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Seasonal Cycle of Phytoplankton in Aquaculture Ponds in Bangladesh

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A study on the seasonal changes in the phytoplankton community was carried out in four aquaculture ponds of Bangladesh over a period of 16 months from August 2000 to November 2001. Out of 45 phytoplankton species identified, 30 belong to Cyanophyceae, 7 to Chlorophyceae, 5 to Bacillariophyceae and 3 to Euglenophyceae. The highest phytoplankton abundance was observed in spring followed by early autumn, summer, and the lowest was in winter. The annual succession of Cyanophyceae was characterized by spring and early autumn period dominated by *Microcystis* sp. *Anabaena* sp. and *Planktolymbya* sp. with *Microcystis* sp. as the main blue-green algae represented. Chlorophyceae was characterized by rainy season domination of *Chlorella vulgaris, Pediastrum* sp. and *Scenedesmus denticulatus* with maximum abundance of *Chlorella vulgaris.* Whereas Bacillariophyceae was dominant during the winter period. *Navicula angusta* and *Cyclotella meneghiniana* were the most frequently occurring species of Bacillariophyceae throughout the study period. Euglenophyceae was dominant in late autumn and *Euglena* sp. was the dominant species. The effect of various physicochemical water quality parameters on the seasonal distribution and succession of the above mentioned phytoplankton population as well as the interaction and eutrophication are discussed.

Key Words: aquaculture, Bangladesh, bloom, ponds, phytoplankton, seasonal succession

INTRODUCTION

Changes in the phytoplankton community of large freshwater lakes have been long recognized as a good indicator of the trophic status and environmental quality (Reynolds 1996). Temporal variability in the structure and function of a phytoplankton community are the fundamental importance to aquatic system. Aquatic environments are subject to high temporal variation, with frequent reorganization of relative abundance and species composition of phytoplankton, as a result of interaction between physical, chemical and biological variables (Reynolds *et al*. 2000). In freshwater phytoplankton ecology, seasonality is often used to specify those patterns of successional sequences which occur during an annual cycle in response to changing in climatic variables.

In general, different planktonic species can tolerate different ranges of temperature as well as nutrient concentrations. These tolerance levels determine the dominance of different species within different seasons (Fogg 1975). Hence the seasonal changes in the dominant classes of phytoplankton can be explained in terms of variations in water temperature with the relationship of competition for nutrients and light. Phytoplankton abundance and taxonomic diversity depend upon the supply of nutrient in natural waters, where abundance increases with increasing nutrient concentrations. The relationship between the physical and chemical environment and phytoplankton species composition has been the subject of much discussion (Margalef 1978).

In Bangladesh there are millions of ponds and lakes where extensive fish culture is mainly practiced depending on natural food (phytoplankton) which is produced through fertilization. In some fish farms nutrient concentrations also increased from different sources such as artificial feeds and fertilizers (both organic and inorganic) etc., which lead to nutrient enrichment in fishponds. These nutrients eutrify the water body and enable it to support a large variety of

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phytoplankton assemblage.

Actual mechanism of phytoplankton assemblage with the seasonal changes in aquatic environment is very much necessary for the maintenance of water quality and sustainable aquaculture in Bangladesh. Most of the published references in Bangladesh are based on general limnological survey (Islam and Shaha 1975; Wahab and Ahmed 1992; Saha *et al.* 1999). However, references on seasonal changes in phytoplankton community structure in aquaculture ponds are scarce. The present study was undertaken to investigate the seasonal dynamics of different phytoplankton groups in relation to changes in the aquatic environment, with especial emphasis on cyanobacteria (blue-green algae) in aquaculture ponds.

MATERIALS AND METHODS

Study area and sampling

The study was conducted in four ponds for a period of 16 months from August 2000 to November 2001 (Fig. 1): Ishakha lake in Bangladesh Agricultural University (BAU) campus (Pond-1), a pangas culture pond at Sutiakhali village (Pond-2), a fingerling rearing pond at Bangladesh Fisheries Research Institute (BFRI) (Pond-3) and a farmers' fish culture pond at Kewatkhali village (Pond-4).

Among the four ponds, the Pond-1 receives domestic wastes and decomposed organic nutrients through drains of three residential halls of university students situated 20 m from the inlet. There are two drains that directly open in Pond-4 which continuously discharge nutrient rich water. In addition surface run-off and slums wash were also entered from neighboring households. Pond-2 and Pond-3 were well protected from the entrance of surface run-off, but fertilizers and artificial feeds were applied to these ponds.

For renovation, Pond-1 and Pond-4 were dewatered in April 2001 after 8 months of sampling started. The bottom soil was excavated and removed to reduce the sediment organic matters. During the renovation the drains through which kitchen waters-decomposed organic nutrients entered directly into Pond-1 was blocked permanently. After renovation, when the ponds were refilled with rainwater, regular sampling was resumed in May 2001 and continued until November 2001.

Analysis of water quality parameters

Water samples were monthly collected using two different plastic bottles from each pond; one for chemical analyses of water quality parameters and another for qualitative and quantitative analyses of phytoplankton. Water samples for the phytoplankton analysis were fixed with 3% formaldehyde.

Surface water temperature and pH were determined using a common thermometer and an electronic pH meter (Jenway 3020, Germany). Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) were measured using a HACH kit (DR/2010, a direct reading spectrophotometer) with high range chemicals (NitraVer 5 Nitrate Reagent Powder Pillows for NO_3-N, and PhosVer 3 Phosphate Reagent Powder Pillows for PO_4-P analysis). Chlorophyll *a* was determined spectrophotometrically (Milton Roy Spectronic, 1001, Germany) after 90% acetone extraction.

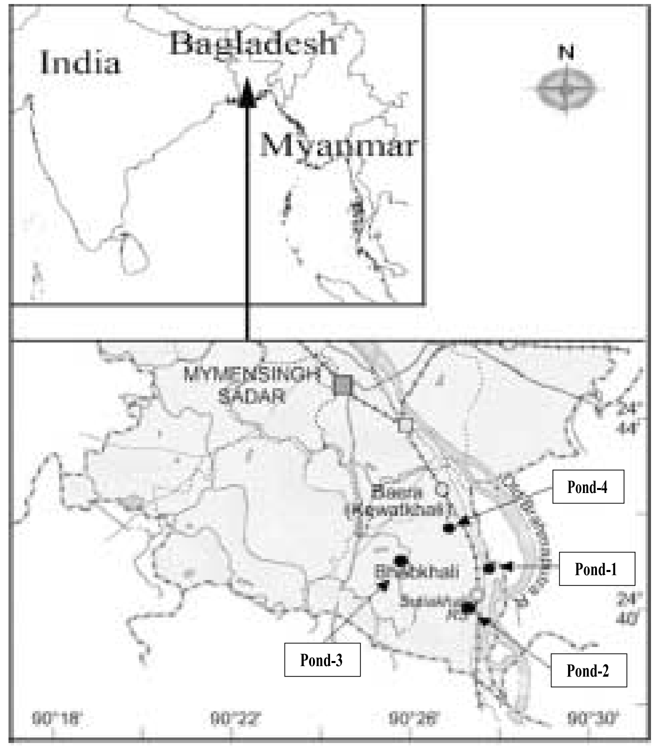

Fig. 1. Map showing the sampling stations at Mymensingh district in Bangladesh.

Phytoplankton study

For species identification samples were gently shaken to resuspend all materials and allowed to settle for one minute. Then 2-3 drops were removed from the middle of the sample and placed on a glass slide. Taxonomic determination of phytoplankton was performed with a phase-contrast microscope (Olympus, Japan) at $\times$ 100 to 400 with brightfield and phase contrast illumination on

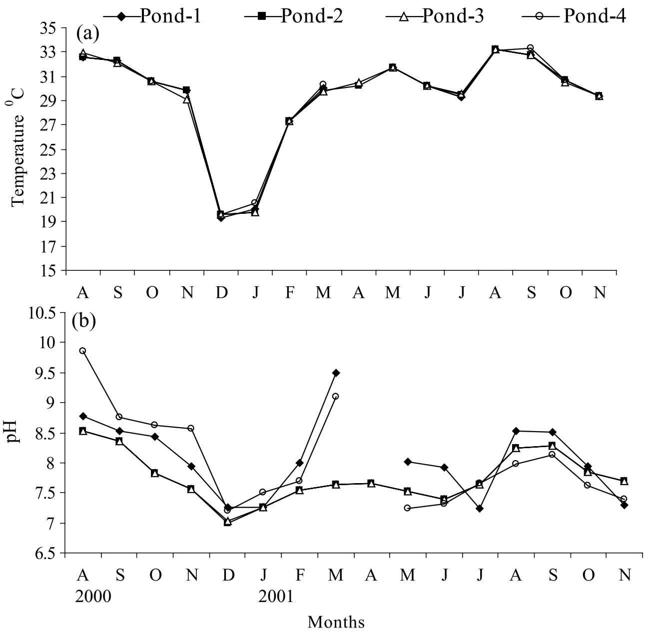

Fig. 2. Variation of water temperature (a) and pH (b) from August 2000 to November 2001 in four aquaculture ponds in Bangladesh.

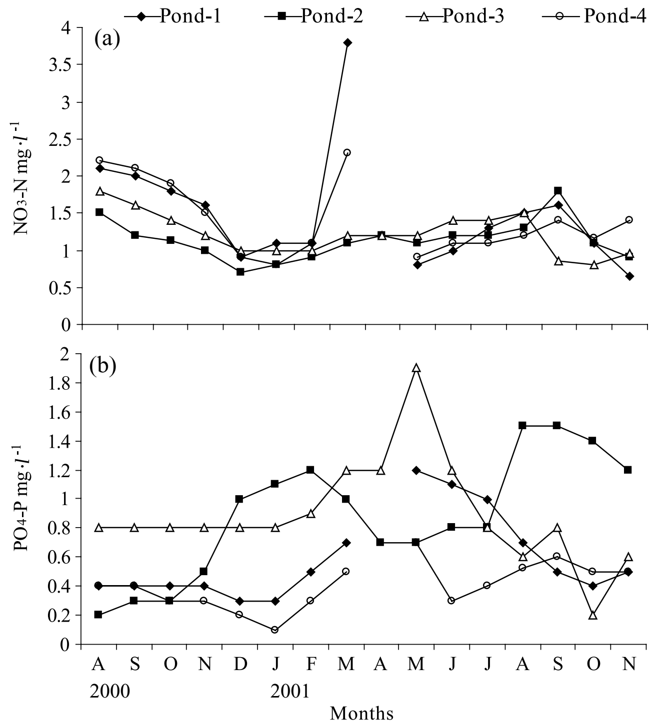

Fig. 3. Fluctuation of nitrate-nitrogen (a) and phosphate-phosphorous (b) concentration from August 2000 to November 2001 in four aquaculture ponds of Bangladesh.

living materials and on samples preserved with formaldehyde. Quantitative estimation of phytoplankton was done on Sedgewick-Rafter counting chamber (S-R cell) following the method described by Stirling (1985). Counting results were summarized as cells per milliliter.

RESULTS

Environmental factors

Surface water temperature ranged from 18.4 to 33.8°C in the studied ponds from August 2000 to November 2001. The minimum temperature was in Pond-3 in January and the maximum was in Pond-4 in August 2001 (Fig. 2). The pH values fluctuated widely from 7.00 to 9.85 with the least in Pond-3 in December 2000 and the highest in Pond-4 in August 2000 (Fig. 2).

The concentrations of NO_3–N fluctuated from 0.70 to 3.80 $mg \cdot l^{-1}$ with the maximum in Pond-1 in March 2001, when a green paint like cyanobacterial bloom was observed and the minimum concentration was in Pond-2 in December 2000 (Fig. 3). Concentrations of NO_3–N were highest in spring (February to March) followed by summer (April to May), rainy season (June to July), autumn (August to September), late autumn (October to November) and winter (December to January). PO_4–P concentrations varied widely from 0.10 to 1.90 $mg \cdot l^{-1}$ with the least concentrations in Pond-4 in January 2001 and the highest was in Pond-3 in May 2001 (Fig. 3).

Chlorophyll *a*

Remarkable variation of chlorophyll *a* content was found among the studied ponds throughout the study period, with the maximum of 15.69 $mg \cdot l^{-1}$ in Pond-1 in March 2001 and the minimum of 0.10 $mg \cdot l^{-1}$ in Pond-4 in May 2001 (Fig. 4). The highest chlorophyll *a* was found in the spring followed by autumn, summer and winter.

Phytoplankton community

In total, 45 phytoplankton species from Cyanophyceae (30 spp.), Chlorophyceae (7 spp.), Bacillariophyceae (5 spp.) and Euglenophyceae (3 spp.) were identified during the study period (Table 1). Phytoplankton abundance varied from 25.6 to 1590.6 $\times$ 10^3 $cells \cdot ml^{-1}$ with the minimum in Pond-4 in May 2001 and the maximum in Pond-1 in March 2001 (Fig. 4). We found two-peaks of phytoplankton abundance throughout the study period; one in August 2000 and another in March 2001, respectively.

Cyanophyceae

During the study period, blue-green algal (cyanobacterial) abundance was found to be higher in the spring and in the early autumn months; one in

Table 1. The list of phytoplankton species observed among the four aquaculture ponds during the study period

Class CYANOPHYCEAE
Order Hormogonales
Family Nostocaceae
Genus Anabaena Bory
- *Anabaena crassa* Lemmermann
- *Anabaena curva* Hill
- *Anabaena fusca* Hill
- *Anabaena lemmermannii* Richter
- *Anabaena macrospora* Klebahn
- *Anabaena mendotae* Trelease
- *Anabaena planctonica* Brunnthaler
- *Anabaena smithii* (Komárek) Watanabe
- *Anabaena spiroides* Klebahn

Genus *Anabaenopsis* Morren
- *Anabaenopsis elenkinii* Miller

Genus *Aphanizomenon* Morren
- *Aphanizomenon flos-aquae* Linné

Order Chroococcales
Family Chroococcaceae
Genus *Aphanocapsa* Nägeli
- *Aphanocapsa delicatissima* West & G.S West

Genus *Aphanothece* Nägeli
- *Aphanothece bachmannii* Komérek
- *Aphanothece clathrata* Skuja

Genus *Chroococcus* Nägeli
- *Chroococcus turgidus* (Kützing) Nägeli

Genus *Cyanodictyon* Pascher
- *Cyanodictyon imperfectum* Corberg & Weibull
- *Cyanodictyon planktonicum* Meyen

Genus *Cylindrospermum* Kützing
- *Cylindrospermum* sp.

Genus *Merismopedia* Nägeli
- *Merismopedia warminginiana* Lagerh

Genus *Microcystis* Lemmermann
- *Microcystis aeruginosa* (Kützing) Lemmermann
- *Microcystis botrys* Teiling
- *Microcystis flos-aquae* (Wittrock) Kirchner
- *Microcystis natans* Lemmermann
- *Microcystis robusta* (Clark) Nygaard
- *Microcystis viridis* (Braun) Lemmermann
- *Microcystis wesenbergii* (Komarek) Starmach

Genus *Nostoc* Vaucher
- *Nostoc commune* Vaucher & Flahault

Order Oscillatoriales
Family Oscillatoriaceae
Genus *Oscillatoria* Vaucher
- *Oscillatoria agardhii* Gomont

Genus *Planktothrix* Anagnostidis & Komárek
- *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek
- *Snowella litoralis* Komarek & Hindak

Class CHLOROPHYCEAE
Order Zygnematales
Family Desmidiaceae
Genus *Closterium* Ralfs
- *Closterium costatum* Prescott

Order Chlorococcales
Family Oocystaceae
Genus *Ankistrodesmus* Corda
- *Ankistrodesmus falcatus* (Corda) Ralfs

Genus *Chlorella* Kessler & Huss
- *Chlorella vulgaris* Beijerink

Genus *Oocystis* Nägeli
- *Oocystis* sp.

Genus *Pediastrum* Meyen
- *Pediastrum duplex* Meyen
- *Pediastrum tetras* (Ehrenberg) Ralfs

Genus *Scenedesmus* Meyen
- *Scenedesmus denticulatus* Lagerheim

Class BACILLARIOPHYCEAE
Order Thalassiosirales
Family Stephanodiscaceae
Genus *Cyclotella* (Kützing) Brébission
- *Cyclotella meneghiniana* Kützing

Order Fragilariales
Family Fragilariaceae
Genus *Melosira* Agardh
- *Melosira granulata* (Ehrenberg) Ralfs

Order Eunotiales
Family Eunotiaceae
Genus *Actinella* Lewis
- *Actinella cholnokii*

Order Naviculales
Family Naviculaceae
Genus *Navicula* Bory
- *Navicula angusta* Grunow

Order Bacillariales
Family Bacillariaceae
Genus *Nitzschia* Hasle
- *Nitzschia sigmoidea* Nitzsch

Class EUGLENOPHYCEAE
Order Euglenales Ehrenberg
Family Euglenaceae
Genus *Euglena* Ehrenberg
- *Euglena* sp.

Genus *Phacus* Dujardin
- *Phacus longicauda* (Ehrenberg) Dujardin

Genus *Trachelomonas* Ehrenberg
- *Trachelomonas* sp.

August 2000 and another in March 2001. *Microcystis* sp. and *Anabaena* sp. were the dominant genera among the blue-green algae (Table 2). Cyanophyceae abundance was higher in Pond-1 and Pond-4 than in Pond-2 and Pond-3. The highest recorded abundances were 1,572.6 $\times$ 10^3 cells$\cdot$ml^{-1} in Pond-1 in August 2000 and 936.4 $\times$

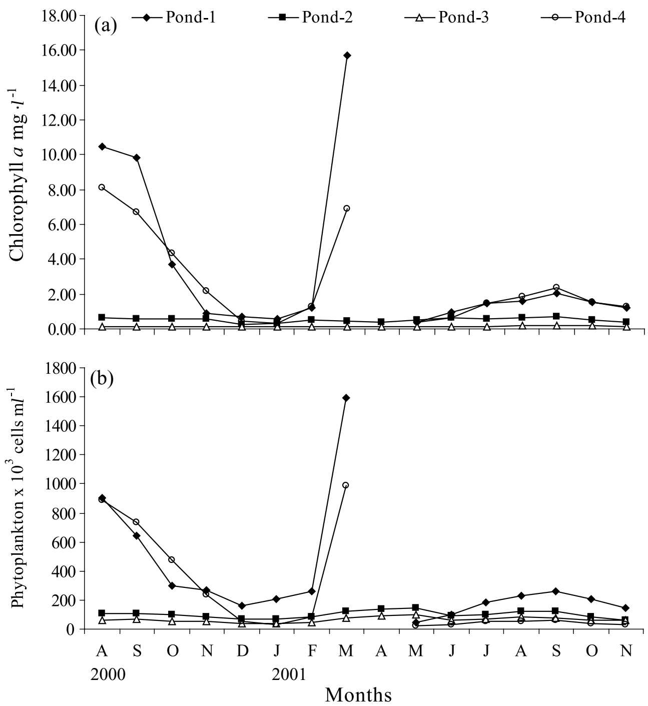

Fig. 4. Fluctuation of chlorophyll *a* (a) and succession of phytoplankton abundance (b) from August 2000 to November 2001 in four aquaculture ponds in Bangladesh.

10^3 cells · ml^{-1} in Pond-4 in March 2001, which contributed 98.8% and 95.2% of total phytoplankton abundance, respectively (Fig. 5). *Microcystis* as a single genus contributed up to 96.2% in Pond-1 and 92.6% in Pond-4 among the phytoplankton abundance during the two peaks. *Microcystis aeruginosa* was the most abundant species in Pond-1 and the next dominant species was *M. wesenbergii*. *M. aeruginosa* occupied 80.8 % among the blue-green algae in Pond-1 in March 2001 (Table 2).

Chlorophyceae

Chlorophyceae ranked as the second among phytoplankton groups in respect to both abundance and number of species in all ponds. Chlorophyceae ranged from 1% to 51.5% to the total phytoplankton abundance with the minimum in Pond-1 in August 2000 and in Pond-4 in August-September 2000, and the maximum in Pond-4 in July 2001 (Fig. 5). The frequently occurring taxa of Chlorophyceae were *Chlorella vulgaris, Pediastrum* sp., *Scenedesmus denticulatus, Ankistrodesmus falcatus*, and *Oocystis* sp. *Chlorella vulgaris* contributed 35% among the total phytoplankton in Pond-4 in July (Table 2).

Bacillariophyceae

Bacillariophyceae showed the relatively higher abundance in all ponds in the winter with the maximum of 51.6% in Pond-1 in January 2001. Bacillariophyceae abundance was higher in Pond-1 and Pond-4 before renovation than after renovation. The abundance percentage of this group varied from 6.7 % to 31.4% with the highest in Pond-3 in May and the lowest in Pond-1 in November 2001 after renovation (Fig.5). Bacillariophyceae was absent during the bloom of Cyanophyceae in Pond-1 in March 2001 and in Pond-4 in August 2000. The frequently occurring taxa of Bacillariophyceae were *Cyclotella meneghiniana* and *Navicula angusta. Navicula angusta* was the dominant species and its highest contribution to the phytoplankton abundance was 46.5% in Pond-1 in the winter (January 2001) (Table 2).

Euglenophyceae

The highest contribution of Euglenophyceae was 41% in Pond-4 in November 2001, when the surface of this pond looked red-paint covered, but this group was absent during the cyanobacterial bloom period in Pond-1 and Pond-4 (Fig. 5). The taxa most frequently occurred among the Euglenophyceae were *Euglena* sp. and *Phacus longicauda* with 21.3% and 22.2% contribution to the total phytoplankton abundance in Pond-3 and Pond-4 in November respectively (Table 2).

DISCUSSION

In our present study, chlorophyll *a* levels in August 2000 and March 2001 were higher than those in other period. The fluctuation of chlorophyll *a* value was concomitant with the abundance variation of large size cyanobacteria (200 to 250 cells per colony). Shiomoto and Hashimoto (2000) reported that large phytoplankton contributed substantially to the high level of chlorophyll *a* exceeding 0.04 mg · l^{-1}.

Phytoplankton community structure is regulated by several factors, which include the growth rate of algal species and the specific rate of loss attributed to grazing, sedimentation and dilution. The seasonal variation in phytoplankton abundance in these ponds suggests that the first favourable period for phytoplankton bloom occurred from February to March, which was due to the low volume of water after draught period in winter. Rapid multiplication of cells due to the availability of adequate amount of nutrients, rising temperature, bright sunlight and pH were other causing factors for the bloom. In general, algae require a supply of nutrient,

Table 2. Seasonal dynamics of dominant phytoplankton in aquaculture ponds in Bangladesh during the study

Species Name	Pond-1																Pond-2															
	2000					2001											2000					2001										
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Cyanophyceae																																
Anabaena crassa	*	*	**										*	**	**																	
Anabaena fusca																																
Anabaena lemmermannii																	*						*									
Anabaena smithii																	**	**							*	**	*	*				
Aphanizomenon flos-aquae																	*						**	**	*	*	*					
Merismopedia warminginiana																																
Microcystis aeruginosa	***	***	**				**	***					**	**			*								*	*	*	*				
Microcystis botrys	*	*					*	**					*																			
Microcystis wesenbergii	*							*																								
Chlorophyceae																																
Ankistrodesmus falcatus																							*	*	*	*	*	*				
Chlorella vulgaris								*	**	**	**	**	**	**													*	*				
Closterium costatum								*				**																				
Scenedesmus denticulatus												*											*	*	*			*				
Bacillariophyceae																																
Actinella cholnokii																				*	*	*										
Cyclotella meneghiniana										*																	*	*				
Melosira granulata																											*	*				
Navicula angusta						***	**			*										*	*	*										
Euglenophyceae																																
Euglena sp.			*													*			*	*												

Species Name	Pond-3																Pond-4															
	2000					2001											2000					2001										
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Cyanophyceae																																
Anabaena crassa																																
Anabaena fusca																																
Anabaena lemmermannii																																
Anabaena smithii																																
Aphanizomenon flos-aquae																	**	**					*	**								
Merismopedia warminginiana	**	**	*				*	*	*				**	**	*																	
Microcystis aeruginosa	*	*	*				**	**	*				*	*			**	**					*	***				*	*	*		
Microcystis botrys																																
Microcystis wesenbergii																	*	*					*	*								
Chlorophyceae																																
Ankistrodesmus falcatus	*	*	*								*	*																				
Chlorella vulgaris	*	*	*								*	**														**	*	**	*			
Closterium costatum																																
Scenedesmus denticulatus																																
Bacillariophyceae																																
Actinella cholnokii																																
Cyclotella meneghiniana					*	**			*	*																						
Melosira granulata																					*	*										
Navicula angusta					*	*															*	*										
Euglenophyceae																																
Euglena sp.			*	*										*	*	**			*	*												**

Remarks: * indicates 10 to 19.9%, ** 20 to 39.9% and *** above 40% of the total phytoplankton abundance

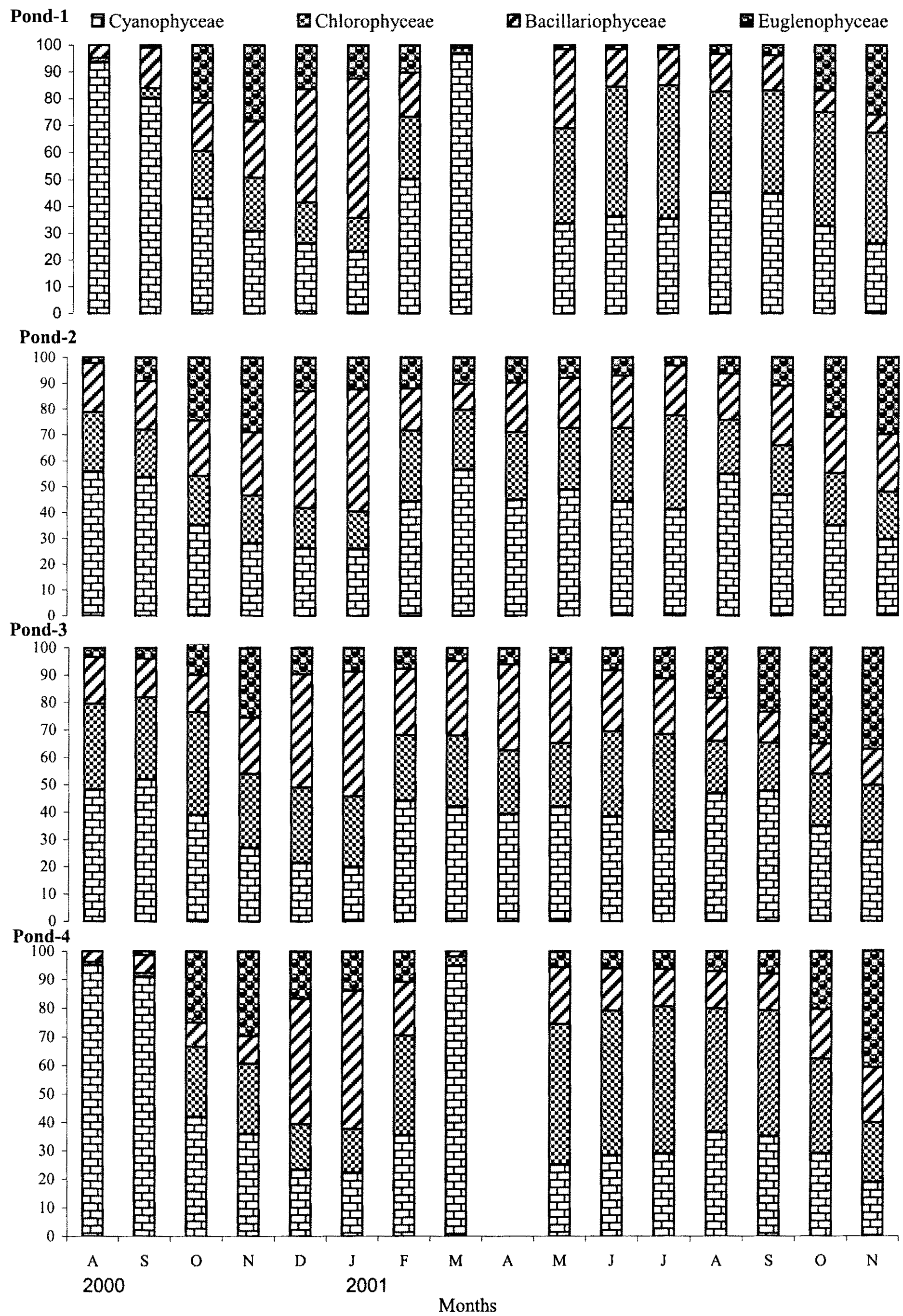

Fig. 5. Monthly variations in percentage composition of different phytoplankton groups from August 2000 to November 2001 in four aquaculture ponds in Bangladesh.

sufficient light and favourable temperatures to grow (Fogg 1975; Bold and Wynne 1978).

The second bloom of phytoplankton occurred from August to September in all ponds, when a higher concentration of nutrient coupled with high temperature, pH, and long daytime was available. Nutrients were accumulated from surface run-off, street and slums wash and from ground seepage in Pond-1 and Pond-4, because of heavy rainfall in rainy season (June to July). More fish feeds (8% of body weight / day, personal communication) were applied for monoculture of *Pangasius* sp. in Pond-2, and high dozes fertilizers (both organic and inorganic) were applied in fingerling rearing pond (Pond-3). Similar phytoplankton growth due to nutrient accumulation during the rainy season from September to November was observed in Maputo Bay, southern Mozambique (Paula *et al.* 1998). Our finding agrees fairly well with the opinion of Anderson (1958) and Singh (1960) who found that the different physico-chemical parameters of water at optimum level were pre-requisite for the higher growth of phytoplankton.

Phytoplankton abundance was appeared to decrease gradually in the winter; this may be related with lower temperature, shorter day length, low pH and low concentration of nutrients. Supporting evidence to this assumption can be drawn from some previous studies (Van Nguyen and Wood 1979; Pabst *et al.* 1980) which suggest that collapse of phytoplankton occurs in a nutrient depletion condition coupling with meteorological changes such as cloudy weather, low water temperature etc. In addition Boyd (1982) reported that phytoplankton die-offs are associated with calm weather, which reduces mixing with bottom waters that are an important nutrient source of phytoplankton growth in vertically stratified systems (Margalef 1987). Galijuri *et al.* (2002) suggested that the factors involved in structuring a phytoplankton community in reservoirs arising from the relationship generated by chemical (nutrients), physical (temperature, underwater light, climate), biological (composition and abundance of zooplankton) condition. However, the above mentioned kinds of phytoplankton abundance fluctuation strategy may be associated mainly with physical and chemical features such as clear alteration of temperature, short and long daily photoperiod, fluctuation of nutrient concentrations and distinct fluctuation of pH with the change of seasons both in the naturally and artificially nutrient fed ponds.

Blue-green algal abundance was found to be the major portion in the phytoplankton community during the spring and in the early autumn in all ponds. The reasons behind this result may be the higher concentration of NO_3–N, temperature, alkaline pH, low water volume and bright sunlight which created favourable condition for better propagation of this group of phytoplankton. Regardless of the nitrogen to phosphorus ratio, cyanobacteria have shown dominance at temperature higher than 20°C (Tilman *et al.* 1986). In our study, *Microcystis* was the most dominant genus among the blue-green algae and formed a bloom at higher temperature, alkaline pH with highest concentration of nutrients (NO_3–N) in March 2001. This result agrees with the result of Westhuizen and Eloff (1983) who found the highest growth rate of *Microcystis aeruginosa* around pH 9.0 in batch culture. Park *et al.* (1993) reported that the increase of dissolved NO_3–N favoured the growth of *Microcystis* at Lake Suwa in Japan. Furthermore Utkilen *et al.* (1996) reported that *Microcystis* population collapsed when NO_3–N concentration decreased. In our study cyanobacteria was observed to be dominant with the reduction of other groups of phytoplankton. This finding agrees with the evidence of some studies (Lam and Silvester 1979; Stockner and Cronberg 2000), which suggest that the toxic substances, high nutrients scavenging capacity and buoyancy properties of Cyanophyceae help them to shift for dominance.

High abundance of Chlorophyceae was found in July 2001 in all ponds with moderate temperature (29.3 to 29.6°C) and high concentration of phosphate-phosphorus. This phenomenon might be associated with frequently occurring cloudy weather and dilution of nutrients due to heavy rainfall. This result supports the finding of Tilman *et al.* (1986) who reported that green algae shifted for dominance at intermediate temperature. In addition, Casabianca and Posada (1998) also showed that the growth of Chlorophyceae was not affected by high nutrients, but their growth became delayed at a lower phosphate-phosphorus concentration with the temperatures above 24°C which played a role of limiting factor for growth.

Bacillariophyceae was most abundant at a low temperature with the least concentration of nutrients in the winter (December to January). In fact, a lower concentration of nutrients was maintained during the winter. It may be due to least rainfall causing not much run-off, calm weather and less mixing with nutrients rich bottom water. There was a less amount of fish feed as the feeding intensity of fish decreased with decreasing temperature. A similar suggestion was expressed by Havens (1991) who reported that fish such as the mad carp (*Cirrhina molitorella*) and mrigal (*Cirrhina mrigala*) that feed on bottom dwelling organisms and organic matters sedimented do not stir up sediments due to less demand of food requirement at low temperature. These results agree with the finding of Talbot and Bate (1987) who concluded that blooms of surf diatom species, including *Asterionella* sp. and *Aulacodiscus* sp. appear to be unrelated to nutrient availability.

Euglenophytes showed their higher proportion in the phytoplankton community in November. A moderate temperature and accumulation of organic loads from surface run-off, surrounding slums wash, municipal sewage after heavy rainfall and clear sun-shine may be the reasons for the dominance of Euglenophytes in the late autumn. Supporting evidence can be drawn from the study of Phang and Ong (1988) which suggested that

Euglenoides were dominant in water rich with organic loads at elevated temperature. In addition Wild *et al.* (1995) reported that *Euglena* assemblages were widely distributed in higher eutrophicated ponds at elevated temperature.

The seasonal changes of phytoplankton in four aquaculture ponds exhibited the classic pattern, being dominated by Cyanophyceae (*Microcystis* sp. and *Anabaena* sp.) in the spring to autumn months, diatoms (*Cyclotella* sp. and *Navicula angusta*) in the winter months, Chlorophyceae (*Chlorella* sp. and *Oocystis* sp.) in the rainy season and Euglenophyceae (*Euglena* sp.) in the late autumn months. This seasonal distribution of phytoplankton has been found in many other ponds and lakes, and suggests a typical pattern in Bangladesh.

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