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Limnological Studies of Temple Ponds in Cachar District, Assam, North East India

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Abstract

A comparative analysis of limnological status of two representative temple ponds of Cachar district in Assam, North East India, was carried out during December 2009 to November 2010. While one pond (Pond 1) was located at the center of the township area, the other pond (Pond 2) was located away from the township complex but was within the vicinity of a tea garden complex. For carrying out the present study, physico-chemical and biological variables of water were analyzed. The study revealed significant variations in some physico-chemical and biological properties of water in the two ponds. A total of 32 genera of phytoplankton and 11 genera of zooplankton were observed in the study area as a whole, out of which Pond 1 had greater taxonomic richness of both the phyto- and zooplankton communities. In both the ponds the most dominant class of phytoplankton was Chlorophyceae and most dominant group of zooplankton was Copepoda. TSI values revealed that both the ponds were in mesotrophic conditions though located under different land use systems. However, when compared Pond 1encountered greater organic input than Pond 2. Canonical correspondence analysis revealed that amongst all the environmental variables, rainfall, conductivity, water temperature and free carbon dioxide bring highest variability to the plankton communities of the temple ponds.

Keywords: Temple ponds, water quality, chlorophyll, plankton, TSI.

Introduction

Freshwaters of the world are collectively experiencing markedly accelerating rates of qualitative and quantitative degradation[1]. Poor water quality is often associated with increased trophic state which in turn disturbs the numerous ecosystem services[2] and in this regard temple ponds are not exception. Over the years ecological studies have shown that chemical measurements reflects water quality at a given time while biological assessment reflects condition that have existed in a given environment over a long period of time[3]. Plankton are very sensitive to the aquatic environment they live in and any change in the water properties (both- physical and chemical) leads to change in their community structure and ultimately their functions in aquatic ecosystems. Therefore, plankton population observation may be used as a reliable tool for biomonitoring studies to assess the pollution status of aquatic bodies[4].

Some limnological studies on temple ponds were made in India[5-9]. In Cachar district of Assam, North East India, Das and Gupta[10] studied insect community (Hemiptera) of temple ponds. However, no literature regarding the limnology of temple pond with special reference to the phyto- and zooplankton communities is found in Assam, North East India. The present study has been undertaken to assess the physico-chemical properties of water and the abundance of the planktonic communities in two representative temple ponds located under different land use systems in Cachar district of Assam.

Material and Methods

For carrying out the present work, two temple ponds which represent the general scenario of temple ponds in Cachar district of Assam were taken into consideration. The map of the study area is represented in figure-1. Pond 1 -Lolita Sorobar (Mandir Dighi), Bilpar, Silchar (lat-24° 49.105' N; long-92° 48.045'E; altitude-97 masl; total area-4, 44,646 m^2) located at the center of a town complex (Silchar) and Pond 2 -Bharambaba temple pond, Silcoorie (lat-24° 43.756'N; long-92° 47.297'E; altitude-57masl; total area-1,56,037m^2) located 15 km away from the township of Silchar but in close vicinity to a tea garden (1 km approx.) and a tea factory (0.5 km approx). Both the ponds are inhabited by macrophytes like *Nymphoides*, *Nymphaea*, *Nelumbo, Alternanthera, Polygonum, Ludwizia, Cynodon* etc. These ponds are used by local people for washing, bathing besides many religious rituals. However, in Pond 1 dumping of idols and throwing of ritual goods and household wastes such as empty bottle and leftovers of vegetables etc. into it were also observed.

For the present study sample collection was made from December 2009 to November 2010. Sampling was done on seasonal basis following winter (December- February), pre-monsoon (March to May), monsoon (June-August) and post monsoon (September-November). At each pond, sampling was done from 5 randomly selected points so that it represented the entire pond.

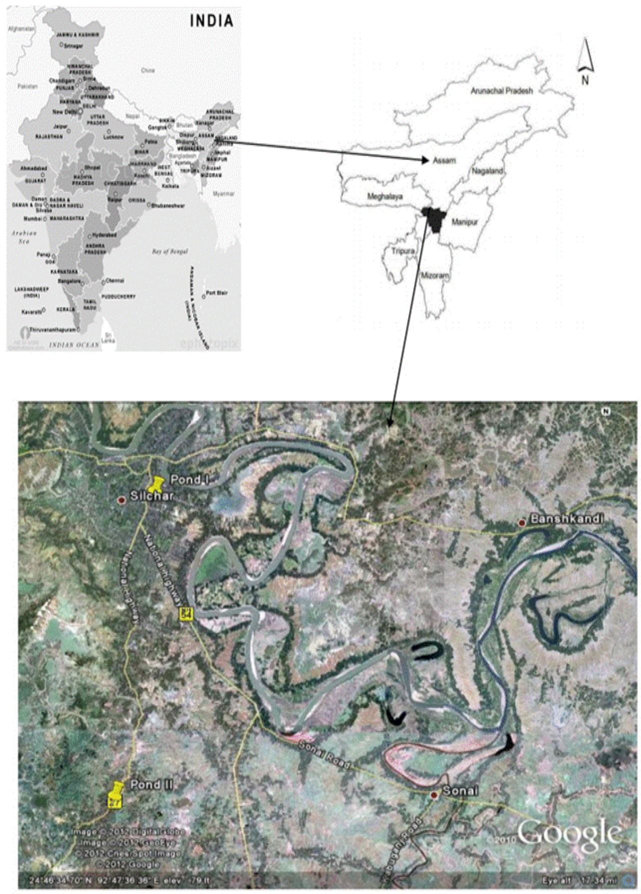

Figure -1
Map showing study area

Air temperature (AT), water temperature (WT) and transparency (Trans) were noted down with the help of a mercury bulb thermometer (0-50°C) and a Secchi disc respectively. pH was measured by digital pH meter (Make: MK Vi and conductivity (Cond) was measured by microprocessor based conductivity meter (Make: ESICO Model: 1601). Dissolved oxygen (DO) and biological oxygen demand after 5 days of incubation at 20°C (BOD_5) were determined by Winkler titration method[11]. Free carbon dioxide (FCO_2), total alkalinity (TA) and chloride (Cl) were analyzed by titration method[12-13]. Estimation of concentration of nitrate-nitrogen (nitrate-N) was done by UV spectrophotometer method[13] and that of phosphate-phosphorous (phosphate-P) by ammonium molybdate method[11]. For collecting samples for chlorophyll- a, b, c and pheophytin from both the ponds, 50 liters of water were collected from different regions of each of the ponds and passed through plankton net (mesh size of 40µm and mouth radius of 14 cm). These samples were immediately brought to the laboratory for analysis by following standard method[14]. Trophic State Index (TSI) was estimated by following Carlson[15].

For both qualitative and quantitative estimation of phyto- and zooplankton communities, 50 liters of water from different regions of each pond were passed through plankton net (mesh size- 40µm). Samples were immediately preserved in separate vials in 5% formalin. Qualitative estimations of both the phyto- and zooplankton were done by their identification using an inverted microscope (Make: Olympus Model: CH20i) at 40X and 10X resolutions respectively following the standard keys[16-18]. Quantitative estimations of both phyto- and zooplankton were determined by Lackey's drop method[19]. Dominance status of both phyto- and zooplankton in both the ponds were analysed on the basis of the value of relative abundance following Engelmann's scale[20]. Diversity indices of the planktonic communities (Shannon-Wiener Diversity Index, Buzas and Gibson's Evenness Index, and Berger Parker's Dominance Index) were calculated by using the statistical software, PAST version 2.13[21]. Independent *t*-test was performed to test for significant differences in water properties, chlorophyll content and phytoplankton biomass of the two ponds by using the software, SPSS version 11.5. Canonical Correspondence Analysis (CCA) was done by using the software PAST version 2.13[21]. CCA was performed after logarithmic transformation of data, except for the pH values.

To look into the rainfall pattern during the study period, rainfall data were collected from the nearest meteorological station at TOCKLAI tea Station, Silcoorie, Cachar, Assam.

Results and Discussion

Rainfall is the most important process recurring in cycles which bring variation in physico-chemical parameters of water in any aquatic bodies which in turn leads to variations in distribution and diversity of aquatic communities.

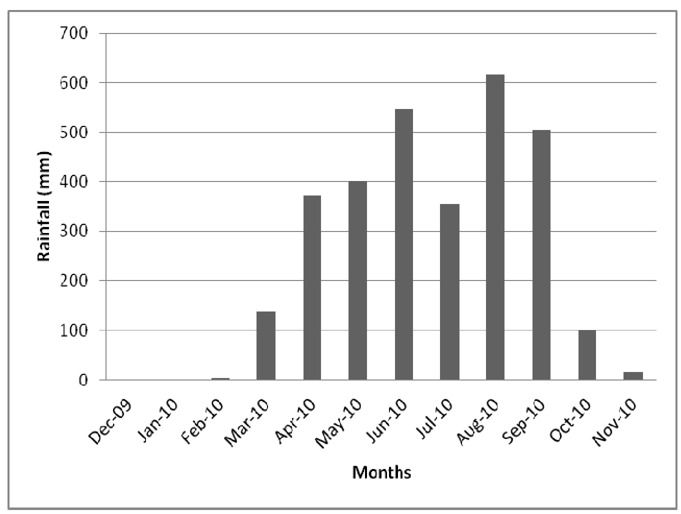

Figure- 2
Monthly variation in rainfall in the study area during the study period
(Source: TOCKLAI tea Station, Silcoorie, Assam)

Figure-2 shows that during the sampling period the study area had highest rainfall in monsoon (June-August; 507mm) and lowest in winter (December- February; 2 mm). However, it may be mentioned here that there was no rainfall in December and January months during the study period.

Table-1 represents the morphometric features, variations in physico-chemical properties and TSI of water in the two ponds. It shows that water temperature ranged between 19.1-34.5°C in Pond 1 and 21.7-30.96°C in Pond 2. Average water temperature was higher in Pond 2 because of its shallowness and hence easy penetration of solar radiation till the bottom of the pond. Transparency was higher in Pond 1 (35.99±7.36 cm) due to its greater depth that helped in faster settlements of the allochthonous matters[22] as compared to Pond 2 (30.20±10.02 cm). Pond 1 had greater TA (65.13±7.18 mgl^{-1}) and Cl (27.16±5.72 mgl^{-1}) as compared to Pond 2 (TA- 24.23±3.64 mgl^{-1}; Cl- 19.22±4.15 mgl^{-1}) thereby revealing deterioration of water quality[23] and greater human interference through washing clothes, bathing and immersing God idols etc. in Pond 1. Greater anthropogenic interference in Pond 1 is also revealed by greater values of FCO_2 (5.87±2.27 mgl^{-1}), BOD_5 (3.84±1.88 mgl^{-1}) and lower value of DO (7.66±2.17 mgl^{-1}) compared to Pond 2 (FCO_2- 3.80±2.23 mgl^{-1}, BOD_5- 3.54±2.06 mgl^{-1} and DO- 8.68±2.03 mgl^{-1}). According to Hynes[24], BOD_5 values between 1–2 mgl^{-1} or less represent clean water; 2–7 mgl^{-1} represent slightly polluted water and more than 8 mgl^{-1} represent severe pollution. Based on these criteria, it can be stated that both the ponds were slightly polluted. Further, as per water quality standard for human use as prescribed by CPCB[25], water of both the temple ponds were not fit for bathing (as revealed by the higher BOD values). Results also show that, Pond 2,

Table-1
Variations in morphometric features, physico-chemical properties and Trophic State Index of water in the study area

Parameters	Pond 1	Pond 2	*t*-value
Area (m^{-2})	4,44,646	1,56,037	-
Water depth (m)	0.52±15.80 (0.30-0.71)	0.45±14.76 (0.20-0.63)	1.422
Air temperature (°c)	27.20±4.60 (21.1-32.12)	27.11±2.04 (24.6-29.4)	0.076
Water temperature (°c)	27.88±5.77 (19.1-34.5)	28.14±3.92 (21.7-30.96)	- 0.167
Transparency (cm)	35.99±7.36 (25.65-44.1)	30.20±10.02 (25.56-44.4)	2.080*
pH	7.16±1.06 (5.99-8.74)	6.48±0.86 (5.30-7.59)	2.250*
Conductivity ($mSppt^{-1}$)	1.60±0.60 (1.27-2.61)	0.86±0.24 (0.89-1.07)	5.129*
Dissolved oxygen (mgl^{-1})	7.66±2.17 (4.74-10)	8.68±2.03 (7.08-10.41)	-1.537
Biological oxygen demand (mgl^{-1})	3.84±1.88 (1.17-5.24)	3.54±2.06 (1.32-5.14)	0.481
Free carbon dioxide (mgl^{-1})	5.87±2.27 (3.19-8.15)	3.80±2.23 (1.56-6.48)	2.910*
Total alkalinity (mgl^{-1})	65.13±7.18 (54.2-71.2)	24.23±3.64 (20.8-28.2)	22.714*
Chloride (mgl^{-1})	27.16±5.72 (18.85-33.46)	19.22±4.15 (13.58-24.08)	5.030*
Phosphate-P (mgl^{-1})	0.03±0.01 (0.015-0.039)	0.03±0.01 (0.019-0.030)	0.304
Nitrate-N (mgl^{-1})	0.24±0.13 (0.11-0.37)	0.49±0.58 (0.05-1.45)	-1.846
Trophic State Index	43.34±5.00 (41.34-50.73)	44.36±3.65 (39.58-48.02)	- 0.547

(Mean ±SD; n=20); *p<0.05, (Number in parenthesis designate range of mean values of the physico-chemical properties of water in the study area)

Even though located away from the township area, had more nitrate-N (0.49±0.58 mgl^{-1}) as compared to Pond 1(0.24±0.13 mgl^{-1}). This might be due to input of nitrogenous matters from the tea garden and the tea factory through runoff, leaching and direct mixing with water from the surrounding water bodies particularly during monsoon. Besides, the smaller size of Pond 2 retained less volume of water, which in turn lead to greater concentration of nutrients particularly nitrate-N. All these resulted in greater TSI value in Pond 2. Never the less, the TSI values of both the ponds reveal their mesotrophic status even though both are located under different land use types. In Pond 1 the main source of pollution were the organic matters from the township area whereas in Pond 2 the main source of pollution were the nutrient input from the surrounding tea garden and tea making factory. This result therefore, depicts that in spite of the fact that Pond 2 is looked after by the caretakers of the temple, unlike in Pond 1, there was relatively greater input of allochthonous nutrients especially nitrate-N which highlights the necessity of management of nutrients of the surrounding tea gardens and disposal of tea factory wastes in water bodies which are in close vicinity to Pond 2. Greater pH value in Pond 1 (7.16±1.06) is attributed to greater abundance of phytoplankton[26] as depicted in figure-3, accompanied by greater water depth (0.52±15.80m) as shown in table-1 and presence of macrophytes which remove FCO_2 by photosynthesis through bicarbonate degradation[27]. Alkaline nature of water as in Pond 1 was also observed in other temple ponds of India viz., Thirumullavaram temple pond of Kerala[6], Texi temple pond of U.P.[7], Gnanaprekasam temple pond of Chidambaram[8] and Kanyakumari temple ponds of Tamilnadu[9]and in some ponds of Gujarat [28-29]. However, till now no study on temple ponds reported the acidic nature of water as found in Pond 2. Further, on the basis of alkalinity as per Spence[30], Pond 1 (65.13 ± 7.18 mgl^{-1}) belonged to nutrient-rich systems while Pond 2 (24.23±3.64 mgl^{-1}) belonged to moderately nutrient-rich systems. Further, the two ponds showed significant differences in Cond (t= 5.13, P< 0.00), FCO_2 (t= 2.91, P< 0.01), TA (t= 22.71, P< 0.00) and Cl (t= 5.03, P< 0.00), all of which had greater values in Pond 1. All these results therefore, indicate that Pond 1 encountered more input of organic wastes than Pond 2.

Table-2 represents chlorophyll contents, biomass and turnover of phytoplankton in the study area. Greater concentration of chlorophyll-a (0.12±0.13 $\mu g\ l^{-1}$) and total chlorophyll (0.16±0.174 $\mu g\ l^{-1}$) in Pond 1 was due to greater abundance of phytoplankton in this pond as shown in figure-3. Greater ratio of pheophytin-a to chlorophyll-a indicates poorer water quality[14]. In this context it may be mentioned here that Pond 1 was undergoing greater disturbance (ratio of pheophytin-a to chlorophyll-a- 2.76±2.47) as compared to Pond 2 (ratio of pheophytin-a to chlorophyll-a- 2.60±4.51). The phytoplankton biomass was significantly higher in Pond 1 (8.11±6.25$\mu g\ l^{-1}$). This indicates favorable condition for the phytoplankton growth in Pond 1, which is also reflected by greater value of phytoplankton turn over in Pond 1.

Table-2
Chlorophyll contents, biomass and turnover of phytoplankton in the study area

Parameters	Pond 1	Pond 2	*t*- value
Chlorophyll a ($\mu g\ l^{-1}$)	0.12±0.13(0.02-0.25)	0.03±0.02(0.01-0.06)	3.090*
Chlorophyll b ($\mu g\ l^{-1}$)	0.02±0.038(0.00-0.06)	0.01±0.01(0.01-0.03)	1.030
Chlorophyll c ($\mu g\ l^{-1}$)	0.02±0.032(0.00-0.06)	0.01±0.01(0.00-0.02)	1.465
Total chlorophyll ($\mu g\ l^{-1}$)	0.16±0.174(0.02-0.37)	0.05±0.03(0.02-0.11)	2.772*
Pheophytin a ($\mu g\ l^{-1}$)	0.17±0.289(0.00-0.36)	0.04±0.03(0.02-0.09)	1.963
Ratio of pheophytin a and chlorophyll a	2.76±2.47(0.52-6.05)	2.60±4.51(0.00-9.32)	- 0.221
Phytoplankton biomass ($\mu g\ l^{-1}$)	8.11±6.25(1.38-16.42)	2.48±1.20(1.46-4.45)	2.809*
Phytoplankton turnover per year	0.46	0.24	-

(Mean ±SD; n=20); *p<0.01, (Number in parenthesis designate range of mean values of the parameters taken for the study)

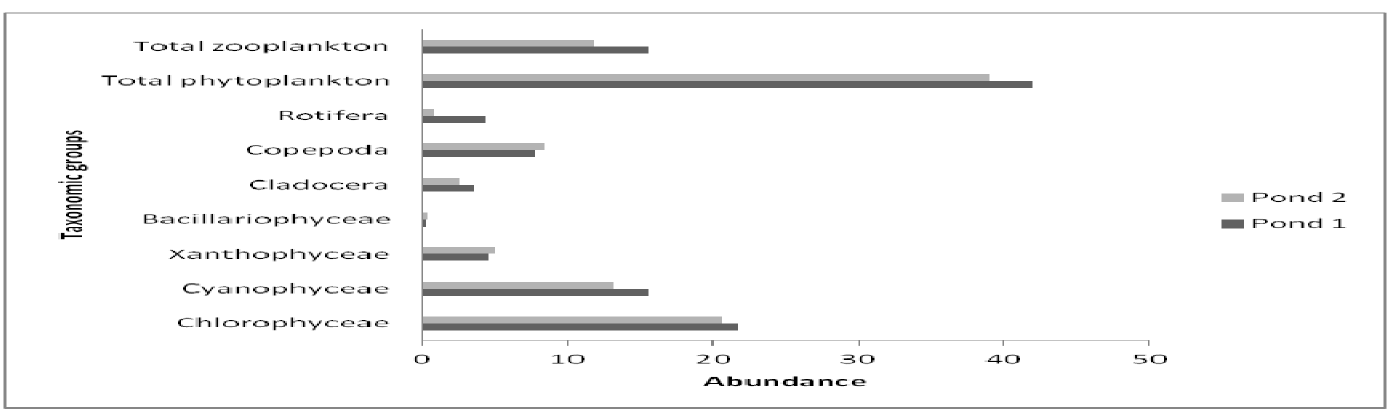

Figure- 3
Abundance of plankton (Individual l^{-1}) belonging to different taxonomic groups in the study area

Table-3 shows that taxonomic richness of both phyto- and zooplankton communities were more in Pond 1(phytoplankton-24 and zooplankton- 11) which revealed the optimum environmental conditions in terms of nutrients and habitat quality in Pond 1 for the prevailing aquatic communities there. Figure-3 depicts that both the ponds had phytoplankton belonging to classes Chlorophyceae, Cyanophyceae, Xanthophyceae and Bacillariophyceae; and zooplankton belonging to the groups Branchiopoda, Copepoda and Rotifera. Chlorophyceae was the most dominant phytoplankton class in both the ponds which reflected abundance of macrophytes in both the systems that might have provided better substrates for their growth and development. The dominant status of Chlorophyceae was also observed in ponds of Barak Valley, Assam[31], a perennial pond in Kanyakumari, Tamil Nadu[32], two Himalayan ponds, Badrinath, Uttarkhand[33] . The dominance of Chlorophyceae in both the ponds also indicated their tendency towards mesotrophy[34]. Figure-3 also reveals that amongst zooplankton, Copepoda was the most dominant group in both the ponds which reflected their better habitat condition in both the ponds because of presence of dense macrophytes and greater availability of food in terms of detritus, bacteria and phytoplankton[35]. When compared with similar studies elsewhere in India, this result differed from the dominant zooplankton group (Rotifera) as reported in three perennial ponds of Virudhunagar district, Tamilnadu[36]. Based on Engelmann's scale[20] as shown in table-3 , phytoplankton in Pond 1 were represented by 4 dominant taxa, 4- subdominant, 7- recedent and 9- subrecedent, whereas in Pond 2 they were represented by 3 dominant taxa, 8- subdominant, 6- recedent and 5-subrecedent. On the other hand, in Pond 1, zooplankton were represented by 4 dominant taxa, 3- subdominant, 4- recedent whereas in Pond 2, 4 zooplankton genera were dominant, 3-subdominant, 2– recedent. Table-3 also reveals that amongst phytoplankton, *Spirogyra indica* and *Microcystis aeruginosa* and amongst zooplankton *Bosmina* and *Diaptomus* were the most dominant taxa in both the ponds. These were followed by *Triploceros*, *Uronema* and *Mesocylops*, *Branchionus* in Pond 1 and *Tribonema* and *Cyclops*, *Mecrocyclops* in Pond 2. The algae like *Microcystis aeruginosa* can be used as the best single indicator associated with highest degree of civic pollution[37] and eutrophication[38]. Greater abundance of *Spirogyra* also indicate organic pollution in water[39]. Based on this information it can be stated that both the ponds were undergoing organic pollution.

Table-3
Distribution, relative abundance (individual l^{-1}) and dominance status of phytoplankton and zooplankton in the study area

Taxa	Pond 1			Pond 2		
	Abundance	Relative abundance	Dominance status	Abundance	Relative abundance	Dominance status
Phytoplankton						
Class: Chlorophyceae						
Ulothrix zonata	0.50±1.00 (0-2)	1.03	Recedent	0.75±1.50 (0-2)	2.03	Recedent
Microspora sp.	3.50±4.12 (0-13)	7.22	Subdominant	2.00±2.16 (0-5)	5.41	Subdominant
Spirogyra indica	12±13.34 (0-31)	24.74	Dominant	3.25±4.72 (0-9)	12.77	Dominant
Uronema gigas	6.50±2.65 (4-10)	13.40	Dominant	1.50±3.00 (0-5)	4.05	Subdominant
Radiofilum conjunctivum	0.50±1.00 (0-2)	1.03	Recedent	0.25±0.50 (0-1)	0.68	Subrecedent
Spirotaenia condensata	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Trebauria trigonum	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Chlorocloster pirenigera	0.75±1.50 (0-3)	1.55	Recedent	-	-	-
Bulbochaete elatier	0.50±1.00 (0-2)	1.03	Recedent	-	-	-
Triploceros gracilis	5.50±4.51 (0-11)	11.34	Dominant	1.50±1.73 (0-3)	4.05	Subdominant
Pediastrum duplex	0.75±1.50 (0-3)	1.55	Recedent	0.25±0.50 (0-1)	0.68	Subrecedent
Sphaeroplea annulina	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Cladophora sp.	2.00±4.00 (0-8)	4.12	Subdominant	3.25±2.50 (0-6)	8.78	Subdominant
Closterium tumidum	0.25±0.50 (0-1)	0.52	Subrecedent	2.25±2.22 (0-5)	6.08	Subdominant
Closterium acerosum	-	-	-	1.25±1.50 (0-3)	3.38	Subdominant
Netrium digitus	0.50±1.00	1.03	Recedent	1.00±0.82 (0-3)	2.70	Recedent

	(0-2)					
Pleurotaenium ehrenbergii	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Hormidium flaccidum	-	-	-	1.00±1.41 (0-3)	2.70	Recedent
Dinobryon sp.	-	-	-	1.25±2.50 (0-5)	3.38	Subdominant
Class: Cyanophyceae						
Chroococcus tenax	2.50±1.91 (0-4)	5.15	Subdominant	-	-	-
Anabaenopsis arnoldii	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Synechococcus elongatus	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Gomphosphaeria aponina	1.00±2.00 (0-4)	2.06	Recedent	0.75±1.50 (0-3)	2.03	Recedent
Gloeocapsa nigrescens	0.25±0.50 (0-1)	0.52	Subrecedent	-	-	-
Microcystis aeruginosa	5.25±10.50 (0-21)	10.82	Dominant	8.25±16.5 (0-33)	22.30	Dominant
Synechocystis crassa	-	-	-	1.00±1.41 (0-3)	2.70	Recedent
Spirulina meneghiniana	-	-	-	0.50±1.00 (0-2)	1.35	Recedent
Lyngbya semiplena	-	-	-	0.25±0.50 (0-1)	0.68	Subrecedent
Aphanocapsa banaresensis	-	-	-	2.00±4.00 (0-8)	5.41	Subdominant
Eucapsis sp.	-	-	-	0.25±0.50 (0-1)	0.68	Subrecedent
Class: Xanthophyceae						
Tribonema sp.	4.50±1.29 (3-6)	9.28	Subdominant	4.50±2.08 (2-7)	12.16	Dominant
Class: Bacillariophyceae						
Fragillaria sp.	0.25±0.50 (0-1)	0.52	Subrecedent	0.25±0.50 (0-1)	0.68	Subrecedent
Total taxa: 32	**24**			**22**		
Zooplankton						
Group: Cladocera						
Acroperus sp.	0.50±1.00 (0-2)	3.28	Subdominant	-	-	-
Bosmina sp.	2.25±2.63 (0-6)	14.75	Dominant	1.75±2.36 (0-5)	18.92	Dominant
Leptodora sp.	0.25±0.50 (0-1)	1.64	Recedent	0.25±0.50 (0-1)	2.70	Recedent
Daphnia sp.	0.25±0.50 (0-1)	1.64	Recedent	-	-	-
Macrothrix sp.	0.50±1.00 (0-2)	1.64	Recedent	0.50±1.00 (0-2)	5.41	Subdominant
Group: Copepoda						
Cyclops sp.	1.00±1.41 (0-3)	6.56	Subdominant	2.00±3.37 (0-7)	21.62	Dominant
Diaptomus sp.	3.25±2.50 (2-7)	21.31	Dominant	2.25±2.63 (0-6)	24.32	Dominant
Mesocyclops sp.	2.25±1.26 (1-4)	14.75	Dominant	0.50±1.00 (0-2)	5.41	Subdominant
Macrocyclops sp.	1.25±1.26 (0-3)	8.20	Subdominant	1.25±1.50 (0-3)	13.51	Dominant
Group: Rotifera						
Lepadella sp.	0.25±0.50 (0-1)	1.64	Recedent	0.50±1.00 (0-2)	5.41	Subdominant
Brachionus sp.	4.00±5.48 (0-12)	26.23	Dominant	0.25±0.50 (0-1)	2.70	Recedent
Total taxa:11	**11**			**9**		

(Mean ±SD; n=20). Numbers in parenthesis designate range of mean values of the parameter taken for the study
'-' indicates absence of the genus concerned. (Relative abundance ≤1%= Subrecedent; 1.1–3.1 %= Recedent; 3.2–10 %= Subdominant; 10.1–31.6 %= Dominant and ≥31.7 %= Eudominant as per Engelmann's scale)

Greater value of Shannon Weiner diversity index for phytoplankton community was observed in Pond 2 as shown in table-4. This might be due to the grazing pressure of zooplankton in Pond 2 that prevented the dominance of particular phytoplankton genus[40]. On the other hand, greater value of Shannon Weiner diversity index for zooplankton community was observed in Pond 1 as shown in table-4. This reflects the presence of diversified resources and greater niche overlap[41] for the zooplankton community in Pond 1. However, on the basis of classification of water quality based on Shannon's diversity index for aquatic communities[42], both the ponds belonged to moderately polluted systems.

The influence of 15 environmental variables (rainfall, air temperature and water properties) on the distribution of different taxonomic groups of phyto- and zooplankton in the two ponds were assessed using CCA biplot graph as represented in figure-4. CCA axis 1 (57.77%) and axis 2 (27.85 %) explained variability in the composition of plankton in the study area. Axis 1 is mainly associated with water temperature, rainfall, conductivity, and free carbon dioxide.

Table-4
Diversity indices of plankton in the study area

Plankton	Diversity indices	Pond 1	Pond 2
Phytoplankton	Shannon–Wiener species Diversity index (H')	1.83±0.52 (1.56-2.6)	1.88±0.20 (1.61-2.08)
	Berger-Parker Dominance index (d)	0.30±0.09 (0.17-0.40)	0.32±0.15 (0.20-0.54)
	Buzas and Gibson's evenness index (e^H/S)	0.82±0.16 (0.67-0.95)	0.74±0.20 (0.45-0.91)
Zooplankton	Shannon–Wiener species Diversity index (H')	1.53±0.17 (1.28-1.65)	1.09±0.28 (0.69-1.35)
	Berger-Parker Dominance index (d)	0.38±0.04 (0.33-0.42)	0.46±0.13 (0.28-0.6)
	Buzas and Gibson's evenness index (e^H/S)	0.84±0.14 (0.63-0.95)	0.89±0.12 (0.74-1)

(Mean ±SD; n=4), Number in parenthesis designate range of mean values of the parameter taken for the study

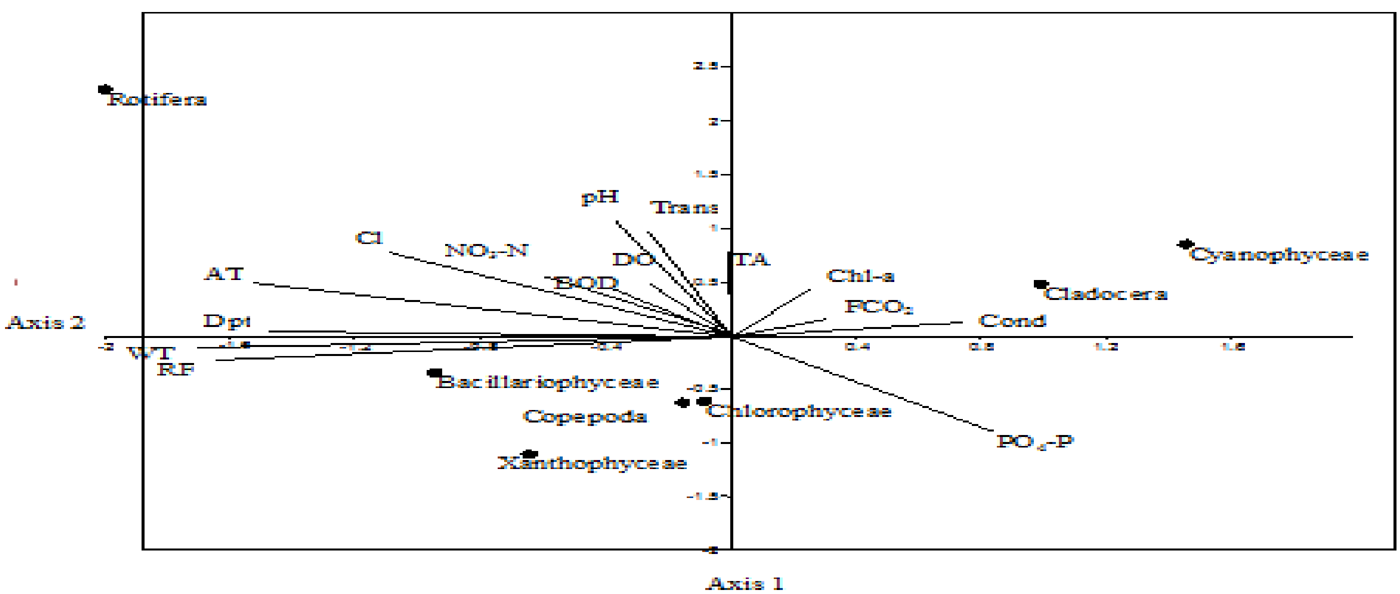

Figure-4
Ordination diagram for Canonical Correspondence Analysis of plankton taxonomic groups in the study area. Environmental variables are represented by black lines and the taxonomic groups of plankton are depicted by black dots. The position of the species points indicates the environmental preference of the species. (AT- Air temperature; WT- Water temperature; Dpt-Water depth; Trans-Transparency; Cond-Conductivity; DO- Dissolved oxygen; BOD- Biological oxygen demand; FCO_2- Free carbon dioxide; TA-Total alkalinity; Cl - Chloride; NO_3 –N, -Nitrate-N; PO_4-P-Phosphate- P; RF- Rainfall; Chl-a-Chlorophyll-a)

The CCA biplot graph reveals that the increase in cladoceran population was associated with conductivity, free carbon dioxide and chlorophyll-a, i. e., factors associated with input of organic matters and increase in phytoplankton biomass. Bacillariophyceae population increased with increase in rainfall i. e., factors associated with increased concentration of silica through runoff water during rainy season. Axis 2 is associated with transparency and total alkalinity. This reveals that with increase in transparency, there was a decrease in the population of Chlorophyceae and Copepoda. This discloses the fact that phytoplankton belonging to class Chlorophyceae and zooplankton belonging to group Copepoda preferred habitat with macrophytes (which acted as better substrate of Chlorophyceae to grow and reproduce), and suspended detritus, bacteria and phytoplankton biomass (which serve as food resource for copepods), that in turn lead to a decline in transparency. Rotifera population was associated with increase in concentration of chloride and nitrate-N, i. e., the factors associated mainly with sewage pollution.

Conclusion

From the overall study it can be concluded that the temple ponds of Cachar, Assam are undergoing organic pollution and are presently in the mesotrophic status. If the anthropogenic disturbances as mentioned above are continued in these ponds, it is likely that in near future these ponds would turn to highly eutrophic systems; which are undesirable not only for human use but also for the local environment, as these ponds might later on turn to breeding grounds of mosquitoes, snails and other pathogenic organisms. Therefore, there is a necessity to manage these ponds. The study also reveals that management of temple ponds should take into consideration not only the disturbances within the pond but also the disturbances in their immediate upland or catchment areas. For carrying out the management activities of temple ponds, riparian people should be made aware of the fact and accordingly necessary management steps should be taken into hand.

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