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Microalgal ecology in experimental carp - pangas polyculture ponds

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Abstract

Microalgal ecology was studied for a period of 18 weeks from 15 June to 18 October 2003 in experimental carp - pangasiid catfish polyculture ponds under four different stocking rates (treatments: T) each with three replications in the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The ponds were dried, limed (CaO) at the rate of 247 kg/ha and exposed to sunlight for about two weeks. Urea, super phosphate and cowdung were applied 7 days before stocking of fish fingerlings and then at 10 days interval at the rates of 24.70 kg/ha, 24.70 kg/ ha and 617.50 kg/ha respectively. A total of 34 microalgal genera were identified under four major groups. Some water quality parameters e.g. temperature, transparency, pH, depth and nutrients (NO_3-N and PO_4-P) were recorded at regular intervals and their relationship with the occurrence and abundance of microalgae were studied. The highest microalgal cell density was found during 16th week (4 October) in all of the treatments corresponded with high nutrient concentrations (NO_3-N and PO_4-P). Chlorophyceae was the most dominant group followed by Cyanophyceae, Bacillariophyceae and Euglenophyceae except in T_4 where Cyanophyceae was dominant. Dissolved oxygen (4.2 to 9.6 mg/l), pH (7.0 to 8.1), temperature (30.2 °C to 32.6 °C), NO_3-N (0.46 to 1.38 mg/l) and PO_4-P (0.83 to1.73 mg/l) were favourable both for microalgal and fish growth.

Keywords: Microalgae, Ecology, Carp, Pangas, Polyculture

Introduction

Several available hypotheses on the factors influencing the distribution and abundance of planktonic organisms include changing physico-chemical parameters (Goss and Bunting, 1970; Craddock, 1976; Shafi *et al.*, 1978), food condition and abundance of predator species (Wong and Ward, 1972; Noble, 1975).

Microalgae play an important role as primary producer in the aquatic ecosystem (Nozaki, 1999) and have been the major nutritional source available to the fish from nature. It is well recognized that the water quality plays an important role on the survival, growth and production of fish. A pond with good water quality produces more healthy fish than a pond with poor water quality. Microalgal blooms (cyanobacterial and euglenophycean bloom) have become increasingly common and causing water quality problems in ponds and lakes in many countries of the world. Toxic blooms of cyanobacteria have been detected in freshwater lakes all over the world (WHO, 1984) and these toxic cyanobacteria cause death of animals and wildlife when they are consumed with water (Repavich *et al.*, 1990; Carbis *et al.*, 1995; Negri *et al.*, 1995). Larger cyanobacteria including *Anabaena*, *Aphanizomenon*, *Microcystis*, *Oscillatoria* and others produce common off-flavour and form surface scum that often lead to algal die-off and water quality deterioration (Perschbacher, 1995).

The traditional aquaculture in rural Bangladesh is predominated by carp polyculture composed of only Indian or both Indian and exotic species and stocked in such species combination and ratios that the natural food resources (plankton and benthos) present in all niches of the water column are properly utilized. To enhance the natural food production,

fertilization, organic and inorganic, is made and occasionally supplemental feeds are given. To augment the fish production and to satisfy the national fish demand the culture of pangasiid catfish (*Pangasius hypophthalmus*) has recently expanded to a large scale. The culture of this species is completely supplemental feed dependent and in most cases monoculture is practiced. The farming of this fish is facing serious problems with massive microalgal blooms formed due to enrichment of nutrients from microbial decomposition of unused feed and fish metabolic wastes. Moreover, the marginal farmers are facing hardship from the very high input costs needed in farming this fish. To overcome both of the above mentioned problems a number of rearing experiments combining both pangasiid catfish and carps in different species ratios and densities have been undertaken to develop sustainable carp-pangasiid catfish polyculture technologies. In the present experiment a small number of pangasiid catfish was added to carp polyculture keeping the carp density same with an understanding that the unused feed (if any) and metabolic wastes of pangasiid catfish will be directly and/or indirectly utilized by the carps that will enhance the carp production. As the production of carps largely depends on natural food organisms, i.e. qualitative and quantitative presence of microalgae, the objective of the present study was to see the microalgal ecology in different supplemental feed input conditions and stocking densities of pangasiid catfish in different rearing treatments.

Materials and Methods

The study was conducted for a period of 18 weeks from 15 June to 18 October, 2003 in 12 equal sized (each 200 m^2), adjacent, rain-fed, rectangular ponds in the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The ponds were dried during the end of May, treated with lime (CaO) at the rate of 247 kg/ha and exposed to sunlight for about two weeks. Then the ponds were filled with water pumped from an adjacent large pond. The fish fingerlings were stocked on 15 June and harvested on 18 October. The ponds were arranged in four treatments (T) each with three replications. The fish stocking densities were 10,000/ha in T_1 (5000 catla *Catla catla*, 2500 rui *Labeo rohita* and 2500 mrigal *Cirrhinus mrigala*); 12,500/ha in T_2 (5000 catla, 2500 rui, 2500 mrigal and 2500 pangasiid catfish); 15,000/ha in T_3 (5000 catla, 2500 rui, 2500 mrigal and 5000 pangasiid catfish) and 17,500/ha in T_4 (5000 catla, 2500 rui, 2500 mrigal and 7,500 pangasiid catfish). The ponds were initially fertilized 7 days before stocking of fish fingerlings and then regularly at 10 days interval with urea, super phosphate and cow-dung at the rates of 24.70 kg/ha, 24.70 kg/ha and 617.50 kg/ha respectively. Commercial pelleted feed (Quality Fish Feed Ltd., Bangladesh) was provided only for pangasiid catfish at the rates of 8% of fish biomass per day during the first six weeks, 6% during the second six weeks and 4% thereafter.

Samplings were made biweekly. On each sampling day the collection of plankton and water samples and measurement of some other water quality parameters were made between 0900 to 1100 hrs at a fixed site of each pond. Dissolved oxygen (mg/l) and pH were measured on the spot by using a digital DO meter (HANNA instruments, HI-9142 Portugal) and a pH meter (HANNA instruments, HI-9142, Portugal) respectively at the depths of 0.00 m, 0.5 m and 1.0 m (pond depth 1.10-1.50 m). Surface water temperature was measured by using an ordinary Celsius thermometer and a Secchi disc was used to measure the transparency of water.

Water samples were collected from the selected sites by using a one meter long plastic tube (4 cm diameter) and kept into separate bottles of 250 ml capacity and were then labeled properly. The water was filtered in the laboratory through a Whatman GF/C filter paper (Whatman International Ltd., England). The concentration of nitrate-nitrogen and phosphate-

phosphorus in the filtrate were determined by a data logging spectrophotometer (Odyssey DR/2500 HACH, USA) using NitraVer 5 and PhosVer 3 powder pillows respectively. The chlorophyll-*a* content of the water was determined spectrophotometrically after acetone extraction (Stirling, 1985). To study the microalgae, a known volume of water from each pond was collected and concentrated to about 200 ml by passing through a plankton net (mesh 15μm). The collected samples were then stored in plastic bottles and preserved in 5% buffered formalin for laboratory analysis. For qualitative and quantitative study of plankton 1 ml sample was taken by a dropper and drained on a S-R (Sedgwick- Rafter) counting cell. The plankton in 20 randomly selected squares was identified and counted under a compound microscope. The mean number of microalgae were recorded and expressed numerically per liter of water (cells/l) for each pond. The qualitative study of microalgae was made following Prescott (1964), and Bellinger (1992). The microalgae per liter of original water were estimated following Rahman (1992). Water quality and microalgal data were analyzed statistically following Gomez and Gomez (1984).

Results and Discussion

Environmental parameters

The changes in surface water temperature, transparency, water depth and chlorophyll-*a* in ponds of four different treatments are shown in Table 1. The experiment was conducted during the summer months, as a result, the water temperature was high throughout the study period, and it ranged from 30.2 ºC to 32.6 ºC. There was no significant variation in temperature among the treatments. The secchi-disk transparency of water ranged from 43.7 – 46.0 cm at the start of the experiment that decreased with the increase of the culture period and during the end of the experiment it ranged from 23.3 – 34.0 cm. The transparency was reduced mainly due to the growth of phytoplankton in the ponds. The pH of water was neutral or alkaline in ponds of all treatments and ranged from 7.0 to 8.1. No significant variation in pH was found among the treatments. The dissolved oxygen in pond water measured between 0900 and 1100 hrs varied between 4.2 and 9.6 mg/l and did not show any definite increasing or decreasing trend. The concentrations of NO_3-N and PO_4-P in pond water found during the study period are shown in Figs. 1 and 2. The concentration of both NO_3-N and PO_4-P in water increased with the increase of the culture period in all treatments, and the rate of increase was highest in T_4 where highest amount of supplemental feed was given to the highest number of stocked pangasiid catfish. Remarkable variation of chlorophyll-*a* content was found among the studied ponds during the study period. The chlorophyll-*a* content increased gradually from the beginning of the study up to 4 October and then decreased, the increasing rate was comparatively high in T_4 followed by T_3, T_2 and T_1. Highest chlorophyll-*a* content was recorded in T_4 and lowest in T_1 (Table 1).

Microalgal community

A total of 34 microalgal genera were identified under four major groups: 15 genera belong to Chlorophyceae, 9 to Cyanophyceae, 7 to Bacillariophyceae and 3 to Euglenophyceae. Microalgal cell density varied from 12.38 to 45.05 $\times$ 10^4 cells/l with the minimum in T_1 during initial sampling and the maximum in T_4 during 16th week. Total microalgal cell density ($\times 10^4$ cells/l) was registered higher in T_4 followed by T_3, T_2 and T_1 on all of the sampling dates except initial sampling (Fig. 3). Total microalgal cell density ($\times 10^4$ cells/l) gradually increased and reached in peak during 16th week when nutrients concentrations (NO_3-N and PO_4-P) were high in all of the treatments. Fortnightly variations in percentage composition of different microalgal groups in ponds of different treatments are shown in Fig. 4. The occurrence,

abundance and distribution of different groups of microalgae did not show any uniform pattern during the study period. Chlorophyceae was the highest group of phytoplankton in percentage composition and abundance of cell density in all of the treatments except in T_4 where Cyanophyceae was the highest group of phytoplankton (Fig. 4). Microalgal cell density increased gradually with the progress of the study period and reached in peak during 16th week (4 October), then decreased in all of the treatments (Fig. 3). The values of correlation coefficient (r), intercept (a) and regression coefficient (b) estimated for microalgal cell density and different water quality parameters are shown in Table 2. The values of correlation coefficient (r) and regression coefficient (b) showed positive relationship in case of NO_3-N (mg/l), PO_4-P (mg/l), chlorophyll-*a* (μg/l) and dissolved oxygen (mg/l) (Table 2).

Table 1. Fortnightly variations in temperature (^{0}C), transparency (cm), water depth (cm) and chlorophyll-a (μg/1) in ponds of different treatments. Values represented mean ± SE, n=3

Parameters	Weeks	Treatment			
		T_1	T_2	T_3	T_4
Temperature (^{0}C)	0	31.0±0.1	31.2±0.1	31.2±0.1	31.3±0.1
	2	31.3±0.1	31.3±0.1	31.2±0.1	31.3±0.1
	4	32.1±0.1	32.3±0.1	32.2±0.1	32.3±0.2
	6	31.3±0.1	31.2±0.1	31.4±0.1	31.4±0.1
	8	32.6±0.1	32.5±0.2	32.6±0.1	32.6±0.1
	10	32.6±0.1	32.4±0.2	32.6±0.2	32.5±0.2
	12	31.3±0.1	31.3±0.1	31.3±0.1	31.3±0.1
	14	31.3±0.1	31.3±0.1	31.2±0.1	31.2±0.1
	16	30.2±0.1	30.3±0.1	30.4±0.1	30.4±0.1
	18	30.4±0.1	30.4±0.1	30.3±0.1	30.3±0.1
Transparency (cm)	0	43.6±4.7	44.3±6.9	46.0±5.4	43.7±1.9
	2	36.0±2.2	34.3±1.2	36.0±1.4	29.0±0.9
	4	40.0±2.5	37.3±2.7	33.0±0.8	30.7±0.9
	6	33.3±0.7	33.0±1.2	29.7±1.7	26.0±2.2
	8	35.3±2.2	28.3±1.9	25.0±2.6	22.3±0.5
	10	33.7±1.4	27.2±0.7	28.7±1.9	25.8±0.7
	12	31.0±0.5	29.0±1.9	23.7±2.1	17.7±0.9
	14	32.0±1.2	26.0±1.2	24.7±1.4	22.7±1.2
	16	37.0±3.3	25.0±0.8	23.3±1.5	26.3±2.4
	18	34.0±1.2	28.3±0.9	32.0±1.7	23.3±1.4
Water depth (cm)	0	119.5±2.5	122.5±1.2	120.5±0.8	114.8±0.7
	2	116.1±0.8	119.6±2.1	114.7±0.9	121.2±1.3
	4	120.1±2.2	122.1±3.2	123.4±2.1	124.3±2.7
	6	122.2±2.1	123.3±3.6	128.3±1.8	129.5±3.4
	8	129.6±2.4	133.6±2.7	137.8±1.9	134.7±1.5
	10	127.5±3.8	130.1±3.6	133.9±3.3	130.5±1.1
	12	124.5±3.4	127.5±0.5	130.2±2.5	124.3±2.3
	14	120.7±4.4	121.9±2.9	125.0±1.9	126.7±2.1
	16	117.4±4.2	117.5±1.9	120.2±0.4	122.6±0.5
	18	115.1±2.6	114.8±1.2	117.3±0.3	116.8±0.6
Chlorophyll-a(μg/1)	0	18.2±3.8	17.21±2.6	19.2±0.9	18.1±0.9
	2	33.8±4.6	38.9±2.1	44.9±4.3	48.9±4.6
	4	45.4±4.0	51.3±9.9	66.7±3.8	74.6±30.8
	6	65.3±2.6	79.5±5.4	97.4±8.4	104.2±4.6
	8	127.3±5.8	136.1±9.1	152.8±9.2	171.2±7.7
	10	120.8±6.1	142.9±2.6	183.7±15.6	192.7±15.4
	12	148.7±3.7	175.5±24.1	228.8±18.4	237.9±55.4
	14	154.3±3.9	169.5±5.5	220.8±8.1	234.9±7.5
	16	160.9±4.9	183.5±21.4	251.4±10.8	284.7±47.8
	18	131.5±21.6	172.1±4.4	222.2±24.5	238.9±25.1

Table 2. Estimation of the degree of relationship between environmental parameters and microalgal growth in ponds of different treatments

Treatments	Phytoplankton	Parameters	Values of regression coefficient	Values of intercepts	Values of correlation coefficient
	Y	X	b	a	r
T_1	Microalgal cell density	Temperature (°C)	-0.076	32.67	-0.296
		Transparency (cm)	-1.189	56.54	-0.574
		Water depth (cm)	0.147	118.78	0.097
		pH	-0.054	8.51	-0.600
		Dissolved oxygen (mg/l)	0.278	2.87	0.588
		NO_3-N (mg/l)	0.058	-0.152	0.924
		PO_4-P (mg/l)	0.051	0.275	0.930
		Chlorophyll-*a* (μg/l)	16.19	-171.0	0.940
T_2	Microalgal cell density	Temperature (°C)	-0.054	32.62	-0.297
		Transparency (cm)	-1.325	60.20	-0.912
		Water depth (cm)	0.032	124.02	0.025
		pH	-0.051	8.65	-0.698
		Dissolved oxygen (mg/l)	0.159	3.56	0.618
		NO_3-N (mg/l)	0.044	-0.109	0.959
		PO_4-P (mg/l)	0.044	0.210	0.959
		Chlorophyll-*a* (μg/l)	13.83	-184.5	0.921
T_3	Microalgal cell density	Temperature (°C)	-0.014	31.81	-0.102
		Transparency (cm)	-1.109	57.85	-0.927
		Water depth (cm)	0.467	113.5	0.372
		pH	-0.025	8.128	-0.533
		Dissolved oxygen (mg/l)	0.131	3.371	0.575
		NO_3-N (mg/l)	0.026	0.325	0.970
		PO_4-P (mg/l)	0.036	0.329	0.957
		Chlorophyll-*a* (μg/l)	13.45	-185.8	0.936
T_4	Microalgal cell density	Temperature (°C)	-0.018	32.04	-0.212
		Transparency (cm)	-0.573	44.65	-0.797
		Water depth (cm)	0.246	116.8	0.391
		pH	-0.029	8.37	-0.802
		Dissolved oxygen (mg/l)	0.009	6.371	0.073
		NO_3-N (mg/l)	0.021	0.511	0.966
		PO_4-P (mg/l)	0.025	0.543	0.977
		Chlorophyll-*a* (μg/l)	8.789	-112.4	0.946

Chlorophyceae

During the study period, Chlorophyceae registered highest group of phytoplankton in respect to both abundance (cell density) and number of genera. The most dominant genera of Chlorophyceae were *Chlorella* and *Scenedesmus*. Chlorophyceae ranged from 34.59% to 48.33% among the total phytoplankton with the maximum in T_1 and the minimum in T_3. The cell density of Chlorophyceae was found to be gradually increased with formation of peaks during 16th week (4 October) in all of the treatments when NO_3-N and PO_4-P concentrations were high (Fig. 1 and 2).

Cyanophyceae

Cyanophyceae ranked second among phytoplankton groups in respect of both abundance and number of genera in all of the treatments except in T_4 where its percent composition was high. *Microcystis, Oscillatoria* and *Gomphosphaeria* were the dominant genera of this group. The highest contribution of Cyanophyceae to the total phytoplankton was 39.15% in T_4 and the lowest was 30.08% in T_1. The cell density of Cyanophyceae ranged from 3.72 to 16.49 $\times 10^4$ cells/l with the maximum in T_4 and the minimum in T_1.

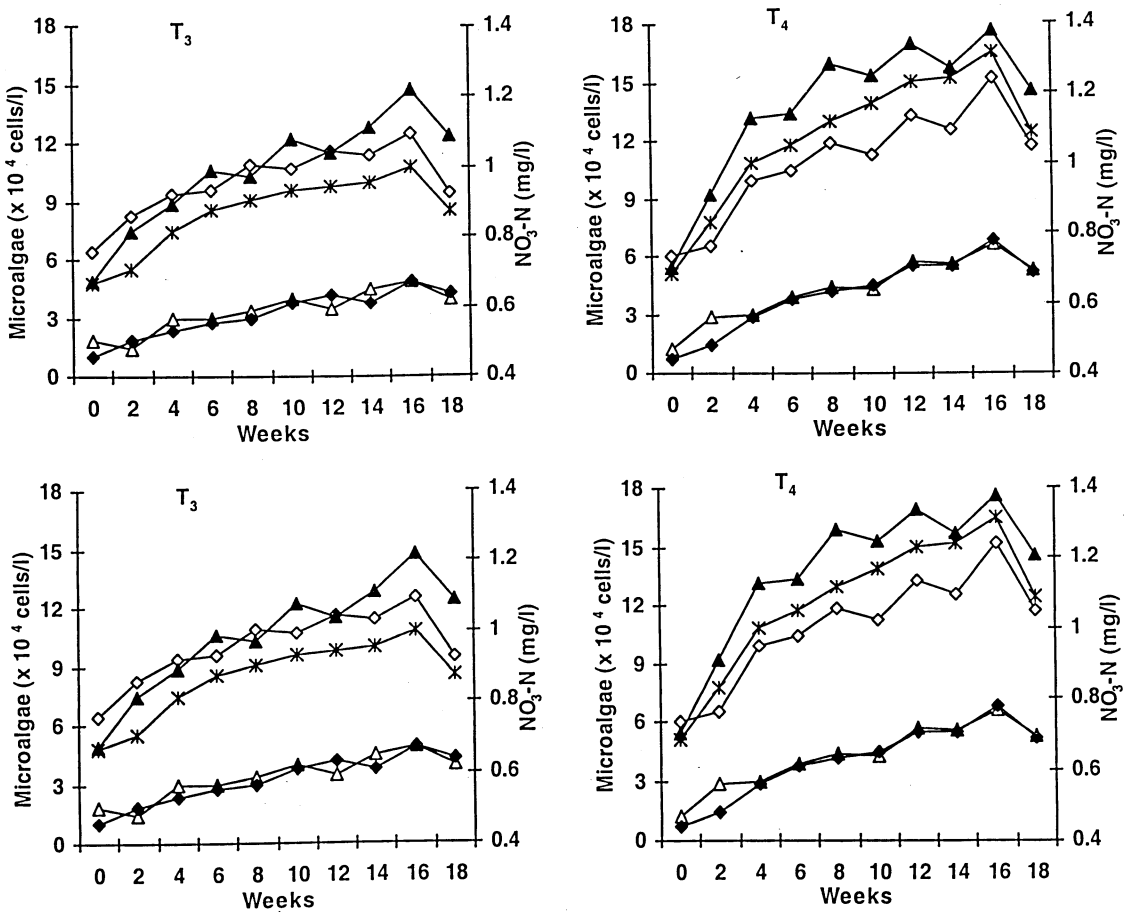

Fig. 1. Relationship between microalgal growth and nitrate-nitrogen (mg/l) during the study period in ponds of different treatments

Bacillariophyceae

Bacillariophyceae was found to be a small group of phytoplankton and ranked third in all of the treatments where *Cyclotella, Navicula* and *Nitzschia* were the dominant genera. Bacillariophyceae was highest (14.78%) in T_2 and lowest in T_1 (8.8%). The cell density of Bacillariophyceae ranged from 1.09 to 6.59 $\times$ 10^4 cells/l with the maximum in T_4 during 16th week and the minimum in T_1 during initial sampling.

Euglenophyceae

Euglenophyceae was a minor group of phytoplankton among the four groups in all of the treatments. Among the Euglenophyceans, *Euglena* was the most dominant genera followed by *Phacus* and *Trachelomonas*. The cell density of Euglenophyceae was found to be highest in T_4 (6.79 $\times$ 10^4 cells/l) during 16th week and the lowest in T_1 (0.79 $\times 10^4$ cells/l) during initial sampling.

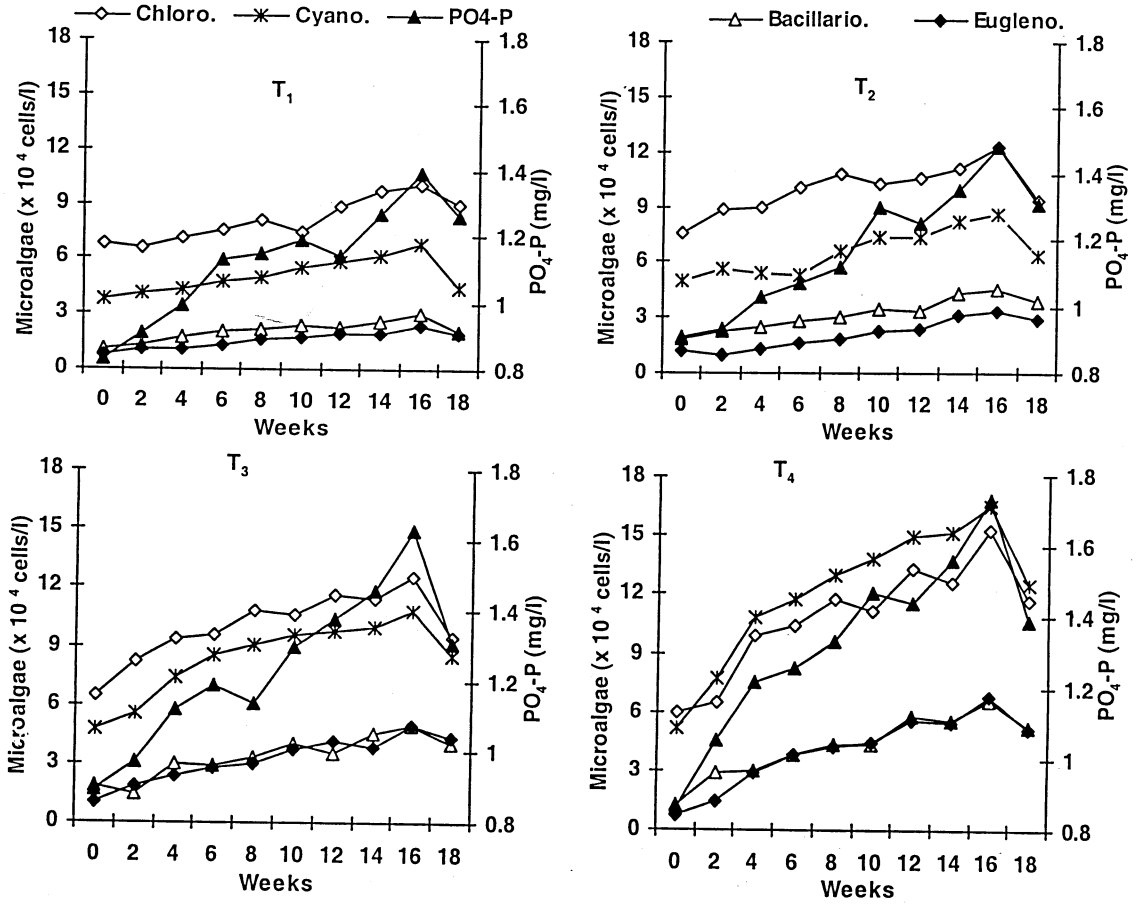

Fig. 2. Relationship between microalgal growth and phosphate-phosphorus (mg/l) during the study period in ponds of different treatments

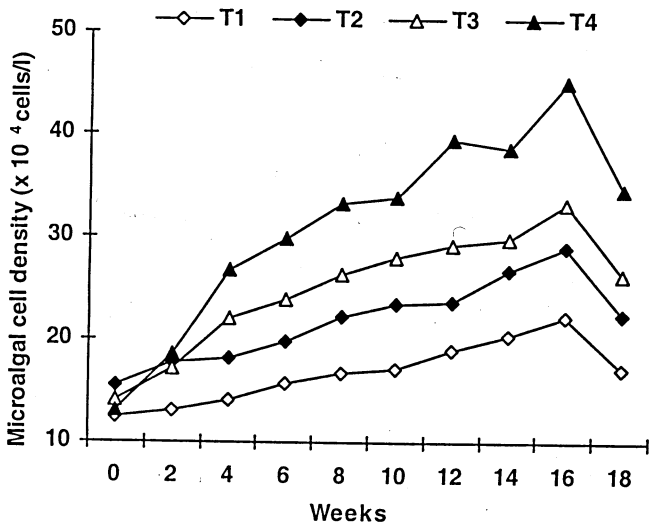

Fig. 3. Total microalgal cell density ($\times 10^4$ cells/l) during the study period in ponds of different treatments

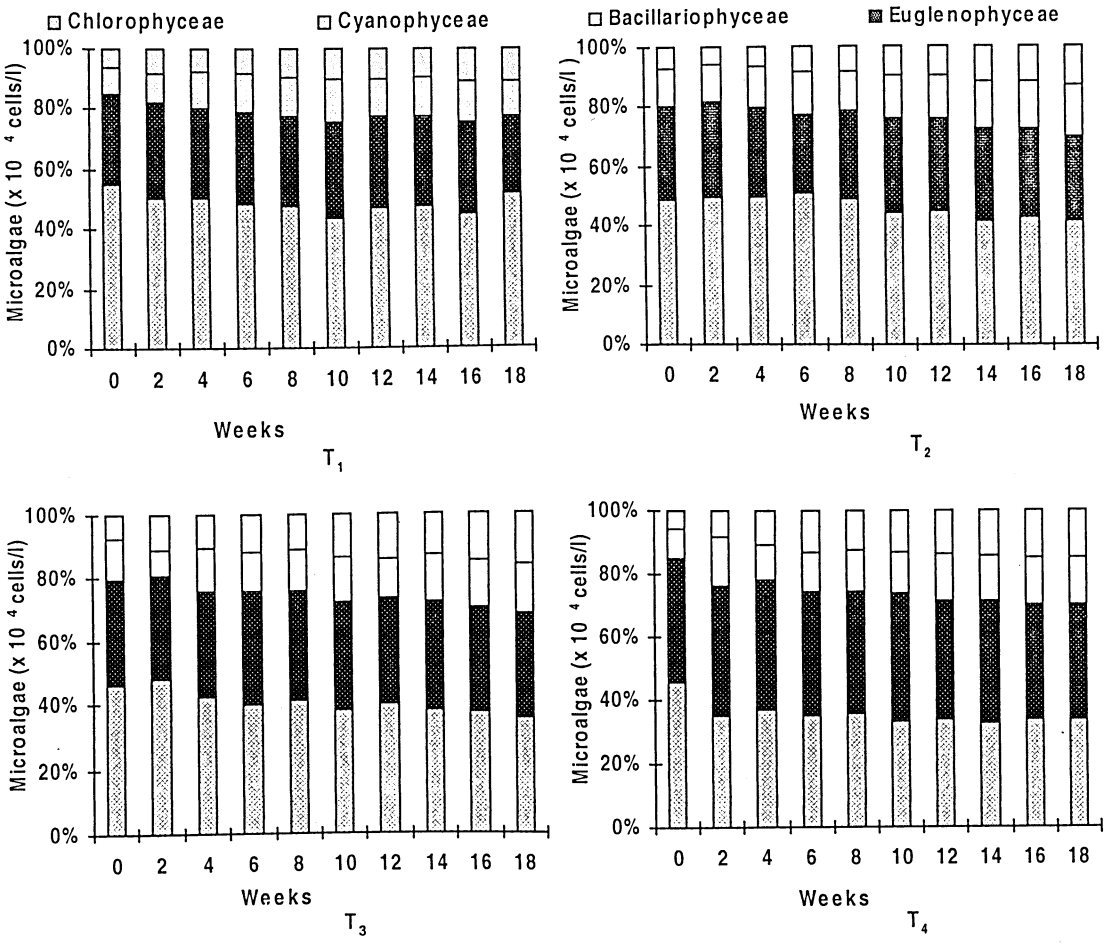

Fig. 4. Fortnightly variations in percent composition of different microalgal groups during the study period in ponds of different treatments

It is well-known that the productivity of phytoplankton depends on the ecological balance between the various physico-chemical and biological factors (Ronald *et al.*, 1987). Microalgal population indicates the productivity status of a waterbody, because they are the direct and basic sources of food for most of the organisms in an aquatic habitat. The occurrence and abundance of microalgal population in nature is regulated by a multitude of environmental factors such as temperature, light, dissolved oxygen, pH, nutrient concentration, soil condition etc.

The dynamics of microalgal population structures are a function of many of the environmental processes that affect species diversity (Roelke and Buyukates, 2002). Variation in microalgal population may be due to the variation in nutrients and other favourable conditions of water. In polyculture ponds of our present study, variations in mixing conditions, precipitation, nutrients availability as well as light illumination was important for maintaining high diversity. Temperature appears to be the most important factor in aquatic productivity through influencing other physical, chemical and biological conditions of a waterbody. In the present study, recorded data of temperature was high (30.2 °C to 32.6 °C) and it had no significant correlation to microalgal population as temperature fluctuation was not significantly different

during the study period. The production of microalgal population in an aquatic environment depends on the combined effect of various factors. A similar suggestion was expressed by Jhingran (1991) and Boyd (1982) who reported that 26.6 °C to 31.97 °C temperature was suitable for microalgal production in tropical ponds. Kiss (1955) suggested that high temperature is important for the growth of algae. The value of pH (7.02 to 8.11) was also found to be favourable for microalgal production during the study period. Swingle (1969), Bhuiyan (1970) and Rahman (1992) suggested that slightly alkaline pH is most suitable for fish culture.

The sources of dissolved oxygen concentration in water are mixing of air into water and photosynthesis of phytoplankton. The average dissolved oxygen concentration was low in T_4 compared to the other treatments which was possibly due to higher utilization of it by higher fish biomass, by microalgal respiration and by microbial decomposition of organic materials. In T_4, both the number of fish species and total microalgal abundance were high followed by T_3, T_2 and T_1.

In the present study, nutrients especially NO_3-N (0.46 to1.38 mg/l) and PO_4-P (0.83 to1.73 mg/l) concentrations were the most important ecological parameters that influenced the growth of microalgae. Both NO_3-N and PO_4-P concentrations were found to be high in T_4 and reached in peaks on 4 October. The correlation coefficient was highly positive between nutrient concentrations and microalgal population. These are in agreements with the findings of Kruger and Eloff (1981), Plinski and Jozwiak (1996) and Roelke and Buyukates (2002). The values of regression coefficient (b) showed that an increase of 0.1 mg/l NO_3-N concentration resulted phytoplankton biomass increase of 1.8, 2.5, 3.5 and 4.0 ($\times 10^4$ cells/l) times in T_1, T_2, T_3 and T_4 respectively; but in case of PO_4-P, these values were 2.0, 2.3, 2.5 and 3.0 ($\times 10^4$ cells/l) times in T_1, T_2, T_3 and T_4 respectively. Microalgal population was more positively correlated with NO_3-N than with PO_4-P. Khan *et al.* (1998) reported that the requirement of NO_3-N concentration was more than PO_4-P concentration for the growth of a diatom, *Skeletonema costatum*. Chlorophyll-*a* contents were found to be gradually increased with the increase of the study period in all treatments and were concomitant with the abundance of microalgal population In the ponds. Shiomoto and Hashimoto (2000) reported that large phytoplankton contributed substantially to the high level of chlorophyll-*a* content.

In the present study, 34 genera of microalgae were recorded belonging to Chlorophyceae (15 genera), Cyanophyceae (9 genera), Bacillariophyceae (7 genera) and Euglenophyceae (3 genera). These groups' richness and floristic composition are characteristic for small eutrophic water bodies. In agreement with the present findings 33-39 genera of microalgae were reported in ponds and lakes in Bangladesh by different authors (Ehshan *et al.*, 1997; Rahman *et al.*, 1999; Hasanat *et al.*, 2000).

Total microalgal cell density ($\times 10^4$ cells/l) was registered higher in T_4 followed by T_3, T_2 and T_1 on all of the sampling dates other than initial one. Stocking density of carps were same in all treatments. In T_1 pangasiid catfishes were not stocked but in T_2, T_3 and T_4, additionally 2,500, 5,000 and 7,500 pangasiid catfish per hectare respectively were stocked and commercial pelleted feed was applied for them. Uneaten feed and faeces of additionally stocked pangasiid catfish increased the nutrient availability in ponds which might have stimulated the growth of algae as it was explained by some other authors (Opuszynski, 1979; Starling, 1993). Boyd (1973) reported that fish excreta and uneaten portion of feed in catfish ponds supply large quantities of nutrients. The nutrient concentrations especially NO_3-N and PO_4-P were found high during 16th week (4 October) and their values were found to increase gradually from the beginning with the increase of culture period. Microalgal cell density

gradually increased with formation of peaks during 16th week and then gradually decreased in all of the treatments. Again, in T_4, all of the physico-chemical factors such as temperature, pH, dissolved oxygen, NO_3-N and PO_4-P were most favourable for the growth of microalgae. As a result fish biomass and microalgal population were high in T_4 followed by T_3 and T_2.

The cell density of Chlorophyceae was found to be highest during 16th week in all of the treatments when temperature and nutrient concentrations were high. The higher water temperature and nutrient (NO_3-N and PO_4-P) concentrations are usually considered as the most important factors in regulating the growth of Chlorophyceae (Plinski and Jozwiak, 1996; and Roelke and Buyukates, 2002). Rao (1953) found high concentration of blue-green algae in brewery ponds with pH near 7 and abundant dissolved organic matter. In the present study, the highest cell density of Cyanophyceae was registered in T_4 where NO_3-N and PO_4-P concentrations were higher compared to other treatments (Fig. 1 and 2). In T_4, Cyanophyceae was found to be highest with the reduction of other groups of microalgae. Similar phenomenon was described by Lam and Silvester (1979) and Stockner and Cronberg (2000). Temperature is one of the most important factors for the growth of Cyanophyceae. Pearsall (1932) mentioned higher temperature as an important factor for favourable growth and development of Cyanophyceae.

In the present study, the cell density of Bacillariophyceae and Euglenophyceae were found to be the highest during 16th week when temperature, dissolved oxygen and nutrient (NO_3-N and PO_4-P) concentrations were most favourable for the growth of these two groups of phytoplankton. Bacillariophyceae was higher compared to Euglenophyceae in number of cell density and percent composition of microalgae in all treatments except in T_4 where Euglenophyceae was higher. In T_4, NO_3-N and PO_4-P concentrations were higher compared to other treatments; it indicated that NO_3-N and PO_4-P concentrations were more responsible for the higher growth of Euglenophyceae which is in agreement with the findings of Lam and Silvester (1979).

In the present study microalgal bloom was not formed in ponds of any treatments and increased nutrient concentrations (NO_3-N and PO_4-P) and healthy growth of microalgae was found in ponds of treatments where supplemental feed was given for the additionally stocked catfishes. This suggests that possibility of microalgal bloom formation is less due to stocking of a small number of pangasiid catfish in carp polyculture ponds.

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