
10	<i>Synedra</i> (2)	2	2	2	2
TOTAL		16	16	24	24

Table 4.49: Check list of fish fauna represented in the catch from lake Pichhola, Udaipur

	Family	Species	
		Scientific name	Local name
A.	Cyprinidae	1. <i>Catla catla</i> (Ham.)	Catla
		2. <i>Labeo rohita</i> (Ham.)	Rohu
		3. <i>Cirrhinus mrigala</i> (Ham.)	Mrigal or Narain
		4. <i>Labeo gonius</i> (Ham.)	Sarsi
		5. <i>Labeo kalbasu</i> (Ham.)	Kalaunt
		6. <i>Labeo boggut</i>	
		7. <i>Labeo pengusia</i>	
		8. <i>Amblypharyngodon mola</i> (Ham.)	Malwa
		9. <i>Puntius ticto</i> (Ham.)	Puthi
		10. <i>Puntius sophore</i> (Ham.)	Puthi
		11. <i>Puntius sarana</i> (Ham.)	Puthi/Kharpata
		12. <i>Puntius punctulus</i> (Ham.)	
		13. <i>Puntius samphibius</i> (Ham.)	
		14. <i>Puntius dorsalis</i> (Ham.)	
		15. <i>Tor tor</i> (Ham.)	Mahseer
		16. <i>Rasbora daniconius</i> (Ham.)	Chal
		17. <i>Oxygaster clupeoides</i> (Ham.)	Silueschal
		18. <i>Cyprinus carpio</i>	Common carp
		19. <i>Ctenopharyngodon idella</i>	Grasp carp
		20. <i>Hypophthalmichthys molitrix</i>	Silver carp
B.	Siluridae	21. <i>Heteropneustes fossilis</i> (Bloch)	Singhi
		22. <i>Wallago attu</i> (Bloch & Schneider)	Lanchi
C.	Notopteridae	23. <i>Notopterus notopterus</i> (Pallas)	Patola
D.	Bagridae	24. <i>Mystus seenghala</i> (Sykes)	Singhara
		25. <i>Mystus aor</i> (Ham.)	Pitar
E.	Mastacembelidae	26. <i>Mastacembelus armatus</i> (Lacepede)	Bam
F.	Opheocephalus	27. <i>Opheocephalus marulius</i> (Ham.)	Sawal
		28. <i>Opheocephalus striatus</i> (Bloch)	Kabra
		29. <i>Opheocephalus punctatus</i> (Ham.)	Girhi
G.	Centropomidae	30. <i>Chanda nama</i> (Ham.)	Chalputhi
H.	Belonidae	31. <i>Xenentodon cancelai</i> (Ham.)	Suhia

I.	Cobitidae	32. <i>Nemacheilus botia</i> (Ham.)	Botia
J.	Osphronemidae	33. <i>Trichogaster lalius</i> (Ham.)	Dwarf gourami
K.	Loricariidae	34. <i>Hypostomus plecostomus</i> (Linnaeus)	Sucker mouth catfish

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