Sains Malaysiana 41(3)(2012): 277–284

Dynamics of Cyanobacteria *Planktothrix* species (Oscillatoriales: Phormidiaceae) in Earthen Fish Ponds, Northwestern Bangladesh

(Kedinamikan *Planktothrix* spesies (Oscillatoriales: Phormidiaceae) dalam Kolam Ikan Bertanah Liat, Barat Laut Bangladesh)

MD. YEAMIN HOSSAIN*, MD. ABU SAYED JEWEL, BERNERD FULANDA, FERDOUS AHAMED, SHARMEEN RAHMAN, SALEHA JASMINE & JUN OHTOMI

ABSTRACT

The seasonal abundance, dynamics and composition of the filamentous Cyanobacteria Planktothrix *spp. was studied over a 1-year period in two storm-water-fed earthen fishponds in Rajshahi city, northwestern Bangladesh. Sampling was conducted monthly using plankton net (25 µm mesh size) and the samples preserved in 5% formalin. Water quality parameters including water temperature, transparency, pH, dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide (CO_2), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), ammonium (NH_4^+), oxidation reduction index (rH_2) were recorded during each sampling. Two species;* Planktothrix agardhii *and* Planktothrix rubescens *were identified during the study with* P. agardhii *recording higher abundance ($p<0.05$) all year round. The* Planktothrix *cell density was highest during March: 3.06×10^6 cells/L and 1.23×10^6 cells/L in Pond-1 and 2, respectively. The abundance of* P. agardhii *was relatively higher in spring. The cell densities increased with increasing temperature, pH, and nutrient concentration. Lower cell densities were recorded during periods of high BOD. The results of this study provide a useful guide for aquaculturists and other environmental scientists for the management of the cyanotoxin producing algal blooms of* Planktothrix *spp. in fertilized fish ponds and other aquatic habitats.*

Keywords: Bangladesh; earthen fish pond; Planktothrix*; seasonal dynamics; storm run-off*

ABSTRAK

Kelimpahan, kedinamikan dan komposisi bermusim Cyanobacteria Planktothrix *spp. yang berfilamen telah dikaji sepanjang tempoh masa 1 tahun dalam dua kolam ikan bertanah liat di bandar raya Rajshahi, barat laut Bangladesh. Pensampelan telah dijalankan setiap bulan menggunakan jaring plankton (saiz mata pukat 25 µm) dan sampel telah diawet dalam 5% formalin. Parameter kualiti air termasuk suhu air, kelutsinaran, pH, oksigen terlarut (DO), keperluan oksigen biologi (BOD), karbon dioksida bebas (CO_2), nitrit-nitrogen (NO_2-N), nitrat-nitrogen (NO_3-N), ammonium (NH_4^+), indeks penurunan pengoksidaan (rH_2) telah direkodkan semasa setiap pensampelan. Dua spesies;* Planktothrix agardhii *dan* Planktothrix rubescens *telah dikenal pasti semasa kajian dengan* P. agardhii *merakamkan kelimpahan lebih tinggi ($p<0.05$) sepanjang tahun. Ketumpatan sel* Planktothrix *adalah tertinggi pada bulan Mac: 3.06×10^6 sel/L dan 1.23×10^6 sel/L masing-masing dalam Kolam-1 dan 2. Kelimpahan* P. agardhii *adalah lebih tinggi secara relatifnya semasa musim bunga. Ketumpatan sel bertambah dengan peningkatan suhu, pH, dan kepekatan nutrien. Ketumpatan sel yang lebih rendah telah direkodkan semasa tempoh BOD tinggi. Hasil kajian ini menyediakan satu panduan berguna untuk ahli akuakultur dan para saintis alam sekitar lain untuk pengurusan mekar alga* Planktothrix *spp. yang menghasilkan sianotoksin dalam kolam ikan tersenyawa dan habitat air yang lain.*

Kata kunci: Air larian; Bangladesh; dinamik bermusim; kolam ikan bertanah liat; Planktothrix

INTRODUCTION

The genus *Planktothrix* belongs to the important, water-bloom forming, planktonic and potentially toxic filamentous Cyanobacteria (Anagostidis & Komarek 1988; Komárek & Komárková 2004). It was originally classified into the genus *Oscillatoria*, because it grows in solitary trichomes without sheaths, heterocytes and akinetes (Walsby et al. 1983). However, because of the different ultra-structure, life strategy and phenotypic appearance of the *Planktothrix* spp., the genus was later separated from the *Oscillatoria* genus (Rippka & Herdman 1992; Castenholz 2001; Suda et al. 2002). The genus *Planktothrix* is cosmopolitan. It is one of the most important microcystin producing genera found in freshwater habitats in the Northern hemisphere (Fastner et al. 1999). *Planktothrix* blooms typically occur in sub-alpine lakes in Europe; Lake Mondsee, Austria (Dokulil & Jagsch 1992), Lake Nantua (Feuillade 1994) and Lac du Bourget in France (Jacquet et al. 2005) as well as in several lakes in Germany (Padisak et al. 2003) and in the Nordic countries (Willen & Mattsson 1997). The genus is comprised of nine species: *Planktothrix agardii, P. iwanoffiana, P. lacustris, P. miyadii, P. mougeotii,* *P. penornata, P. planctonica, P. pseudoargadii* and *P. rubescens* (Komárek 2003). Among these, *P. agardhii* is the most abundant species in shallow and eutrophic lakes (Rucker et al. 1997).

Studies on toxic Cyanobacteria showed that metalimnetic blooms dominated by *Planktothrix* produce the highest level of toxins per biomass (Fastner et al. 1999). However, majority of the studies on the environmental factors that control the growth and distribution of *Planktothrix* species have been conducted in central-Europe (Halstvedt et al. 2007). Moreover, in-vitro tests confirm that *P. agardhii* strains that are non-toxic to mice are highly toxic to aquatic organisms including the brine shrimp *Artemia salina*, Daphnia *Daphnia pulex* as well as to aquatic larval stages of the mosquito *Aedes aegypyi* (Landsberg 2002). Cyanobacterial bloom toxins lead to the loss of ion homeostatic processes in fish because of the inhibitory action of microcystin toxin on the ion pumps of gill chloride cells thus leading to fish kills (Gaetel et al. 1994). In humans, the symptoms associated with microcystin intoxication range from diarrhea and vomiting to piloerection, weakness and pallor (Bell & Codd 1994). Recently, several dog mortalities have been associated with the production of anatoxin-*a* from benthic mats of *Planktothrix* (Landsberg 2002).

Urban and storm run-off often contains high concentrations of nutrients, oxygen-consuming wastes, pathogens and toxic substances such as pesticides, heavy metals and oils (Peterson et al. 1985). At low flush rates in storm water fed ponds, continued enrichment of the aquatic ecosystems may lead to eutrophication, which is often associated with sewage and/or sewage effluent discharge into streams that feed lakes and aquaculture ponds (Odiete 1999). There are extensive literature sources describing the seasonal abundance, bloom dynamics and species composition of cyanobacterial algae in the freshwater ecosystems of Bangladesh. However, majority of the studies have been focused on the toxic *Microcystis* species (Affan et al. 2005; Jewel et al. 2003; Jewel 2004; Jewel et al. 2006). Consequenetly, data and information on the abundance and seasonal dynamics of the toxic *Planktothrix* species in urban storm water-fed earthen fish ponds in Bangladesh is clearly lacking. This study aimed to improve on the understanding of environmental factors that control *Planktothrix* algal blooms in order to be able to make predictions about abundance, seasonal dynamics and species composition of this genus and the potential hazards associated with the toxic algal blooms in storm water-fed earthen fish ponds.

MATERIAL AND METHODS

STUDY AREA

The study was conducted in two urban storm water-fed earthen fish ponds situated in Baliapukur (Pond-1) and in Hadirmor (Pond-2) in Rajshahi city, western Bangladesh (Figure 1). Sampling was conducted over a 1-year period from January through December, 2006. The ponds, which are managed by the local communities, are utilized for culture of the Indian major carps: *Catla catla, Labeo rohita, Cirrhinus mrigala* with the exotic silver carp (*Hypophthalmichthys molitrix*). Pond-1 is fed by two drains that discharge storm water directly into the pond. At the south-western side of the Pond-1, there is a solid waste dumpsite which also leaks waste into the pond. On the other hand, Pond-2 is fed by five storm water drains that discharge runoff water directly into the pond. Furthermore, there are three manholes situated on the eastern side of the Pond-2. During the rainy season, both ponds are often flooded because of increased storm water runoff. Therefore, the flush rate is considerably higher in Pond-2 owing to the amount of storm water discharged by the five drains feeding the pond.

PHYTOPLANKTON SAMPLING AND ANALYSIS

Plankton samples were collected using plankton net (25 µm mesh size) and fixed in 5% formalin on site. Identification of the phytoplankton species was conducted under a phase contrast light microscope at 100×-400× magnification (Olympus CX21, Tokyo, Japan) with bright field and phase contrast illumination (Anagnostidis & Komarek 1985; Skulberg et al. 1993). Quantitative estimation of phytoplankton was done on Sedgewick-Rafter counting chamber (S-R cell) following the method described by Stirling (1985). The monthly analyses data was grouped into seasons as follows: summer (June through August), autumn (September through November), winter (December through February) and spring (March through May). The rainy season runs from early June through September.

WATER QUALITY ANALYSIS

Surface water samples were collected once in a month between 10:00 and 11:00 hours for analysis of various physico-chemical parameters using dark bottles. The water samples were chilled in ice and transferred to the laboratory at 4°C. Water temperature was measured on site using a mercury thermometer. Physico-chemical parameters including pH, nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), and ammonium (NH_4^+) were determined using a portable aquaculture kit (Model FF2, HACH, USA). Dissolved oxygen (DO), free Carbon dioxide (CO_2), and biochemical oxygen demand (BOD) were estimated by the Winkler's titration method (APHA 1976) while the oxidation-reduction Index (rH_2) was calculated using the formula given by Mukherjee (1996). Transparency was measured using a Secchi disc at two depths (disappearing, reappearing) using a black and white standard colour coded disc.

STATISTICAL ANALYSES

Statistical analyses were performed using Microsoft® Excel-add-in-DDXL, GraphPad Prism 5 and SPSS 17 softwares. All data were tested for normality by visual

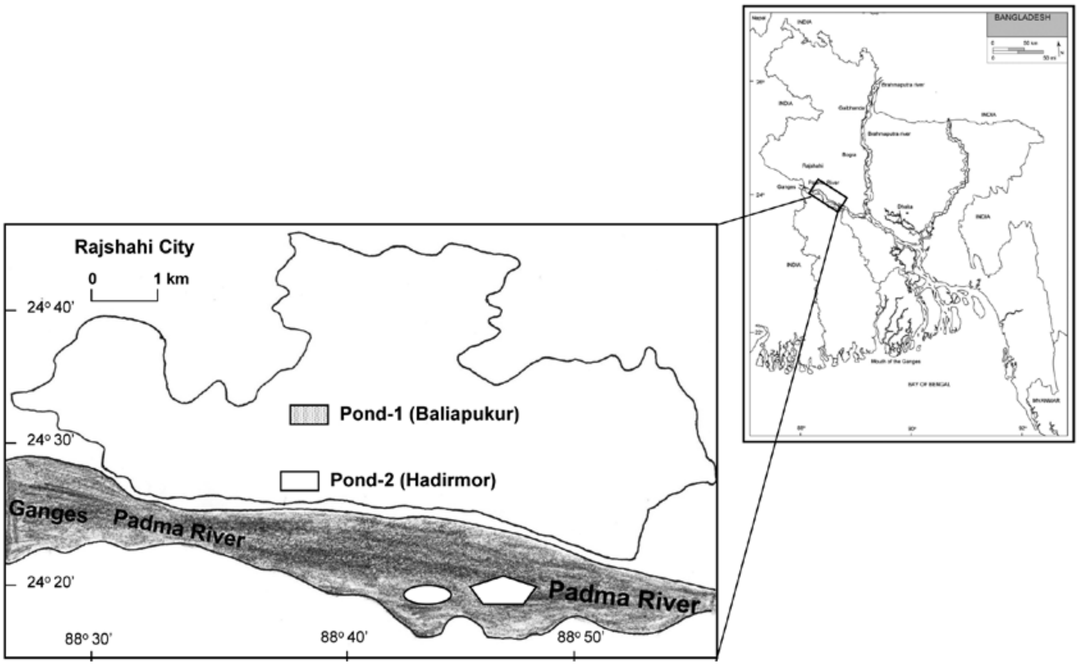

FIGURE 1. Map showing the sampling Ponds within Rajshahi City Corporation, northwestern Bangladesh. The solid and open rectangles indicate study site including the Pond-1 and Pond-2, respectively

assessment of histograms and box plots, and by use of the Kolmogorov-Smirnov test. Where test for normality assumption was not met, the non-parametric Mann-Whitney U test was used to compare the variables between the two ponds and Spearman rank test was used to correlate between the variables. All statistical analyses were considered significant at 5% ($p<0.05$).

RESULTS

During this study, two species of *Planktothrix*: *P. agardhii* and *P. rubescens* were identified. In overall, *P. agardhii* being most abundant. The cell densities of the two *Planktothrix* species varied widely: from 0.22×10^6 to 3.06×10^6 cells/L in Pond-1 and from 0.13×10^6 to 1.23×10^6 cells/L in Pond-2. The highest cell densities were recorded during March 2006 for both ponds while the lowest densities were recorded in January for Pond-1 and in August for Pond-2 (Figure 2).

The *Planktothrix* species varied throughout the year. In Pond-1, *P. agardhii* was dominant in spring (Mar-May at 85.3% of the total cell density) and lowest during winter (Dec-Feb at 77.8%). On the other hand, *P. rubescens* density was higher in winter at 22.2% of the cell density and lower during spring at 14.7%. Similarly the seasonal abundance of *Planktothrix* species in Pond-2 showed that, *P. agardhii* was dominant in spring at 84.4% but lower during the summer season a 66.7%. Further, *P. rubescens* recorded higher densities during summer at 33.3% compared to 15.6% during spring (Figure 3). Analysis of the results show that the *Planktothrix* cell density was slightly higher in Pond-1 (median: 0.47 $\times10^6$ cells/L) than Pond-2 (median: 0.33×10^6 cells/L) throughout the study period (Figure 4). Nevertheless, the Mann-Whitney U-test observed no significant difference ($p>0.05$) of the abundance of *Planktothrix* species between the two ponds (Mann-Whitney U=52.00; p=0.260).

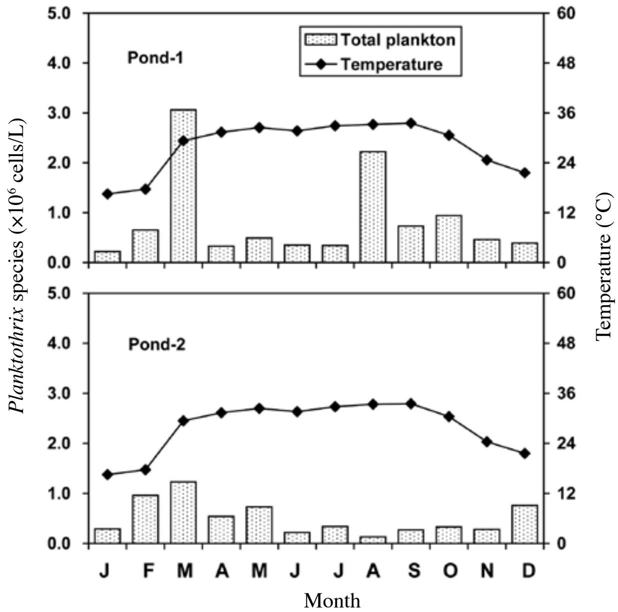

FIGURE 2. Monthly variations of *Planktothrix* species (*P. agardhii* and *P. rubescens*) in relations to water temperature from two earthen fish ponds, Rajshahi, northwestern Bangladesh during January to December 2006

Monthly variations in the physico-chemical parameters are given in Table 1. Water temperatures ranged from 16.5ºC to 33.5 in Pond-1 while in Pond-2, the temperature range was 16.5ºC to 33.5ºC. The lowest and highest temperatures were recorded in January and September, respectively, for both ponds. There was no significant difference in water temperature between two ponds (p=0.908). However, transparency was relatively higher in Pond-1 than in Pond-2 (p< 0.01) and varied from 25.3 to 57.6 cm in Pond-1 and 15.9 to 35.5 cm in Pond-2. Majority of the physico-chemical parameters were not significantly different between the two ponds: pH (p=0.977), DO (mg/L) (p=0.840), free CO_2 (mg/L) (p=0.885), BOD_5 (mg/L) (p=0.977), and rH_2 (p=0.908). The DO content was very low in both ponds and ranged from 0.36 mg/L to 3.08 mg/L and 0.36 mg/L to 3.08 mg/L in Pond-1 and Pond-2, respectively. However, NO_2-N, NO_3-N and NH_4^+ were significantly different between Pond-1 and Pond-2, with the latter recording higher values (Mann-Whitney U-test, p<0.01). The nutrients were: NO_2-N 0.25 mg/L for Pond-1 and 0.48 mg/L for Pond-2) and NH_3-N (1.8 mg/L for Pond-1, and 2.6 mg/L for Pond-2) during March. However, NH_4^+ recorded higher concentrations during the same period, at 2.03 mg/L for Pond-1 and 3.02 mg/L for Pond-2. In addition, rH_2 values were relatively low in March: 25.71 and 25.83 in Pond-1 and Pond-2, respectively.

Discussion

Information on the occurrence and potential hazards of the genus *Planktothrix* is quite insufficient from northwestern Bangladesh, although a number of studies have been done from other regions (Jewel 2004; Jewel et al. 2003; Jewel et al. 2006). Most of the earlier studies were aimed at assessing the link between fish mortality in fish ponds and Cyanobacterial blooms. However, this study estimated the seasonal abundance, dynamics and composition of the filamentous Cyanobacterial *Planktothrix* spp using a 1-year study from two urban storm water-fed earthen fishponds in the western Bangladesh city of Rajshahi city.

The cell density for *Planktothrix* was highest in both ponds during March. This is partly attributed to the reduced flush rate during spring augmented by higher temperature and nutrients levels during this period. Rising water temperatures towards March may have triggered blooms of the *Planktothrix* spp. Similar trends were observed in Lake Steinsfjorden (Halstvedt et al. 2007) where *Planktothrix* was dominated than other species when temperature rose above 20ºC. In a separate study in Lake Pusiano (North Italy), Legnani et al. (2005) also reported that at the beginning of the plankton growing season (Feb-Mar), Cyanobacteria were the dominant genera with *Planktothrix rubescens* accounting for very high cell densities (30,000 cells/mL). These results are in agreement with the present study, where the *Planktothrix* spp. started to bloom during the beginning of the March. However, the spearman rank correlation test showed no significant relationships (p>0.05) between temperature and abundance of *Planktothrix* in Pond-1 (r_s=0.259; p=0.417) and Pond-2 (r_s=-0.475; p=0.112) during this study. This may be attributed to low nutrient input since this pond is only fed by two storm water drains although the *Planktothrix* cell density was relatively higher in Pond-1 throughout the study period. In the Lake Pusiano study, Legnani et al. (2005) indicated that PO_4-P was highly concentrated and homogenously distributed along the water column during the winter overturn, allowing *P. rubescens* to bloom. Nevertheless, this study did not estimate PO_4-P from both ponds.

The *Planktothrix* cell density was relatively high in Pond-1 than Pond-2 throughout the study period. This was attributed to lower flushing rate in Pond-1 despite the lower nutrient input since the pond is only fed by 2 storm water drains. In the Pond-2 which receives nutrient enrichment from 5 drains, the flush rate is also relatively higher due to higher recharge rate and likely higher frequency of flooding. Consequently, with flooding and reduced residence-time of the higher nutrient water in Pond-2, the *Planktothrix* cell density is lower and most of the nutrients in the pond are flushed out frequently and wasted downstream, with possible enrichment of the receiving aquatic ecosystems. On the other hand, nutrient enrichment in Pond-1 resulted in faster growth of the *Planktothrix* spp. due to the longer residence-time and less disturbance of the nutrient equilibrium which would occur during flooding. Jewel et al. (2006) noted that enriched urban discharge in addition to storm runoff rich especially from fertilized agricultural lands triggers rapid eutrophication if discharged into earthen ponds where the residence-times are longer. In Pond-1, *Planktothrix* was lowest in January due to low temperatures, pH and nutrients levels.

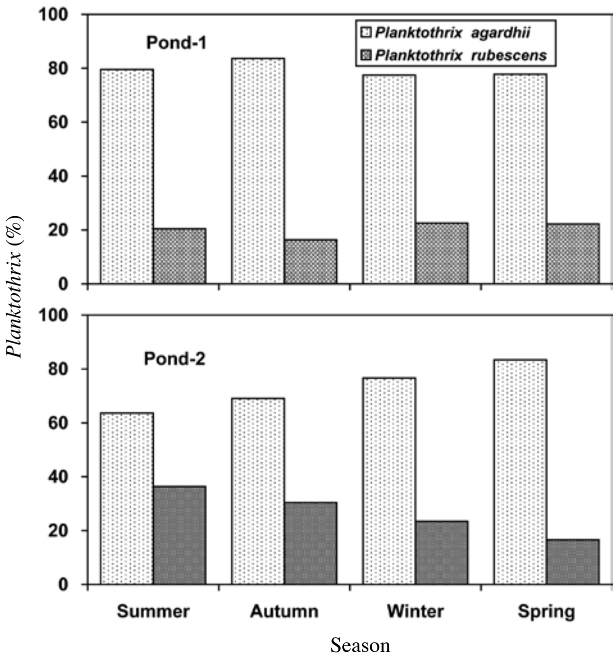

FIGURE 3. Seasonal variations of relative abundance for the most common *Planktothrix* species (*P. agardhii* and *P. rubescens*) in two earthen fish ponds, Rajshahi, northwestern Bangladesh during January to December 2006. Summer (June-August), Autumn (September-November), Winter (December-February), Spring (March-May)

However, low cell densities of *Planktothrix* in this pond during August may have been attributed to massive blooms of *Microcystis* and *Anabaena* leading to the collapse of the *Planktothrix* community. Similar observations were made by Legnani et al. (2005) who noted that *P. rubescens* continuously decreased until August when it the densities dropped down to lowest biovolume of 644 mm^3m^{-3}. During this period, they also noticed an increase in the density of *Microcystis aeruginosa*, *Aphanizomenon flos-aquae* and *Pseudoanabaena* suggesting some species succession in the plankton communities within these aquatic ecosystems. The sudden increase in pH to alkaline condition (8.3 and 8.2 in Pond-1 and Pond-2, respectively) during March may explain the dominance of *Planktothrix*in both ponds.

In both ponds, the BOD was inversely related to the densities of the *Planktothrix* species. This is in agreement with Chowdhury et al. (1996) who reported higher abundance of phytoplankton with low BOD values in the Padma water near Rajshahi. Nitrogen, (as nitrates NO_3-N and ammonia NH_3-N) were 0.25 mg/L and 0.48 mg/L NO_2-N in Pond-1 and Pond-2, and 1.8 mg/L and 2.6 mg/L NH_3-N in Pond-1 and Pond-2 during March which may have supported the dominance of the *Planktothrix* spp. According to Pereira et al. (2001) nutrients (Nitrate and Ammonia) in the water apparently accumulate before the occurrence of the algal blooms towards the end of winter through early spring). The NH_4^+ was highest in March (2.03 mg/L in Pond-1 and 3.02 mg/L in Pond-2) which may have triggered the blooming and dominance of *Planktothrix* species. Halstvedt et al. (2007), reported similar trends of high levels of nitrates and ammonium in Lake Steinsfjorden, Norway in March due to heavy rainfall during the autumn triggering blooms of the *Planktothrix* species.

The oxygen-reduction index rH_2 was relatively low during periods of high *Planktothrix* cell abundance suggesting that the organic load in ponds was relatively high. Goutam (1992) observed that in any aquatic ecosystem with high organic load, the concentration of the reduced form of organic matter (C_2HO) are higher thus resulting in lower rH_2 values, generally <28.

In Pond-1 *Planktothrix agardhii* was dominant in spring (85.3%) with lower values in winter (77.8%). On the contrary, *P. rubescens* cell density was higher during winter (22.2%) with lower abundance values in spring (14.3%). Seasonal abundance of both species in Pond-2 showed that, *P. agardhii* was dominant in spring (84.4%) and least in summer (66.7%). Halstvedt et al. (2007) observed a 90% drop in the population of *Planktothrix* sp. Lake Steinfjorden (Norway) during summer stratification. The *P. rubescens* was dominant in summer (33.3%) and least in spring (15.6%). Similarly, a natural population of the red and green forms of *Planktothrix* sp. formed blooms in the metalimnion during summer (June-September) (Edvardsen 2002). In the present study, the blooms of both species appeared to alternate, with *P. agardhii* recording highest cell densities in spring in both Pond-1 and Pond-2 while *P. rubescens* cell density was low during the same period. Feuillade (1994) reported that the main growth periods of *Planktothrix* spp. was in spring and autumn when the lake was vertically mixed and nutrients become more available.

Transparency was relatively low during March (26.82 cm and 19.63 cm in Pond-1 and Pond-2, respectively) suggesting higher plankton turbidity during this period attributable to the blooms of the *Planktothrix* species. Furthermore, higher pH levels (8.3 and 8.2 in Pond-1 and Pond-2, respectively) were recorded during the same period (Figure 2). During these periods, the BOD was also relatively low (0.53 mg/L and 0.36 mg/L in Pond-1 and Pond-2, respectively) confirming that the lower transparency recorded during this period was due to plankton turbidity. On the contrary, during the periods of relatively lower *Planktothrix* cell density higher BOD values

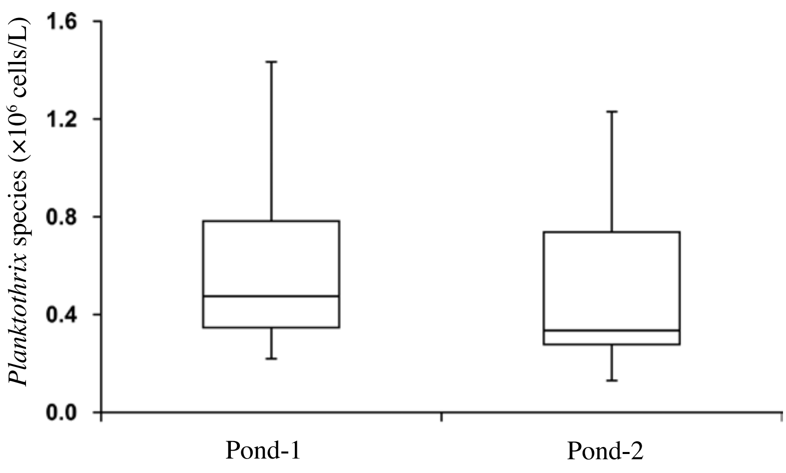

FIGURE 4. Box-whiskers plots of *Planktothrix* cell density for two earthen fish ponds, Rajshahi, northwestern Bangladesh during January to December 2006. The horizontal line indicates the median, and the vertical line represents the range of the values

TABLE 1. Monthly variations of water quality parameters of the two earthen fish ponds, Rajshahi, northwestern Bangladesh during January to December 2006

Month	Water Temperature (^0C)		Transparency (cm)		pH		DO (mg/L)		Free CO_2 (mg/L)		BOD_5 (mg/L)		NO_2 - N(mg/L)		NO_3-N (mg/L)		NH_4^+		rH_2	
	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2
Jan.	16.51	16.50	35.49	28.48	7.00	7.10	1.58	1.95	44.92	42.31	0.86	1.56	0.03	0.15	0.30	0.90	0.39	1.17	29.62	29.6
Feb.	17.63	17.67	31.26	22.51	7.40	7.30	1.62	2.00	21.74	27.50	0.92	1.80	0.10	0.35	1.20	1.70	1.55	2.2	28.81	29.21
Mar.	29.30	29.40	26.82	19.63	8.30	8.20	0.53	0.36	45.62	59.80	0.53	0.36	0.25	0.48	1.80	2.60	2.03	3.02	25.71	25.83
Apr.	31.35	31.35	38.17	29.95	7.80	7.90	1.92	0.96	61.36	64.51	1.92	0.96	0.20	0.40	1.40	2.40	1.73	2.92	27.44	26.76
May	32.46	32.39	55.23	33.78	7.50	7.50	2.09	1.65	53.96	55.65	2.09	1.65	0.10	0.20	0.90	1.20	1.14	1.52	28.84	28.62
Jun.	31.68	31.61	57.63	35.45	7.90	8.00	2.38	1.99	32.54	35.11	2.38	1.99	0.10	0.30	1.30	1.80	1.58	2.15	27.47	27.07
Jul.	32.91	32.79	49.24	32.11	8.10	8.20	3.26	3.08	28.27	28.44	3.00	3.08	0.15	0.36	1.60	2.00	1.86	2.27	27.49	27.2
Aug.	33.21	33.37	25.33	20.09	8.80	8.50	0.62	0.85	48.24	32.33	0.62	0.85	0.30	0.45	2.00	2.90	1.65	2.91	24.72	25.46
Sep.	33.53	33.50	31.20	15.85	8.50	8.80	0.93	0.46	52.21	60.47	0.93	0.46	0.23	0.50	1.70	3.00	1.706	2.47	25.5	24.64
Oct.	30.62	30.42	44.51	34.83	8.30	8.30	0.76	1.25	73.33	79.84	0.62	1.00	0.16	0.30	1.00	2.50	1.12	2.79	25.83	26.07
Nov.	24.67	24.38	43.33	31.12	8.00	8.10	1.21	1.30	38.11	43.00	1.21	1.30	0.10	0.25	0.80	2.20	0.99	2.69	26.67	26.51
Dec.	21.58	21.57	38.21	31.02	7.50	7.00	2.47	2.23	25.52	18.98	2.47	2.23	0.05	0.20	0.60	1.90	0.77	2.46	29.03	29.94

(0.86 mg/L in January in Pond-1 and 0.85 mg/L in August in Pond-2) were recorded confirming that the observed turbidity during these periods were due to suspended solids (Figure 3). The NO_2-N and NH_3-N nutrients were 0.25 mg/L and 0.48 mg/L and 1.8 mg/L and 2.6 mg/L in Pond-1 and Pond-2, respectively. This may have supported the dominance of the *Planktothrix* too. The NH_4^+ was highest during March in both ponds (2.03 mg/L and 3.02 mg/L, in Pond-1 and Pond-2, respectively and appeared to be the main triggering parameter for the *Planktothrix* dominance. Moreover, free CO_2 was found to be relatively high during *Planktothrix* dominance. The rH_2 values were relatively low during March: 25.71 and 25.83, in Pond-1 and Pond-2 respectively when *Planktothrix* cell density was also highest (Figure 4).

Planktothrix is one of the bloom-forming genera of Cyanobacteria with the highest toxicity potential (Fastner et al. 1999) and it is therefore important to know how to manage these populations, for preventing further blooms and predicting situations of high toxin production. Low water transparencies were well associated with high levels of chlorophyll *a* in the ponds, suggesting that the abundance of the cyanobacteria in these ponds may have a significant effect on the light environment. Phytoplankton especially of the Cyanobacteria is an important diet item of *C. catla*, *L. rohita, C. mrigala* and *H. molitrix* cultured in the ponds. Furthermore, the blooming of the toxic Cyanobacterial species: *Planktothrix* and *Microcystis* in the ponds may pose a threat to human health due to possible bio-accumulation in the liver or muscle tissue. Moreover, the ingestion rates and growth rates of the juveniles of the species cultured may be affected by the presence of *Planktothrins* and microcystins in their diets. Likewise growth and survival rates of the zooplankton including cladoceran *Daphnia* spp. may be affected by the presence of toxins: *Planktothrins* and microcystins in their diets. Some Cyanobacteria species such as *Microcystis aeruginosa* have been to be poor sources of nutrients especially for juvenile fish and zooplankton since they don't stimulate growth. The cultures species in the two ponds probably ingest cyanotoxins mostly through the cell-bound fraction, since Cyanobacteria (especially *P. agardhii*) are an important constituent of their diet. Adult fish may have the ability to efficiently get rid of ingested cyanotoxins, but this may not be so for juvenile carps and zooplankton. Small amounts of Cyanobacteria may actually stimulate growth in juvenile fish and even zooplankton, and if ingested in high proportions in the diets, they hinder growth, survival, and reproduction. Juvenile fish and most especially zooplankton, are unlikely to graze on Cyanobacteria either due to their frequent formation of large colonies or because juvenile fish and zooplankton may lower their ingestion rates in the presence of cyanotoxins. Further studies are needed to assess the tolerance of cultured carp species and zooplankton towards Cyanobacterial toxins as well as their ability to utilize Cyanobacteria and cope with levels of *Planktothrins* registered in the ponds. Moreover, since these ponds flood during the June-September rainy season when the Cyanobacteria have already bloomed, an assessment of the receiving waters for the *Planktothrins* and *mycrocystins* is important for the management of the nutrient input into these aquatic ecosystems and alleviation of possible health risks associated with the Cyanobacterial blooms.

ACKNOWLEDGEMENT

The authors express their gratitude to pond owners (Rajshahi city, Bangladesh) for providing facilities during sampling and the Department of Fisheries, University of Rajshahi (Bangladesh) for laboratory facilities. Also they would like to express their acknowledgements to the Editor-in-Chief and the anonymous referees for their useful comments.

REFERENCES

Affan, M.A., Jewel, M.A.S., Haque, M., Khan, S. & Lee, J.B. 2005. Seasonal cycle of phytoplankton in aquaculture ponds in Bangladesh. *Algae* 20: 43-52.

Anagnostidis, K. & Komárek, J. 1985. Modern approach to the classification system of cyanophytes. 1-Introduction. Algological Studies/Arch. *Hydrobiologia* (Suppl. Vol. 71) 38/39: 291-302.

Anagnostidis, K. & Komárek, J. 1988. Modern approach to the classification system of cyanophytes. 3-Oscillatoriales. Algological Studies/Arch. *Hydrobiologia* (Suppl. Vol. 80) 50-53: 327-472.

APHA. 1976. *Standard Methods for the Examination of Water and Waste Water* (14th ed.). Washington: American Public Health Association.

Bell, S.G. & Codd, G.A. 1994. Cyanobacterial toxins and human health. *Rev. Med. Microbiology* 5: 256-264.

Castenholz, R.W. 2001. Oxygenic photosynthetic bacteria. *In* DR Boone, RW Catenholz, (eds). *Bergey's Manual of Systematic Bacteriology* (2nd edition). New York: Springer-Verlag.

Chowdhury, A.H., Naz, S. & Zaman, M. 1996. Effect of Industrial effluents on the physico-chemical and biological conditions of Padma water near Rajshahi. *Journal of Biological Science* 4: 9-19.

Dokulil, M.T. & Jagsch, A. 1992. The effects of reduced phosphorous and nitrogen loading on phytoplankton in Mondsee, Austria. *Hydrobiologia* 243: 389-394.

Edvardsen, B. 2002. *Monitoring of Toxic Cyanobacteria in Lake Steinsfjorden in 2001 with Results from 1997-2001*. In Norwegian, English Summary. Norwegian Institute for Water Research, Oslo, pp. 33-50.

Fastner, J., Neumann, U., Wirsing, B. & Weackesser, J. 1999. Microcystins (hepatotoxic heptapeptides) in German freshwater bodies. *Environmental Toxicology* 14: 13-22.

Feuillade, M. & Druart, J.C. 1994. The long-term effect of the sewage diversion on the phytoplankton composition and biomass. *Archives Hydrobiologia* 41: 55-76.

Gaetel, V., Canelo, E., Lagos, N. & Zambrano, F. 1994. Inhibitory effects of Microcystis aeruginosa toxin on ion pumps of the gill of freshwater fish. *Toxicon* 32: 121-127.

Goutam, A. 1992. *Aquatic Environment*. New Delhi: Ashish Publishing House, Punjab Bagh..

Halstvedt, C.B., Rohrlack, T., Andersen, T., Skulberg, O. & Edvardsen, B. 2007. Seasonal dynamics and depth distribution of *Planktothrix* sp. in Lake Steinfjorden (Norway) related to environmental factors. *Journal of Plankton Research* 29: 471-482.

Jacquet, S., Briand, J.E. & Leboulanger, C. 2005. The proliferation of the toxic cyanobacterium *Planktothrix rubescens* following restoration of the largest natural French Lake (Lac de Bourget). *Harmful Algae* 4: 631-672.

Jewel, M.A.S. 2004. Improvement of water quality and reduction of noxious algae in a eutrophic lake in Bangladesh through renovation. *University Journal of Zoology, Rajshahi University* 23: 31-35.

Jewel, M.A.S., Affan, M.A. & Khan, S. 2003. Fish mortality due to cyanobacterial bloom in an aquaculture pond in Bangladesh. *Pakistan Journal of Biological Sciences* 6: 1046-1050.

Jewel, M.A.S., Rahman, M.M. & Sarker, M.A. 2006. Effects of environmental parameters on the cyanobacterial bloom in a pond of Bangladesh. *Bangladesh Journal of Progressive Science & Technology* 4: 159-164.

Komárek, J. & Komárková, J. 2004. Taxonomic review of the cyanoprokaryotic genera *Planktothrix* and *Planktothricoides*. *Czech Phycology, Olomouc* 4: 1-18.

Komárek, J. 2003. Planktic oscillatorialean cyanoprokaryotes (short review according to combined phenotype and molecular aspects). *Hydrobiologia* 502: 367-382.

Landsberg, J.H. 2002. The effects of harmful algal blooms on aquatic organisms. *Reviews in Fisheries Science* 10: 113-390.

Legnani, E., CopettiOggioni, D.A., Tartari, G., Palumbo, M.T. & Morabito, G. 2005. *Planktothrix rubescens* seasonal dynamics and vertical distribution in Lake Pusiano (North Italy). *Journal of Limnology* 64: 61-73.

Mukherjee, B. 1996. *Environmental Biology*. New Delhi, India: Tata McGraw Hill Pub. Co. Ltd.

Odiete, W.O. 1999. *Environmental Physiology of Animals and Pollution:* Lagos: Diversified Resources Ltd.

Padisak, J., Barbosa, E. & Koschel, R. 2003. Deep layer *Cyanoprokaryota maxima* in temperate and tropical lakes. *Archives Hydrobiology*, Spec. Issue *Advances Limnology* 58: 175-199.

Pereira, E., Anne, I., Fidalgo, M.L. & Vasconcelos, V. 2001. Phytoplankton and nutrient dynamics in two ponds of the Esmoriz wastewater treatment plant (Northern Portugal). *Limnetica* 20: 245-254.

Peterson, S.A., Miller, W.E., Greene, J.C. & Callahan, C.A. 1985. Use of bioassays to determine potential toxicity effects of environmental pollutants. In *Perspective on Nonpoint Source Pollution*. Environmental Protection Agency, EPA 440/5-85-001, Washington DC, USA, pp. 38-45.

Rippka, R. & Herdmann, M. 1992. *Pasteur Culture Collection of Cyanobacterial Strains in Axenic Culture, Catalogue and Taxonomic Hand Book*. Paris, Institut Pasteur, 103 pp.

Rucker, J., Wiedner, C. & Zippel, P. 1997. Factors controlling the dominance of *Planktothrix agardhii* and *Limnothrix redekei* in eutrophic shallow lakes. *Hydrobiologia* 342/343: 107-115.

Skulberg, O.M., Carmichael, W.W., Codd, G.A. & Skulberg, R. 1993. Taxonomy of toxic Cyanophyceae (Cyanobacteria). In *Algal Toxins in Seafood and Drinking Water*, edited by Falcnor I.R., London: Academic Press Ltd., pp. 145-164.

Stirling H.P. 1985. *Chemical and Biological Methods of Water Analysis for Aquaculturists*. Institute of Aquaculture, Scotland: University of Stirling, 119 pp.

Suda, S., Watanabe, M.M., Otsuka, S., Mahakahant, A., Yongmanitchai, W., Nopartnaraporn, N., Liu, Y. & Day, J.G. 2002. Taxonomic revision of water bloom–forming species of oscillatorioid cyanobacteria. *International Journal of Systemic Evolution and Microbiology* 52: 1577-1595.

Walsby, A.E., Utkilen, H.C. & Johnsen, I.J. 1983. Buoyancy changes of a red coloured *Oscillatoria agardhii* in Lake Gjersjoen, Norway. *Archives Hydrobiologia* 97: 18-38.

Willen, T. & Mattsson, R. 1997. Water-blooming and toxin-producing Cyanobacteria in Swedish fresh and brackish waters, 1981-1995. *Hydrobiologia* 353: 181-192.

Md. Yeamin Hossain* & Jun Ohtomi
Faculty of Fisheries
Kagoshima University
Shimoarata 4-50-20
Kagoshima 890-0056
Japan

Md. Abu Sayed Jewel, Sharmeen Rahman & Saleha Jasmine
Department of Fisheries
Faculty of Agriculture
University of Rajshahi
Rajshahi 6205
Bangladesh

Bernerd Fulanda & Ferdous Ahamed
The United Graduate School of Agricultural Sciences
Kagoshima University
Korimoto 1-21-24
Kagoshima 890-0065
Japan

*Corresponding author; email: yeamin2222@yahoo.com

Received: 27 July 2011
Accepted: 8 August 2011