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Journal of Environmental Biology

ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Interrelationship between physico-chemical characteristics of a tropical lake and their impact on biodiversity of planktons

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Publication Info

Paper received:
14 August 2015

Revised received:
25 January 2016

Re-revised received:
29 March 2016

Accepted:
10 May 2016

Abstract

The physicochemical parameters including temperature, pH, dissolved O_2, free CO_2, total alkalinity, permanent hardness, salinity, transparency, specific conductivity, BOD, COD, phosphate and nitrate were studied in a tropical lake, called Bonhooghly Lake (situated at Baranagar, Kolkata) around the year 2014 and the correlation between the said parameters, as well as their impact on Biodiversity indices were made. There is stable increase of CO_2 content in water from August (27.24 mg l^{-1}) and afterwards due to decaying of plant materials. Therefore there is a slight fall of pH (7.1). Significant negative correlation ($p<0.01$) between pH and CO_2 content was also obtained. It also shows a significant negative correlation with O_2 content as well. During February and March transparency of water falls significantly with the increase of algal bloom. It significantly decreases dissolved O_2 content and pH but increases free dissolved CO_2 ($p<0.01$). Phosphate has a definite correlation with nitrate content of the Lake, possibly because both are among the most essential nutrients of living system. Increase of one obviously indicates escalation of other. During the early months of the year phosphate and nitrate content of water increased steadily (up to 0.13 and 1.85 mg l^{-1} respectively) and a very high number of *Chlamydomonas*(up to15100 l^{-1}) and *Chlorella (*up to 13140 l^{-1})were observed. Species richness indices (Menhinick's index) of Phytoplanktons were observed maximum in the month of May, dominance (Simpson's index) in January and diversity (Shannon-Weaver index) in April. Zooplanktons also followed the same trend indicating close interdependence. It was significant that apart from other factors, temperature played a most pivotal role in bringing the diversity in the plankton community.

Key words

Physicochemical parameters, Correlation, Planktons, Simpson's index, Shannon-Weaver index

Introduction

Water the essence and sustenance of life, is among the biggest and the most crucial natural resource both in terms of quantity and quality. Disputes on water are on increasing day by day and water is becoming an issue of concern. Although abuse of water and destruction of aquatic systems is as old as civilization, escalating industrialization, urbanization and agricultural activities have brought irreversible change in such systems. Unplanned and excessive exploitation and mounting anthropogenic influences in and around aquatic ecosystems have resulted in pollution problems. Lakes, being fragile ecosystems are vulnerable to such problems. Pollution caused by plethora of human activities primarily affects physico-chemical characteristics of water leading to destruction of community, disrupting delicate food webs, deteriorating environment of the Lake.

This is the basic perspective of Limnology, which is an interdisciplinary science that involves a great deal of detailed field as well as laboratory studies to understand the structural and functional aspects and problems associated with the freshwater environment, from a holistic point of view. Aquatic biodiversity is threatened primarily by human abuse and mismanagement of both living resources and the ecosystems that support them. Most of the ponds are getting polluted due to domestic waste, sewage, industrial and agricultural effluents (Shiddamallayya and Pratima, 2008; Shekhar et al., 2008). The requirement of water in all lives, from micro-organisms to man, is a serious problem today because all water resources have reached to a point of crisis due to unplanned urbanization and industrialization. Most of the species of planktonic organisms are cosmopolitan in distribution. Water quality assessment generally involves analysis of physico-chemical, biological and microbiological parameters and reflects on abiotic and biotic status of the ecosystem (Kulshrestha and Sharma, 2006; Mulani et al., 2009). In ecology, phytoplankton has been long used as an effective water bioindicator that is sensitive to environmental changes. Some species thrive in highly eutrophic waters, whereas some others are very sensitive to environmental changes (Sakset and Chankaew, 2013). On the other hand, zooplankton are one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem, such as food chains, food webs, energy flow and cycling of matter (Park and Shin, 2007). Zooplanktons play a vital role as primary consumer of aquatic food chain, which in turn influences the productivity of fresh water ecosystem. The distribution of zooplankton community depends on a complex of factors such as, change of climatic conditions, physical and chemical parameters and vegetation cover. According to Contreras *et al.,* 2009 the zooplankton plays an integral role and serves as bio-indicators and it is a well-suited tool for understanding water pollution status. A number of studies by Smitha et al (2007), Kolayli and Sahin (2009), Mukherjee et al (2010), Rajagopal *et al.* (2010), have been carried out on ecological condition of freshwater bodies in various parts of India in relation to phyto and zoo planktons. On the other hand, Chattopadhyay (2012), Kanagasabapathi and Rajan (2010), Giripunge *et al.* (2013), Mishra *et al.* (2010), Gayathri *et al.* (2013), Balakrishna, et al (2013), Naik et al (2014), Gadekar et al (2014), and Bera *et al.* (2014) concentrated their studies on physicochemical parameters and zooplanktons. However, information on relationship between physico-chemical parameters and planktonic biodiversity indices is very limited. The present investigation attempted to study the correlation between physicochemical parameters, like temperature, pH etc., as well as their impact on species richness, species dominance and species diversity indices of the ecosystem.

Materials and Methods

Bonhooghly Lake (also called Baranagar Lake, situated at Baranagar, Kolkata) was selected for the purpose of present study. The Lake has an average elevation of 12 meters (39feet). It is situated east of the Hooghly River. It is basically an oxbow lake, created by silting of a tributary of river Hooghly. Some parts of the lake occasionally remains infested with hyacinth and fed by two sewage canals at the South-East and North-East sections**.** It is a rich source of biodiversity of the area. The zone is now facing a hazard of urban sewage pollution. Five sites surrounding Bonhooghly Lake were selected for this investigation.

The survey of the Lake was carried out for the period of one year from January 2014 to December 2014.Water samples were collected regularly from the five selected sites of the lake, during the early hours within 9.30 to 10 am from five spots thrice every month, therefore the total number of samples equals to 15. The physicochemical parameters including temperature, pH, dissolved O_2, free CO_2, total alkalinity, permanent hardness, salinity, transparency, specific conductivity, BOD, COD, phosphate and nitrate of the lake were studied (following APHA and AWWA. 2012). Temperature (air and surface water) was recorded on the spot using Centigrade thermometer. Water sample pH was studied by digital pH meter (model, EI, Delux 101 E, SR 1406045); specific conductivity was measured by conductance instruments (Conductivity meter); dissolved oxygen content of Lake water was measured by Winkler's iodometric titration method by sodium thio sulfate, using starch as an indicator; dissolved carbon dioxide was measured by titrating the sample with sodium hydroxide solution taking phenolphthalein as indicator; total alkalinity was measured by titrating the sample with sulfuric acid taking phenolphthalein and methyl orange as indicator; salinity (from chloride content) was measured by titrating the sample with silver nitrate solution with potassium chromate indicator; permanent hardness was measured by titrating it with standardized EDTA by sodium carbonate taking Eriochrome Black-T as indicator; alkalinity was measured by titration with sulfuric acid using methyl orange as an indicator. Secchi disc was employed to measure transparency of water. BOD was measured by 5 days incubation of the sample in BOD incubator at 20^{o} C and then after by titration method. COD was measured by potassium dichromate oxidation in 2 hours and by titrating the sample with ferrous ammonium sulfate with ferronin indicator. The nitrite nitrogen (NO_2) was measured by spectrophotometric method at 220 and 275nm wavelength by Spectrophotometer: (Electronics India model No. 2373 E) using potassium nitrate as standard. Soluble reactive phosphorus (PO_4) and total phosphorus (TP) was measured by the ascorbic acid reduction method. Absorbance of thus formed phosphomolybdenum blue was measured from 800 nm to 900nm spectrophotometrically.

For the qualitative and quantitative analyses, the plankton samples were collected by filtering with standard silk nets with the capacity of 10 liters of water with 20 mesh size. The collected samples were preserved in 4% formalin solution and stored in 200 ml bottle and they were concentrated into 20 ml using 6000 rpm centrifuge for two minutes and then observed microscopically using Sedgwick-Rafter plankton counting cell. For community structure analysis three indices are generally used to obtain the estimation of species richness (Menhinick, 1964), species dominance (Simpson, 1949) and species diversity (Shannon-Weaver, 1949).Statistical values of correlation coefficient were calculated by the method of Birader (2002).

Results and Discussion

The inter-relationship between the physicochemical parameters and their relation with plankton production are very important to study the trophic status of the lake. The maximum temperature was obtained in May and minimum in January (Table 1); pH maximum in December minimum in September; O_2 content maximum in July minimum in September; CO_2 content maximum in October (possibly due to putrefaction of aquatic flora and fauna) minimum in June; Alkalinity maximum in September minimum in July (possibly due to onset of rainy season); Hardness maximum in May (possibly due to concentration of salts dissolved in water) minimum in July (possibly due to onset of rainy season); Salinity maximum in March minimum in August; Transparency maximum in September minimum in March (due to algal bloom); Conductivity maximum in February minimum in July; BOD maximum in March (due to algal bloom) minimum in May; COD maximum in April minimum in August; Phosphate content maximum in March minimum in September and Nitrate content maximum in July minimum in November.

It was observed that during the months of January to May due to algal bloom Phosphate and nitrate content was increased along with increase of BOD. There is an increase of CO_2 content in water from August to October due to putrefaction. Therefore there is a slight fall of pH. With the process of putrefaction dissolved O_2 content falls. During February and March transparency of water falls significantly with the increase of algal bloom. It significantly decreases dissolved O_2 content and pH but increases free dissolved CO_2.

Among the phytoplanktons, 18 genera mainly under chlorophyceae, **c**yanophyceae, and bacillariophyceae and among the zooplanktons 20 genera including cladocerans, copepods and rotifers were identified (Table 2). Although all the species were not obtained around the year, except

Table 1 : Physico-chemical parameters of the Bonhooghly Tropical Lake, Kolkata during 2014 (mean± SD)

Month	Temperature (°C)	pH	Dissolved O_2 (mg l^{-1})	Free CO_2 (mg l^{-1})	Total alkalinity (mg l^{-1})	Permanent hardness (mg l^{-1})	Salinity (mg l^{-1})	Transparency (cm)	Specific conductivity (µm hos cm^{-1})	BOD (mg l^{-1})	COD (mg l^{-1})	Phosphate (mg l^{-1})	Nitrate (mg l^{-1})
Jan	17.51	7.95	10.65	17.47	165.27	142.16	620.36	63.78	442.67	5.59	315.56	0.11	0.31
	±1.65	±0.63	±0.78	±1.35	±11.57	±9.95	±58.93	±5.68	±32.31	±0.50	±25.24	±0.01	±0.02
Feb	20.32	7.92	10.6	12.7	185.56	184.26	611.45	51.89	482.89	6.16	324.78	0.12	1.21
	±1.94	±0.51	±0.76	±0.86	±12.99	±16.21	±58.09	±4.57	±47.81	±0.52	±27.61	±0.01	±0.09
Mar	25.44	7.5	11.84	19.47	172.3	164.1	650.6	50.37	436.1	6.88	336.63	0.13	1.54
	±2.39	±0.41	±0.86	±1.36	±12.06	±14.44	±61.81	±4.43	±43.17	±0.61	±26.93	±0.01	±0.11
Apr	29.63	7.22	12.4	20.46	161.2	174.25	558.45	82.12	469.67	4.64	367.02	0.1	1.65
	±2.07	±0.49	±0.91	±1.43	±11.26	±15.39	±53.05	±7.23	±46.50	±0.39	±29.36	±0.01	±0.16
May	33.01	7.1	9.3	16.06	148.35	213.44	510.6	92.54	429.11	1.2	266.59	0.07	1.65
	±2.90	±0.32	±0.79	±1.19	±10.38	±14.94	±48.51	±8.24	±42.48	±0.17	±23.73	±0.01	±0.13
Jun	28.65	7.2	12.44	9.44	80.15	123.9	210.6	98.13	225.05	2.14	144.32	0.08	1.74
	±2.39	±0.35	±1.03	±0.79	±5.61	±8.67	±20.05	±8.73	±20.12	±0.18	±12.84	±0.01	±0.16
Jul	26.05	7.12	13.04	15.84	70.61	103.54	220.35	111.234	212.09	4.2	59.14	0.09	1.85
	±2.16	±0.45	±1.08	±1.17	±4.94	±7.25	±20.93	±9.98	±18.98	±0.35	±5.26	±0.01	±0.15
Aug	24.56	7.1	8.43	27.24	130.44	162.4	112.6	150.11	303.1	4.84	12.13	0.06	0.45
	±2.11	±0.45	±0.70	±2.02	±9.13	±13.48	±10.70	±12.46	±25.28	±0.41	±1.01	±0.01	±0.03
Sep	27.73	6.55	6.47	30.64	200.24	184.33	155.3	170.9	389.83	4.9	37.23	0.01	0.36
	±2.00	±0.39	±0.54	±2.27	±17.80	±15.30	±14.75	±14.18	±32.36	±0.41	±3.09	±0.01	±0.03
Oct	25.22	6.85	6.86	31.83	178.4	168.73	492.45	120.65	471.13	4.43	145.24	0.02	0.2
	±2.37	±0.30	±0.57	±2.36	±15.86	±14.05	±40.87	±10.01	±39.77	±0.37	±12.05	±0.01	±0.01
Nov	22.52	7.15	10.1	12.41	156.21	160.63	492.15	118.09	456.53	4.82	224.5	0.05	0.14
	±1.85	±0.37	±0.84	±1.07	±13.89	±14.28	±43.75	±8.27	±31.96	±0.40	±15.72	±0.01	±0.01
Dec	19.64	8.02	10.38	11.65	152.1	112.3	320.4	82.4	447.04	3.62	303.41	0.06	0.23
	±1.71	±0.52	±0.92	±1.77	±13.57	±9.98	±28.47	±5.77	±31.29	±0.25	±21.24	±0.01	±0.02

Daphnia among the zooplanktons and *Chlamydomonas* and *Volvox* among the phytoplanktons, but in the month of March-April almost all possible type of phyto and zooplanktons were observed. During the early months of the year the number of *Chlamydomonas* and *Chlorella* were observed to be very high in number. Rotifers represented by *Brachionus, Keratella* etc were observed almost throughout the year. *Brachionus* could be regarded as the ideal indicator of water pollution (Chattopadhyay, 2012). Species richness indices of Phytoplanktons were observed maximum in the month of May. Simpson's index of dominance increased maximally in the month of January and diversity (Shannon-Wiener index) in the month of April. (Table 3). Zooplanktons in all cases followed the same trend indicating close interdependence.

There is a definite interrelation between water hardness, alkalinity and specific conductivity. Here it has been observed that though BOD do not have a definite correlation with phosphate and nitrate content of the lake but COD possess definite correlation with phosphate content. Phosphate has a definite correlation with nitrate content of

Table 2 : Occurrence of phyto and zoo planktons per liter (mean, rounded up in a multiple of 10) in Bonhooghly Tropical Lake, Kolkata during 2014

Genus	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Phytoplanktons												
Anabaena	-	-	-	410	100	-	-	-	-	-	-	-
Chlamydomonas	600	15100	6500	610	270	1400	400	400	200	200	200	300
Chlorella	11200	5680	13140	1460	200	600	700	1000	220	-	240	200
Cloelastrum	-	-	-	250	-	-	-	-	-	-	-	-
Closterium	100	2000	1200	620	330	600	100	200	-	10	160	100
Coelastrum	20	1260	1100	200	300	600	100	100	-	240	10	120
Cyclotella	-	-	100	160	-	-	-	-	-	-	-	-
Diatoms	220	1100	260	310	200	800	900	1200	-	200	300	300
Euglena	100	-	10	140	210	300	300	300	20	130	10	100
Melosira	10	-	10	150	10	340	340	300	100	100	10	10
Microcystis	10	-	200	200	100	100	100	200	100	-	-	10
Nitzschia	-	-	200	160	-	-	-	-	-	-	-	-
Nostoc	-	-	200	310	100	-	-	-	-	-	-	-
Phacus	220	200	100	1500	300	400	800	1600	0	200	200	300
Scenedesmus	100	-	200	530	10	100	100	100	200	-	-	100
Spirogyra	100	-	100	220	100	100	100	100	100	-	-	100
Syndera	-	-	200	300	-	-	-	-	-	-	-	-
Volvox	300	300	200	230	300	500	700	900	100	300	100	300
Total	**12980**	**25640**	**23720**	**7760**	**2530**	**5840**	**4640**	**6400**	**1040**	**1380**	**1230**	**1940**
Zooplanktons												
Asplanchna	-	-	100	100	100	-	-	-	-	-	-	-
Asplanchopus	600	-	-	120	-	-	-	-	-	-	-	-
Bosmina	-	-	100	610	10	100	10	10	100	200	100	100
Brachionus	100	400	500	230	100	200	400	200	-	-	100	100
Cephalodella	-	-	100	100	20	10	20	100	110	-	100	-
Ceriodaphnia	100	410	310	100	100	30	200	100	-	20	20	-
Chidorus	-	-	100	230	-	-	-	-	-	-	-	-
Cyclops	30	630	420	340	-	200	300	300	100	220	-	100
Cypris	10	400	400	10	100	10	100	200	-	10	-	-
Daphnia	200	140	100	150	210	400	200	200	100	200	100	10
Diaptomus	10	10	10	100	-	10	100	10	100	-	-	140
Diphanosoma	-	20	20	150	100	120	10	10	-	20	100	100
Filina	-	100	100	150	100	-	-	-	120	10	-	10
Keratella	320	-	-	200	20	500	400	480	100	200	100	100
Moina	10	100	100	900	100	20	100	200	-	10	-	-
Nauplius	100	-	-	300	10	10	20	200	-	-	-	-
Polyarthra	-	10	10	100	-	10	10	10	100	100	20	-
Scaridium	-	-	100	100	100	10	-	20	-	-	-	10
Sida	100	10	10	200	100	-	100	10	-	10	100	200
Testudinella	-	-	-	100	100	-	-	-	-	-	-	-
Total	**1580**	**2230**	**2480**	**4290**	**1270**	**1630**	**1970**	**2050**	**830**	**1000**	**740**	**870**

Table 3 : Species richness, dominance and diversity indices of phytoplanktons and zooplanktons in Bonhooghly tropical lake, Kolkata during 2014

Diversity indices	Plankton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Species richness	Phyto	1.05	0.44	1.04	2	2.78	1.57	1.76	1.5	2.48	2.15	2.57	2.72
	Zoo	2.77	2.33	3.21	3.1	4.21	3.47	3.15	3.31	2.78	3.48	3.31	3.39
Simpson's index D	Phyto	0.75	0.41	0.39	0.1	0.1	0.13	0.13	0.15	0.16	0.15	0.17	0.12
	Zoo	0.22	0.19	0.12	0.1	0.09	0.19	0.14	0.13	0.13	0.18	0.13	0.15
Shannon-Weaver	Phyto	0.67	1.22	1.34	2.6	2.43	2.24	2.19	2.1	1.94	1.92	1.84	2.23
	Zoo	1.82	1.85	2.32	2.7	2.51	1.9	2.18	2.23	2.08	1.87	2.09	2.03

the Lake, possibly because both are among the most essential nutrients of living system. Increase of one obviously indicates escalation of other. Temperature shows significant negative correlation with pH but positive correlation with nitrate content. On the other hand, pH shows significant negative correlation with free CO_2 and transparency but positive correlation with phosphate and COD. Dissolved O_2 shows significant negative correlation with free CO_2, alkalinity and transparency, but positive correlation with phosphate and nitrate. Free CO_2 shows positive correlation with transparency of water; possibly it indicates levels of organic pollution. Total alkalinity shows positive correlation with permanent hardness and specific conductivity, as because increase of salt content in water is responsible to increase permanent hardness and conductivity. Salinity shows negative correlation with transparency but positive correlation with specific conductivity due to the above mentioned reason. Transparency shows negative correlation with COD and phosphate. Specific conductivity shows positive correlation with COD, which shows positive correlation with phosphate. The latter shows positive correlation with nitrate

Species richness index of phytoplankton shows negative correlation with BOD and phosphate. On the other hand, zoopanktons show positive correlation with temperature, BOD and phosphate. Simpson's index of phytoplanktons shows negative correlation with temperature but positive correlation with pH and BOD. Zooplanktons show negative correlation with temperature only. Shannon-Weaver index of phytoplankton shows positive correlation with temperature but negative correlation with BOD. Zooplankton shows the same trend, except it has no significant relation with BOD. It indicates that temperature in most cases plays a pivotal role. Although the implication of BOD on the number of living cells in the community is obvious, so its significant correlation with biodiversity of phytoplanktons and non-significance with zooplanktons possibly does not signify any meaningful conclusion, because oddness or evenness of a community cannot be reflected in their biological need of oxygen.

The present work was compared with the findings of Gayathri *et al.* (2013), Naik *et al.* (2014), Kolayli and Sahin (2009), Gadekar *et al.* (2014), Balakrishna, *et al.* (2013), Rajagopal *et al.* (2010), Mukherjee *et al.* (2010), Chattopadhyay (2012), Kanagasabapathi and Rajan (2010), Giripunge *et al.* (2013) Mishra *et al.* (2010) and Bera et al (2014). Gayathri *et al.* (2013) studied Physico-chemical parameters of water of Nalligudda Lake of Bangalore and obtained temperature (24.2-32.3^{o}C), pH (7.1-8.5), total dissolved solids (300-800 mg l^{-1}), electrical conductivity (468.75-1250 µ mhos cm^{-1}), dissolved oxygen (3.9-7.15 mg l^{-1}), biological oxygen demand (2.4-7.2 mg l^{-1}), chemical oxygen demand (9.9-41.4 mg l^{-1}), phosphate (0.32-3.1 mg l^{-1}) and nitrate (2.86-6.4 mg l^{-1}). In the present investigation phosphate and nitrate shows a bit lower value, but COD shows higher value. Gayathri *et al.* (2013) observed totally 51 species of phytoplankton belonging to different taxonomic groups. Among these, 22 species belonged to Chlorophyceae, 8 species to Euglenophyceae, 2 species to Chrysophyceae, 2 species to Dinophyceae, 10 species to Bacillariophyceae and 7 species to Cyanophyceae. Chlorophyceae formed the dominant group. In the present investigation lower number of varieties was obtained. Distribution of phytoplankton, productivity and chlorophyll-a concentration in relation to physico-chemical parameters viz. water temperature, pH, total suspended solid, turbidity, dissolved oxygen, biochemical oxygen demand, salinity and nutrients (NO_2-N, NO_3-N, PO_4-P and SiO_4-Si) were studied by Naik et al (2014) for pre-monsoon, monsoon and post-monsoon during the year 2005 in Dhamara estuary east coast of India. The major groups of phytoplankton species were diatoms followed by dinoflagellates and other algae. A total of 43 species of phytoplankton comprising 32 diatoms, 6 dinoflagellates and 5 other algae were recorded during the entire study period. The species *Nitzschia*, *Chaetoceros* and *Coscinodiscus* were identified as dominant diatoms group. Higher values of phytoplankton (28612 nos l^{-1}) with high rate of photosynthesis were observed during post-monsoon season, which was responsible for increasing DO (8.72 mg l^{-1}) and pH (8.24) of the water column. Though there was no significant seasonal variation of pH. Generally, the trend distribution of phytoplankton closely followed the distribution of salinity, pH and DO of estuarine water. In the present work similar value phytoplanktons was observed in February and March only and the number of species was much less than the investigation of Naik et al (2014). The epipelic algal flora and its seasonal variations in the Balikli Dam Reservoir were investigated by Kolayli and Sahin (2009) between May and November 2006. A total of 55 species were identified, most of which belonged to the Bacillariophyta (31). Other taxonomic groups present were Chlorophyta (9), Cyanoprokaryota (8) and Euglenophyta (7). *Navicula cryptocephala*, *N. veneta* and *Hannaea arcus* were the most important species, regarding frequency of occurrence and relative abundance in the epipelic algal flora. While the highest density of epipelic community was found in September, the lowest density was in August. The highest Shannon-Weaver diversity index in the epipelic flora was found to be 2.764 in August. In the present investigation the value is 2.1 in August but the maximum value 2.6 occurred in April. In the study of Kolayli and Sahin (2009) ice, light, rainfall and water temperature were found to be the most important factors in regulating the growth of epipelic community in Balikli dam reservoir, because their increase increases most of the phytoplankton production. In Autumn the epipelagic phytoplanktons attained the maximum value.

According to Gadekar *et al.* (2014) zooplanktons are the grazers on the phytoplankton and a food base for the carnivorous as well as omnivorous fishes. Their diversity reflects the quality of water hence constitutes the important ecological parameter to assess it. Zooplanktons are good indicators of the changes in water quality because they are strongly affected by environmental conditions and respond quickly to changes in water quality. They are the intermediate link between phytoplankton and fish. Hence qualitative and quantitative studies of zooplankton are of great importance. Gadekar *et al.* (2014) made qualitative and quantitative studies of zooplanktons in Pangdi Lake of Gondia district during January 2013 to December 2013, using microscopic studies of zooplankton. This investigation revealed that 25 genera belonging to five major groups, i.e., Protozoa (six genera), Rotifera (five genera), Cladocera (five genera), Copepoda (six genera) and Ostracoda (three genera). The zooplanktonic population and the physic-chemical parameters like temperature, pH, transparency, turbidity, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), free CO_2, alkalinity, total hardness, chlorides, sulphates, phosphates, biological oxygen demand (BOD) and chemical oxygen demand (COD) of Ghanpur Lake, Warangal district, Andhra Pradesh, India, have been studied by Balakrishna *et al.* (2013) for a period of twelve months. During summer temperature, pH, conductivity, TDS, DO, alkalinity, total hardness, chlorides and BOD was found to be increased and gradually decreased in rainy season. Sulphates and phosphates were found to be high in winter season and low in summer season. Therefore, this lake has rich number of species and biodiversity of aquatic animals. A total of 13 Zooplanktons were identified, among these rotifers 7 species, Copepods 3 species, Cladocera 2 species, Ostracoda 1 species, of which rotifers and copepods are dominating. Rotifera, Cladocera and Copepod populations were high during summer season and low in rainy season. While the Ostracode species were recorded high in rainy season and low in winter season. The present work also shows almost similar result. Almost similar studies on zooplankton were made by Rajagopal *et al.* (2010). They assessed the zooplankton species richness, diversity, and evenness and to predict the state of three perennial ponds of Virudhunagar district, Tamilnadu according to physico-chemical parameters. A total of 47 taxa were recorded: 24 rotifers, 9 copepods, 8 cladocerans, 4 ostracods and 2 protozoans. More number of zooplankton species were recorded in Chinnapperkovil pond (47 species) followed by Nallanchettipatti (39 species) and Kadabamkulam pond (24 species). Among the rotifers, *Branchionus* sp. was abundant. *Diaphanosoma* sp. was predominant among the cladocerans. Among copepods, numerical superiority was found in the case of *Mesocyclopes* sp. *Cypris* sp. repeated abundance among ostracoda. Their study revealed that zooplankton species richness R_1 (following the method of (Margalef, 1951) and R_2 (following the method of Menhinick, 1964) was comparatively higher (R1: 4.39; R2: 2.13) in Chinnapperkovil pond. The species diversity (Shannon's index =H', N_1 = Hill's first diversity, those most sensitive to changes in rare species, N_2 = Hill's second diversity, those most sensitive to changes in common species) was higher in the Chinnapperkovil pond (H': 2.53; N_1: 15.05; N_2:15.75) as compared to other ponds. The water samples were analyzed for temperature, pH, electrical conductivity, alkalinity, salinity, phosphate, hardness, dissolved oxygen and biological oxygen demand. The findings of Rajagopal *et al* (2010) also included Correlation coefficient values among certain physico-chemical parameters the three ponds. Higher value of physico-chemical parameters and zooplankton diversity were recorded in Chinnapperkovil pond as compared to other ponds. The zooplankton population shows positive significant correlation with physico-chemical parameters like temperature, alkalinity, phosphate, hardness and biological oxygen demand, wherea negatively correlated with rainfall and salinity. The study revealed that the presence of certain species like, *Monostyla* sp., *Keratella* sp., *Lapadella* sp., *Leydigia* sp., *Moinodaphnia* sp., *Diaptomus* sp., *Diaphanosoma* sp., *Mesocyclopes* sp., *Cypris* sp. and *Brachionus* sp. is considered to be biological indicator for eutrophication, which corroborates with the present investigation. Zooplankton plays a crucial role in aquatic ecosystem and a number of water parameters involved in it. Dissolved oxygen content and salinity range of the ponds were lower than the present investigation, alkalinity, hardness and BOD was similar, but phosphate content was a bit higher. Range of species richness index was more or less similar to the present study. The species diversity of a cultural eutrophic lake at Ranchi was studied by Mukherjee et al (2010). The lake receives daily detergent inputs in the form of washings of a variety of objects. A model was constructed for the estimation of detergent inputs from the increase in the phosphate concentration, and from changes in the concentration of inorganic carbon. Nutrients such as inorganic carbon, nitrates, phosphates, sulphates were found to be high in contrast to natural unpolluted systems. The DOM, COD and BOD were also found to be high suggesting organic pollution. The growth and development of the plankton constituents was studied in this regime. The natural planktonic rhythm was found to be modified by the polluted condition existing in the lake. The phytoplankton exhibited four peaks in March, May, August, and November while, the zooplankton showed three peaks in February, July and October. The abundance of zooplankton during the annual cycle oscillated with that of the phytoplankton. There was much more evenness in the zooplankton population in comparison to the phytoplankton. Analysis of both, the zooplankton as well as the phytoplankton population was done using the Bray-Curtis dissimilarity index, importance value index, and Shannon-Weaver diversity index. The importance value index was found to provide a better evaluation of the plankton community than the diversity index. The phytoplankton population showed no correlation with nutrient availability as indicated by the correlation-regression analysis and the planktonic rhythm was not in tune with normal unpolluted conditions. The mean oxygen content of Mukherjee *et al.* (2010) was similar, pH was higher, BOD was higher and COD was lower to present investigation, but a much higher peak of phytoplankton was observed in the month of November.

Chattopadhyay (2012) has made a study of biodiversity on both phyto and zooplankton in relation to different physicochemical parameters including the presence of heavy metals in Bonhooghly Lake during 2011 to 2012. During May to August phytoplanktons, mainly Chlamydomonas population in the lake increased enormously. While in September to December Chlamydomonas population decreased. Noticeably, during January to April their variety relative to total number of individuals was high. Hence, species richness index was high. Moreover, though concentration of all planktons were low in water, but Simpson's reciprocal index and Shannon-Wiener index were high due to 'evenness' of species. On the other hand, during May to August the species richness index (Which does not depend on 'evenness') was depleted. However, in the present work the population of Chlamydomonas and Chlorella increased several fold during the early months of the year. Chattopadhyay (2012) observed that Shannon-Wiener index increased to some extent because the total number of species in the sample along with their relative concentration increased maximally. However, Simpson's reciprocal index became low. Shannon-Wiener index was elevated a little during the period. During September to December there was a decreasing trend of Simpson's index and Shannon-Wiener index due to low abundance and evenness of species. Concentration of rotifers, cladocerans and copepods then decreased significantly. Apart from physico-chemical factors the result can be negatively correlated with the increase of concentration of chromium, manganese, and lead. It was also observed that COD in the lakes increased several fold in the subsequent years. Possibly it indicates silting and/or urban pollution, and/or sewage pollution. Bera *et al.* (2014) continued an investigation for a period of one year from March, 2010 to February, 2011 to assess the correlation between physico-chemical parameters of water and zooplankton availability in Kangsabati Reservoir, Mukutmanipur, West Bengal. Among the zooplankton population four major groups *viz.* Rotifera, Copepoda, Cladocera, Protozoa and two minor groups: *viz.* Ostracoda and Amphipoda were observed. 33 species of Rotifera, 16 species of Copepoda, 22 species of Cladocera, 4 species of Protozoa, 2 species of Ostracoda and 1 species of Amphipoda were identified. The zooplankton population showed strong correlation with the parameters like water temperature, dissolved oxygen, alkalinity, phosphate, total inorganic nitrogen, free CO_2 etc. Available species were *Asplanchna reticulata*, *Synchaeta oblonga*, *Anareopsis fissa*, *Keratella valgatropica* under rotifera; Nauplii, *Microcyclops varicans*, *Paracyclops fimbriatus* under copepoda; *Ceriodaphnia cornuta*, *Daphnia ambigua*, *Bosmina longirostris* etc., under cladocera; *Amoeba proteus* and *Difflugia* sp. under protozoa; *Cyprinotus* sp. under ostracoda and *Hyperia macrocephala* under amphipoda. They found Zooplankton population was high in winter season while low in rainy season. Moreover, Ganai and Parveen (2014), Senthilkumar and Sivakumar (2008), Tas and Gonulo (2007) studied the influence of different physicochemical factors on phytoplankton and algal biodiversity and other workers like Kiran *et al.* (2007), Islam (2007), Goswami and Mankodi (2012), Korai *et al.* (2008), Kadam and Tiwari (2012), Dhembare (2011), Vincent et al (2012), Parikh and Mankodi (2012), studied different aspects of zooplankton biodiversity. Ganai and Parveen (2014) concluded that the most important factors affecting the phytoplankton distribution are water temperature, CO_2, chloride, transparency, TDS, alkalinity and dissolved oxygen. However, conductivity and hardness has lesser influence on the distribution of planktons. In the present work almost similar result was obtained. In case of zooplanktons, according to Bera *et al.* (2014) several groups of are affected differentially to the physicochemical parameters. As for example, pH, dissolved oxygen with rotifers; alkalinity with copepods; cladocera with free CO_2, conductivity; phosphate, total inorganic nitrogen, hardness, rainfall with protozoa ; dissolved oxygen with ostracoda; chloride, salinity and magnesium with amphipod have the positive influence to maintain the zooplanktonic abundance in the reservoir. According to Kumar *et al.* (1912) phosphate is one of the major cellular components of an organism. The compound of phosphate is necessary elements in composition of cell. They are found in DNA, RNA and enzymes in cell. So nutrient like phosphate and nitrate play a key role controlling these fluctuations and the important factor controlling production, growth and distribution of zooplankton in freshwater ecosystem. In the present study also the correlation between phosphate and nitrate as well as their correlation with species diversity of phyto and zoo planktons were established. All the said physicochemical factors along with phosphate and nitrate therefore can bring an additive influence on the biodiversity indices of the zooplanktons.

Acknowledgement

The first author is grateful to UGC (ERO) for financial assistance.

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