

Comparison of physico-chemical parameters and zooplankton diversity in two perennial ponds at Aligarh, India

Saltanat Parveen^{1*} and Hesham R. Abdel Mola²

¹Limnology Research Laboratory, Department of Zoology, Aligarh Muslim University, Aligarh- 202 002, India

² National Institute of Oceanography and Fisheries, 101 Kasr El-Einy st., Cairo- 11516, Egypt

*Corresponding Author email : saltanatparveen@yahoo.co.in

Publication Info

Paper received:
09 February 2012

Revised received:
25 May 2012

Accepted:
28 July 2012

Abstract

Investigations were carried out on the diversity of zooplankton in relation to physico-chemical parameters of two perennial ponds (Chautal Pond and Medical Pond) of Aligarh, India. Thirty nine species of holoplankton were identified belonging to copepoda (2species), rotifera (28species), cladocera (6 species) and protozoa (3species). Other forms; like as meroplankton (insects) and tychoplankton (nematodes and ostracodes) were also recorded. Higher values of physico-chemical parameters and low zooplankton diversity were recorded in the Chautal Pond, whereas low values of physico-chemical parameters and high diversity were recorded in the Medical Pond. Ostracods considered to be the most dominant group in Medical Pond (32.16 % of the total zooplankton) while Cladocerans are considered to be the most dominant group in Chautal Pond (38.83 % of the total zooplankton). Rotifera contributed more in Medical Pond (16.42 %) as compared to Chautal Pond (15.81 %). Five species of *Brachionus* was recorded during study. Out of five, four *Brachionus* species were recorded in Chautal Pond while only two species were recorded in Medical pond. This indicates that Chautal Pond is more eutrophic than Medical pond. In addition, higher carbon dioxide values (37-105 mg l⁻¹), low dissolved oxygen (0.7-3.3 mg l⁻¹) and higher electrical conductivity values (1069-1691 mg l⁻¹) were also indicative of eutrophic nature of Chautal Pond. Present study also revealed that total zooplankton species, species richness and diversity indices (Evenness, Shannon-Winner and Simpson) were comparatively higher in Medical pond. The rotifer species *Philodina roseola* (146 Org. l⁻¹) and *Monstyla closterocerca* (109 Org. l⁻¹) was dominated in Medical Pond while the rotifers *Brachionus urceolaris* (512 Org. l⁻¹) and the cladocern species *Ceriodaphnia cornuta* (1540 Org. l⁻¹) dominated in Chautal Pond during post-monsoon season. This might be due to the effect of rain water which played an important role in replenishment of the ponds. Also, the abundance of cladoceran *C. cornuta* in Chautal Pond might be due to the higher vegetation in this pond. The abundance of these zooplankton species in these ponds suggests that these taxa can be considered as pollution indicators.

Key words

Zooplankton, Physico-chemical parameters, Diversity indices, Pond

Introduction

Ponds directly or indirectly have an enormous ecological, commercial and socio-economic importance. They are rich in components of bio-diversity, like, flora and fauna of local, natural and regional significance. Thus, the ponds play an important role in biodiversity (Ghanai *et al.*, 2010). In India, natural ponds are estimated to have an area of about 0.72 million ha, most of which are found in the vicinity of villages, places of religious worship and other

human inhabitations (Kamat and Sima, 2000; Shiddamallayya and Pratima, 2008; Rajagopal *et al.*, 2010). This makes them quite vulnerable to changes day by day, which would probably give a clear picture about the pollution stress on them (Raja *et al.*, 2008). Zooplankton is the primary consumers forming the second trophic level in the food chain after phytoplankton. Diversity of planktonic organisms is quite high in fertile standing water bodies. Zooplankton diversity responds rapidly to changes in the aquatic environment. Several zooplankton species have

served as bioindicators (Ahmad *et al.*, 2011; Mola, 2011) and thus is a well suited tool for understanding water pollution studies (Ahmad, 1996). Studies on planktonic composition and morphometric, physical and chemical characteristics of water bodies are necessary to obtain basic knowledge on the biodiversity in ponds (Rajagopal *et al.*, 2010). The physico-chemical parameters of water such as nutrient concentrations or oxygen conditions which often a consequence of human activity in the catchment area, may shape the abundance and richness of microinvertebrate communities (Castro *et al.*, 2005; Kucznska- Kippen and Basinska, 2008).

Fresh water zooplankton comprises principally rotifers, cladocerans, copepods and protozoans. In aquatic food webs, zooplankton plays a vital role as they consume the primary producers (phytoplankton) and form a major food source for tertiary producers. Zooplankton considered as the basic principal natural fish feed for the young and some adults of many fishes which support fish production (El-Serafy *et al.*, 2009). Zooplankton communities often respond quickly to environmental changes because most species have short generation times (usually days to weeks). The variations of their spatial distribution based on different physical factors were studied by Epifanio and Garvine (2001) and Kimmel *et al.* (2006). The aim of the present work was to assess physico-chemical parameters, zooplankton population and diversity indices of two different ponds in Aligarh, India.

Materials and Methods

Study area: Aligarh, a district of western Uttar Pradesh is located in the central Ganga- Yamuna Doab at latitude 27° 54'2" N and longitude 78° 42' E.

The Medical pond, locally known as Dhobi Ghat, is perennial fresh water, sewage fed Pond situated at the back side of Jawaharlal Nehru Medical College. The Pond is shallow (depth 0.60 to 1.50 m) covering an area of about 0.57 ha. The source of replenishment is sewage effluent from Medical College through drains and surface run-off from surrounding areas. Bottom of the Pond contains mostly loose mud, sand, stones, dead plankton and decayed littler deposit. The shoreline of Medical Pond is surrounded by Babul (*Acacia arabica*) and some Neem (*Azadirachta indica*) trees.

Chautal Pond is also a perennial sewage fed, Pond situated in north-west of Aligarh Muslim University campus. The shoreline is somewhat irregular. The depth of the Pond varies from 0.5 to 2.5 m. The main source of its water supply is sewage water from adjoining colonies in addition to surface run-off from surrounding areas. This Pond is used extensively by washermen for washing clothes, thereby adding detergents and certain chemicals. The Pond is

characterized by rich growth of macrophytes such as *Eicchornia crassipes*, *Typha latifolia*, *Polygnum* sp., and *Lemna minor*. *E. crassipes* covers about 85 % of the surface during June and July.

Collection and analysis of samples: Water samples were collected from selected ponds for 8 months from October 2010 to May 2011. Samples were collected every month during morning hours between 9.00 and 11.00 a.m. and the data was expressed seasonally as post monsoon season (October and November), winter (December and January), spring (February and March) and summer (April and May).

For physico-chemical analysis: Air and water temperature were measured in shade during the time of sampling using a mercury thermometer graduated to 100 °C. Transparency of water column was determined in cm using black and white enamel coated Secchi Disk with a diameter of 20 cm. Electrical conductivity (EC) was measured in μmScm^{-1} by the conductivity meter. Hydrogen ion concentration (pH) was directly measured by pH meter (model Jenway 3150). All the chemical parameters were determined according to APHA (2005).

Zooplankton was collected by filtration of 30 l surface water through the plankton net (mesh size 55 μm , diameter 25 cm and length 80 cm). All the samples were immediately fixed with 4 % formalin. In the laboratory, the samples were examined with Optic Research Microscope. Three subsamples (1 ml from each) of the homogenized plankton samples were transferred to a counting cell, and the different plankters were counted. Planktonic organisms were classified, identified and described according to description and keys provided by Edmondson (1966), Ruttner-Kolisko (1974), Pennek (1978) and Shehata *et al.* (1998 a, b).

Statistical analyses were conducted with PRIMER 5 (version 5.2.0). The correlation coefficient between different physico-chemical parameters and the dominant zooplankton was carried out by SPSS software (version 12).

Results and Discussion

The variations in water temperature (Table 1) showed agreement with air temperature in Medical Pond. It was recorded highest during summer (30 °C) and the lowest during winter (17 °C). Whereas, Chautal Pond showed high difference between air and water temperature during spring and summer season. This might be due to abundance of floating macrophytes which prevents sunlight penetration as most of the light reflected back and absorbed by these floating macrophytes. Transparency ranged between 15-19 cm in Medical Pond and 13-33 cm in Chautal Pond. The highest reading was recorded during post-monsoon season this might be due to the dilution effect of rains and settlement of sediment after monsoon season. The lowest reading was recorded during summer which might be due to evaporation

Table 1 : Seasonal variations of physico-chemical parameters of Medical Pond (MP) and Chautal Pond (ChP) during the study

Parameter	Pond	Post-Monsoon	Winter	Spring	Summer
Air temperature (°C)	MP	24	18	24	32
	ChP	24	18	25	33
Water temperature (°C)	MP	21	17	21	30
	ChP	23	16	20	25
Transparency (cm)	MP	19	18	18	15
	ChP	33	27	28	13
EC (μmhoScm^{-1})	MP	883	928	1146	2071
	ChP	1100	1069	1448	1691
pH	MP	8.3	9.5	8.6	8.3
	ChP	7.9	8.6	8.8	7.8
CO_3^{2-} (mg l^{-1})	MP	0	57	5	0
	ChP	0	23	0	14
HCO_3^{-1} (mg l^{-1})	MP	199	263	259	409
	ChP	238	243	245	311
CO_2 (mg l^{-1})	MP	37	0	40	127
	ChP	52	37	103	105
DO (mg l^{-1})	MP	4.7	2.6	1.0	2.1
	ChP	3.3	1.7	0.9	0.7
Cl^{-1} (mg l^{-1})	MP	51.8	53.9	62.4	146.4
	ChP	83.8	80.4	111.3	137.1

of ponds water, which caused concentration of dissolved solids at high temperature and production of plankton.

Similar observations were recorded by Kaushik and Saksena (1999). Also, lowest pH value (7.8) was recorded at Chautal Pond during summer. The relative decrease of pH values in this Pond might be due to the effect of inflowing wastewater along with sewage effluent throughout the year (Abdel-Satar, 2001) and the highest pH (9.5) was recorded at Medical Pond during winter.

Dissolved oxygen was recorded lowest (0.9 and 0.7 mg l^{-1}) at Chautal Pond during spring and summer, respectively. This might be attributed to the input of sewage and agricultural wastes, as biochemical decomposition of organic matter leads to increase in ammonia and sulphide production during mineralization of organic matter which lead to enormous oxygen depletion (Abdel-Satar, 2001). The highest value (4.7 mg l^{-1}) was recorded at Medical Pond during post-monsoon. This might be due to the abundance of phytoplankton which enriched water with oxygen during photosynthesis (Rajagopal, 2010).

Electrical conductivity and chloride concentration showed similar distribution in the studied ponds. They increased gradually from one season to another and reached to their maximum values during summer due to the evaporation effect. Medical Pond recorded low values of EC and Cl than Chautal Pond in all seasons except summer. This was due to high evaporation during summer in Medical pond. Bicarbonate concentrations also followed similar pattern of distribution in both ponds.

The absence of CO_2 might be due to the presence of carbonates or high values of pH (8.3 or above). Kaushik and Saksena (1999) reported absence of CO_2 due to similar reason. The highest (57 and 23 mg l^{-1}) values of carbonate was recorded during winter at Medical Pond and Chautal Pond respectively, while the highest (127 and 105 mg l^{-1}) values of CO_2 was recorded during summer at Medical Pond and Chautal Pond, respectively. The CO_2 values in Chautal Pond was relatively higher than Medical Pond. This might be due to abundance of macrophytes in Chautal Pond.

High values of physico-chemical parameters and low zooplankton diversity were recorded in the Chautal Pond, whereas low values of physico-chemical parameters and high zooplankton diversity were recorded in the Medical pond. Chautal Pond considered a highly vegetated Pond especially with floating macrophytes like *Eicchornia crassipes* and *Lemna minor*. This Pond considered lowest in species diversity but showed high density of zooplankton (1085 Org. l^{-1}), while the lowest density was observed at Medical Pond (897 Org. l^{-1}). The present result is not in confirmation with the study of Hamilton *et al.* (1989), who stated that zooplankton density were greatly reduced during passage through a large bed of the floating aquatic grass. In Chautal Pond, the highest density (2896 Org. l^{-1}) was recorded during post-monsoon, while the lowest (281 Org. l^{-1}) during spring. In Medical Pond, the highest density (1814 Org. l^{-1}) was recorded during spring while lowest (446 Org. l^{-1}) during winter (Table 2).

Ostracoda was considered as the most dominant group in Medical Pond (32.16 % of the total zooplankton)

while Cladocera as the most dominant group in Chautal Pond (38.83 % of the total zooplankton). Rotifera was more abundant in Medical Pond (16.42 %) as compared to Chautal Pond (15.81 Org. l⁻¹), while Copepoda density was higher in Chautal Pond (32.89 %) than Medical Pond (25.81 %). The highest (744 and 375 Org. l⁻¹) density of ostracods was recorded during summer at Medical Pond and Chautal Pond, respectively.

The highest density of ostracods, tychoplankton in Medical Pond might be due to the mixing of epibenthic forms from sediment phase, which was rich in ostracods during sampling. Due to the effect of high temperature, especially, in Medical Pond as it has no replenishment so the water level recorded lowest and the other salts were recorded highest during summer season. This coincided with the reports of El-Serafy *et al.* (2009) who recorded a remarkable increase of physico-chemical parameters and all zooplankton groups when water level decreased.

Cladocera constituted only 19.04 % of total zooplankton in Medical Pond while it constituted two times *i.e.* 38.83 % of total zooplankton in Chautal Pond. The highest density of Cladocera during post-monsoon in Chautal Pond and during spring in Medical Pond was due to *Ceriodaphnia cornuta* which contributed 1540 Org. l⁻¹ and 447 Org. l⁻¹ in Chautal Pond and Medical Pond, respectively. The highest abundance of Cladocera in Chautal Pond might be attributed to macrophyte vegetation. This observation coincided with Bozkurt and Guven (2009) who stated that the abundance of Cladocera in the vegetated areas was higher than unvegetated areas. Although, dissolved oxygen showed low values in both ponds but it did not become limiting factor for cladoceran population. This indicated that this group has the ability to live under oxygen deficiency. Bozkurt and Guven (2009) pointed out that water containing low rate of dissolved oxygen adversely affect the distribution, reproduction and growth of zooplankton, especially, zooplankton which suffer from respiration trouble in fresh waters with less DO (<1 mg.l⁻¹). Out of six cladocern species recorded in Chautal Pond only *Daphnia carinata* was reported in Chautal Pond during spring and summer. Alam *et al.* (1995) mentioned that the maximum

abundance of *Daphnia* sp. was recorded during winter and recorded a remarkable decrease during spring and was completely absent in the rest of the year. *Diaphanosoma excisum* showed the highest number in Chautal Pond during monsoon (20 Org l⁻¹) and in Medical Pond during spring (5 Org. l⁻¹). This might be due to that Chautal Pond receives high amount of organic substances from the surrounding residential area. This observation is in agreement with Rajashekhar *et al.* (2009) who stated that the presence of *D. excisum* can be considered as an indicative of increasing organic content in the water bodies.

Rotifera showed highest number of species (28 species) among zooplankton during study. The highest number of rotifers (24 species) was recorded in Medical Pond while lowest at Chautal Pond (19 species). *Brachionus urceolaris*, *Monstyla closterocerca* and *Philodina roseola* were the abundant rotifers. Five species of genus *Brachionus*, namely *B. angularis*, *B. Calyciflorus*, *B. patulus*, *B. quadridentatus* and *B. urceolaris* were recorded during the study. Among these species four *Brachionus* species were recorded in Chautal Pond while two species only were recorded in Medical Pond. This indicated that Chautal Pond is more eutrophic than Medical pond. Mageed (2008), Ahamed (2011) and Mola (2011) mentioned that the presence of *Brachionus* species with high density and high number of species indicate eutrophication in the water body and this genus has the ability to tolerate pollution. *P. roseola* was the second dominant species in Rotifera (149 Org. l⁻¹) in Medical Pond during post-monsoon season. Hegab (2010) mentioned that the presence of *Monstyla* species in water body is an indicator of water pollution.

Copepoda recorded high density in Chautal Pond (357 Org. l⁻¹) than Medical Pond (231 Org. l⁻¹). Copepoda recorded the highest abundance during post-monsoon (382 and 596) in Medical Pond and Chautal pond, respectively. This might be due to the enhancement of water quality during monsoon. Though, nauplius larvae formed the bulk of copepods in the both ponds but only two species; *Mesocyclops* sp. and *Cyclops* sp., were recorded during the study. In the studied ponds, the highest density of *Mesocyclops* sp. was recorded during post-monsoon in

Table 2 : Seasonal variations in density of zooplankton groups (Org. l⁻¹) in Medical Pond (MP) and Chautal Pond (ChP) during the study

Season	Post-Monsoon		Winter		Spring		Summer		Average		% Value	
	MP	ChP	MP	ChP	MP	ChP	MP	ChP	MP	ChP	MP	ChP
Copepoda	382	596	124	484	336	203	83	143	231	357	25.81	32.89
Rotifera	210	596	232	61	108	6	39	22	147	171	16.42	15.81
Cladocera	102	1572	3	2	540	60	38	49	171	421	19.04	38.83
Protozoa	8	0	8	2	15	2	4	3	9	2	0.95	0.14
Nematoda	0	0	61	2	72	5	15	10	37	4	4.10	0.36
Ostracoda	188	128	19	2	202	6	744	375	288	128	32.16	11.77
Insecta	4	4	0	0	42	0	9	5	14	2	1.52	0.20
Grand total	894	2896	447	553	1315	282	932	607	897	1085	100.00	100.00

Chautal Pond (84 Org. l⁻¹) than Medical Pond (50 Org. l⁻¹), whereas *Cyclops* sp. was recorded in Medical Pond (4 Org. l⁻¹) only during post-monsoon. The low numbers of copepod species referred to the effect of pollution in ponds while El-Serafy *et al.* (2009) mentioned that Copepoda was the most dominant group in Lake Nasser, Egypt which attributed to the good environmental conditions of the lake.

Nematodes (tychoplankton) and insects (meroplankton) formed the less dominant groups during study. Each group showed its highest abundance in Medical Pond than in Chautal Pond. This might be due to the low water level in Medical Pond which leads to mixing of water from sediment during sampling. The high numbers (61 and 72 Org. l⁻¹) of nematodes was recorded in Medical Pond

Table 3 : Variations of zooplankton species (Org. l⁻¹) in Medical Pond (MP) and Chautal Pond (ChP) during the study

Group/ Taxa	Post-Monson		Winter		Spring		Summer	
	MP	ChP	MP	ChP	MP	ChP	MP	ChP
Copepoda								
Nauplius larvae	286	480	115	456	215	198	41	120
Cyclopoid copepodites	42	32	3	21	100	3	15	9
<i>Cyclops</i> sp.	4	0	0	0	0	0	0	0
<i>Mesocyclops</i> sp.	50	84	7	8	22	2	27	14
Rotifera								
<i>Anuropis fissa</i>	4	0	5	0	0	0	3	2
<i>Ascomorpha saltans</i>	2	0	3	0	0	0	0	0
<i>Asplachina priodontia</i>	2	4	15	1	22	0	2	1
<i>Brachionus angularis</i>	0	8	0	0	0	0	0	0
<i>B. Calyciflorus</i>	0	0	0	41	0	0	0	0
<i>B. patulus</i>	0	4	0	3	0	0	0	0
<i>B. quadridentatus</i>	2	0	0	0	0	0	0	0
<i>B. urceolaris</i>	0	512	15	0	5	0	0	0
<i>Conochilus</i>	0	40	0	0	0	0	0	0
<i>Coluella adriatica</i>	2	0	0	0	0	0	0	0
<i>Coluella obtuse</i>	0	0	0	0	2	0	0	0
<i>Euclainus dilitata</i>	0	0	2	0	0	0	0	0
<i>Filina longiseta</i>	0	4	0	0	0	0	20	10
<i>Horellaa brehmi</i>	8	8	3	4	3	0	3	2
<i>Lecane</i> spp	0	0	0	0	0	0	3	2
<i>Lecane Aspasia</i>	4	0	0	0	10	2	0	1
<i>Lecane depresa</i>	2	0	0	0	0	0	0	0
<i>L. luna</i>	0	0	0	0	0	0	3	2
<i>Lepadella ovalis</i>	8	0	2	3	5	0	0	0
<i>Monstyla bulla</i>	12	0	48	3	0	2	0	1
<i>Monstyla closterocerca</i>	6	0	109	3	18	0	0	0
<i>Monstyla lunaris</i>	2	0	2	0	0	2	0	1
<i>Mytilina mucronata</i>	4	0	5	0	5	0	0	0
<i>Pompholyx complanata</i>	2	0	0	0	0	0	0	0
<i>Philodina roseola</i>	146	4	12	1	41	2	5	3
<i>Syncheata</i> sp.	0	8	9	0	0	0	0	0
<i>Trichocerca</i> sp.	0	4	3	4	0	0	0	0
<i>Tripleuchlanus</i> sp.	4	0	3	0	0	0	0	0
Cladocera								
<i>Alona</i> sp.	2	0	0	0	13	0	30	15
<i>Ceriodaphnia cornuta</i>	98	1540	3	2	447	59	0	29
<i>Chydorus sphaericus</i>	0	12	0	0	66	0	0	0
<i>Daphnia carinata</i>	0	0	0	0	0	2	0	1
<i>Diaphanosoma excisum</i>	2	20	0	0	15	0	0	0
<i>Simocephalus vetulus</i>	0	0	0	0	0	0	8	4
Protozoa								
<i>Arcella areniata</i>	0	0	0	0	0	2	0	1
<i>A. discoides</i>	4	0	4	1	15	0	4	2
<i>Centropyxis aculeate</i>	0	0	4	1	0	0	0	0

Table 4 : Correlation Coefficient matrix between physico-chemical parameters and zooplankton groups during study period in Medical Pond (MP) and Chautal Pond (ChP) during study

Groups/Parameter	Pond	Cop.	Rot.	Clad.	Proto.	Nemat.	Ostra.	Insec.
Water temperature	MP	-0.36	-0.90	-0.09	-0.55	-0.48	0.99	0.08
	ChP	-0.39	-0.70	0.29	0.22	0.66	0.81	0.90
Transparency	MP	0.78	0.83	0.24	0.59	0.11	-0.88	0.02
	ChP	0.77	0.59	0.58	-0.94	-0.98	-0.90	-0.74
EC	MP	-0.62	-0.90	-0.16	-0.58	-0.27	0.97	0.04
	ChP	-0.94	-0.56	-0.49	0.73	0.93	0.77	0.62
pH	MP	-0.34	0.61	-0.19	0.19	0.67	-0.68	-0.23
	ChP	-0.01	-0.44	-0.44	-0.17	-0.49	-0.80	0.53
CO ₃ ⁻²	MP	-0.45	0.62	-0.38	0.00	0.52	-0.60	-0.41
	ChP	-0.01	-0.48	-0.57	0.62	0.23	0.20	0.05
HCO ₃ ⁻¹	MP	-0.79	-0.82	-0.25	-0.59	-0.10	0.87	-0.03
	ChP	-0.71	-0.43	-0.41	0.85	0.98	0.97	0.86
CO ₂	MP	-0.38	-0.89	-0.12	-0.57	-0.49	0.99	0.05
	ChP	-0.92	-0.49	0.56	0.50	0.75	0.53	0.41
DO	MP	0.31	0.59	-0.58	-0.40	-0.76	-0.20	-0.72
	ChP	0.93	0.96	0.92	-0.85	-0.73	-0.39	-0.12
Cl ⁻¹	MP	-0.64	-0.85	-0.26	-0.67	-0.35	0.97	-0.07
	ChP	-0.92	-0.54	-0.47	0.74	0.95	0.81	0.67

being during winter and spring. This might be due to the fact that this group becomes abundant at moderate temperature and can tolerate the deficiency of dissolved oxygen during these seasons. The significant negative correlation between nematodes and dissolved oxygen was obtained which also proved that this group was not affected by low level of DO. Protozoa showed similar distribution to nematodes, the highest (8 and 15 Org. l⁻¹) numbers at Medical Pond being during winter and spring. It was represented by 3 species namely *Arcella arenata*, *A. discoidea* and *Centropyxis aculeate*. Insects were considered least dominant group during the study. It recorded its highest abundance (14 Org. l⁻¹) in Medical Pond, while lowest (2 Org. l⁻¹) in Chautal Pond.

In the present study, 39 species of holoplankton were identified belonging to Copepoda (2 species), Rotifera (28 species), Cladocera (6 species) and Protozoa (3 species). Ten zooplankton species were found only in Medical pond, while 6 species were recorded in Chautal Pond and 23 species were recorded in both ponds (Table, 3). The low numbers of zooplankton species in Chautal Pond might be due to the fluctuations in pH values and the deficiency of dissolved oxygen. Mageed (2005) claimed that certain deaths occurred due to stress by high pH, which also had a synergistic action upon zooplankton together with ammonia and that there was a direct relationship between temperature increase in water and increase in zooplankton.

The highest positive correlation coefficient matrix (0.99) was recorded between ostracoda and two parameters; water temperature and CO₂ (Table 4) while the highest negative correlation was showed between transparency and

protozoa (-0.94) and transparency and nematoda (-0.98) at Chautal Pond. This indicated that these zooplankton groups can tolerate high organic pollution. Also, the present study revealed that ostracoda recorded a significant positive correlation ($r > 0.87$) with water temperature, electrical conductivity, bicarbonate and chloride in both ponds while it recorded a high negative correlation ($r > -0.68$) with transparency and pH in both ponds. Although the low values of dissolved oxygen were recorded in both ponds but high number of ostracods indicated that it can tolerate the deficiency of DO at high temperature. Dugel *et al.* (2008) mentioned that ostracods are widely distributed in all types of aquatic environment and water temperature, dissolved oxygen and electrical conductivity are the most effective factors influencing species composition of ostracods.

Transparency recorded a significant positive correlation with Cladocera, Rotifera and Copepoda while it recorded a significant negative correlation with Ostracoda in both ponds. Similar correlations were recorded by Mageed and Heikal (2005). In the present study, copepoda recorded a negative correlation with all the recorded physico-chemical parameters except with transparency ($r = 0.78$ and 0.77) in Medical and Chautal Ponds and dissolved oxygen ($r = 0.31$ and 0.93) in Medical and Chautal Ponds which recorded a high positive correlation. El-Serafy *et al.* (2009) stated that copepoda was the most dominant group in Lake Nasser, Egypt and attributed it to the good environmental conditions of the lake. Patalas and Salki (1992) found that high temperature affect physiology of several living organisms and their distribution. Gerten and Adrian (2002) noted that the abundance of cyclopoid copepod particularly in summer time was related to water temperature.

Table 5 : Zooplankton species, richness and diversity indices in Medical Pond (MP) and Chautal Pond (ChP) during the study

Seasons	Pond	Total species	Species Richness	Evenness	Shannon-Weinner	Simpson
Post-Monsoon	MP	23	3.714	0.612	1.920	0.760
	ChP	14	1.684	0.370	0.977	0.479
Winter	MP	19	3.251	0.691	2.036	0.770
	ChP	13	2.779	0.672	1.723	0.685
Spring	MP	15	2.142	0.532	1.439	0.563
	ChP	8	1.632	0.415	0.862	0.346
Summer	MP	11	2.136	0.811	1.944	0.821
	ChP	17	3.547	0.762	2.159	0.839
Average	MP	17	2.811	0.661	1.835	0.728
	ChP	13	2.411	0.555	1.430	0.587

The total number of species, species richness, Shannon-Weinner index and Simpson index values were higher in all the seasons in Medical Pond than Chautal Pond except during summer when all values were highest in Chautal Pond (Table 5). In all the recorded seasons, the zooplankton species richness was found to be high in Medical Pond during post-monsoon season (3.714) and low in Chautal Pond during spring season (1.632). Dash (1996) reported that the high value of Shannon's index, the greater is the planktonic diversity. Bajpai and Agarker (1997) reported that the species diversity would be low following the disturbance such as flood. The highest diversity indices were recorded during summer (pre-monsoon season). High Evenness index was recorded in Medical Pond (0.811) during summer indicated that species are more evenly distributed in this pond. Shannon-Weinner index and Simpson index (being 2.159 and 0.839) recorded the highest number in Chautal Pond indicated the effect of high vegetation. Similar observations were recorded by Kucznska-Kippen and Basinska (2008) who mentioned that the highest diversity index of the crustacean community was found among submerged vegetation in summer months. Dash (1996) reported that lower values of Shannon's index were recorded during September and October may be due to high downpour recorded as 244.2 mm and 100.9 mm. This report gains support from Adesalu and Nwankwo (2008) and Rajagopal *et al.* (2010). They reported that the low value of Shannon's index of plankton population in rainy season is due to dilution of water medium.

The marked variations in physico-chemical parameters and the abundance of floating macrophytes in Chautal Pond lead to environmental stress and can be considered as one of the important factors for reducing zooplankton biodiversity. As Chautal Pond receives high amount of organic matter from surrounding residential area, it is difficult to manage on the other hand, Medical Pond can be managed for fish culture, especially, for air breathing fishes (can face oxygen deficiency) like *Heteropenuste fossils Clarias batrachus* and *Channa punctatus* after monsoon for 6 months (October to March).

Acknowledgments

This work was supported by Center for International Co-operation in Science (CICS), India. The authors thank Prof. Asif A. Khan, Ex-Chairman Department of Zoology and Ex-Dean Faculty of Life Sciences, Aligarh Muslim University, India for their help during this work.

References

- Abdel-Satar, A.M.: Environmental studies on the impact of the drains effluent upon the southern sector of Lake Manzal, Egypt. *Egypt. J. Aqu. Biol. Fish.*, **3**, 17-30 (2001).
- Adesalu, T.A. and D.I. Nwankwo: Effect of water quality indices on phytoplankton of a sluggish Tidel Creek in Lagos, Nigeria. *Pakistan. J. Biol. Sci.*, **11**, 836-844 (2008).
- Ahmad, M.S.: Ecological survey of some algal flora of polluted habitats of Darbhanga. *J. Environ. Pollut.*, **3**, 147-151 (2008).
- Ahmad, U., S. Parveen, A.A. Khan, H.A. Kabir, H.R.A. Mola and A.H. Ganai: Zooplankton population in relation to physico-chemical factors of a sewage fed Pond of Aligarh (UP), India. *Biology and Medicine*, **3**, 336-341 (2011).
- Alam, A., A.A. Khan and R.K. Gaur: Observations on the alternate cladoceran peaks in an eutrophic freshwater pond. *Pure Appl. Sci.*, **14**, 77-78 (1995).
- APHA: Standard methods for the examination of water and waste water. 21st Edn., APHA, AWWA, WPCF, Washington, D.C., USA (2005).
- Bajpai, A.K. and M.S. Agarker: Lower plants at high altitudes, I. some plankton from Auli Skiing field. *Ecol. Environ. Conser.*, **3**, 97-100 (1997).
- Bozkurt, A. and S.E. Guven: Zooplankton composition and distribution in vegetated and unvegetated area in three reservoirs in Hatay, Turkey. *J. Animal Veter. Advan.*, **8**, 984-994 (2009).
- Castro, B.B., S.C. Antunes, R. Pereira, A.M. Soares and F. Goncalves: Rotifer community structure in three shallow lakes: Seasonal fluctuations and explanatory factors. *Hydrobiologia*, **543**, 221-232 (2005).
- Dash, M.C.: Fundamentals of Ecology. Tata McGraw Hill Publishing Company Limited, New Delhi (1996).
- Dugel, M., O. Kulkoyluoglu and M. Kilie: Species assemblages and habitat preferences of Ostracoda (Crustacea) in Lake Abant (Bolu, Turkey). *Belg. J. Zool.*, **138**, 50-59 (2008).
- Edmondson, W.T.: Freshwater Biology. 2nd Edn., John Wiley and Sons. Inc. New York & London, pp 1248 (1966).
- El-Serafy, S.S., A.A. Mageed and H.R. El-Enany: Impact of flood water on the distribution of zooplankton in the main chaneel

- of Lake Nasser, Egypt. *J. Egypt. Acad. Soc. Environ. Develop.* **10**, 121-141 (2009).
- Epifanio, C.E. and R.W. Garvine: Larval transport on the Atlantic continental shelf of North America: A Review. *Est. Coast. Shelf Sci.*, **52**, 51-77 (2001).
- Ghanai, A.H., S. Parveen and A.A. Khan: Study of some physico-chemical parameters in Medical pond, Aligarh. *The Ekologia*, **10**, 89-96 (2010).
- Gerten, D. and R. Adrian: Species- specific changes in the phenology and peak abundance of fresh water copepods in response to warm summers. *Freshwat. Biol.*, **47**, 2163-2173 (2002).
- Hamilton, S.K., S.J. Sippel, W.M. Lewis Jr and J.F. Saunders: Zooplankton abundance and evidence for its reduction by macrophyte mates in two Orinoco floodplain lakes. *J. Plankton Res.*, **12**, 345-363 (1989).
- Khalifa, N. and A. Mageed: Some ecological aspects on the zooplankton in Lake Manzala, Egypt. *Egypt. J. Zool.*, **38**, 293-307 (2002).
- Kamat, S. and V. Sima: Hydrobiological studies of two temple ponds in Ponda Taluka, Goa. *Ecol. Environ. Cons.*, **6**, 361-362 (2000).
- Kaushik, S. and D.N. Saksena: Physico-chemical limnology of certain water bodies of central India. In: *Freshwater Ecosystem of India* (Ed.: K. Vijaykumar). Daya Publishing House, New Delhi, pp. 1-58 (1999).
- Kimmel, D.G., M.R. Roman and X. Zhang: Spatial and temporal variability in factors affecting mesozooplankton dynamics in Chesapeake Bay: Evidence from biomass size spectra. *Limnol. Oceanogr.*, **51**, 131 – 141 (2006).
- Kuczynska-Kippen and A. Basińska: A spatio-temporal distribution of zooplankton between macrophyte and open water zones of Lake W'sowskie. *Teka, Comm. Prote. Format. Natu. Environ.*, **4**, pkt. MNiSW 4 (2008).
- Mageed, A.A.: Effect of some environmental factors on the biodiversity of holozooplankton community in Lake Qarun, *Egyptian J. Aqua. Res.*, **31**, 230-234 (2005).
- Mageed, A.A.: Distribution and long-term historical changes of zooplankton assemblages in Lake Manzala (south Mediterranean sea, Egypt). *Egyptian J. Aqu. Res.*, **33**, 183-192 (2008).
- Mola, H.R.: Seasonal and spatial distribution of *Brachionus* (Pallas, 1966; Eurotatoria: Monogonanta: Brachionidae), a bioindicator of eutrophication in lake El-Manzalah, Egypt. *Biol. Med.*, **3**, 60-69 (2011).
- Patalas, K. and A. Salki: Crustacean plankton in Lake Winnipeg. Variations in space and time as a function of lake morphology, geology and climate. *Can. J. Fish. Aquat. Sci.*, **49**, 1035-1059 (1992).
- Pennak, R.W.: *Freshwater Invertebrates of United States*. 2nd Edn., John Wiley & Sons Inc., New York, p. 803 (1978).
- Raja, P., A.M. Amarnath, R. Elangovan and M. Palanivel: Evaluation of physical and chemical parameters of river kaveri, Tiruchirappalli, Tamil Nadu, India. *J. Environ. Biol.*, **29**, 765-768 (2008).
- Rajagopal, T., A. Thangamani and G. Archunan: Comparison of physico-chemical parameters and phytoplankton species diversity of two perennial ponds in Sattur area, Tamil Nadu. *J. Environ. Biol.*, **31**, 787-794 (2010).
- Rajashankar, M., K. Vijaykumar and Z. Parveen: Zooplankton diversity of three freshwater lakes with relation to trophic status, Gulbarga district, North-East Karnataka, South India. *Inte. J. Systems Biology*, **1**, 32-37 (2009).
- Ruttner-Kolisko, A.: Planktonic rotifers. Biology and Taxonomy. *Binnengewasser. Suppl.*, **26**, 146 (1974).
- Shehata, S.M.A., K.K. Shehata, M.M. Hussien and A.A. Mageed: Taxonomy, population structure, and species diversity of Rotifera in the high Dam Lake. *Egypt J. Aquat. Biol. Fish.*, **2**, 1-36 (1998a).
- Shehata, S.M.A., K.K. Shehata, M.M. Hussien and A.A. Mageed: Taxonomical and ecological studies on some zooplankton species: Ciliata, Rhizopoda, Turbellaria and Crustacea of the High Dam Lake. *Egypt J. Aquat. Biol. Fish.*, **2**, 37-63 (1998b).
- Shiddamallayya, N. and M. Pratima: Impact of domestic sewage of fresh water body. *J. Environ. Biol.*, **29**, 303-308 (2008).