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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 6 (12): 1046-1050, 2003
ISSN 1028-8880

Fish Mortality Due to Cyanobacterial Bloom in an Aquaculture Pond in Bangladesh

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Abstract: Cyanobacterial bloom and fish mortality in ponds and lakes are common in Bangladesh but the relationship between the two has been rarely studied. In April 2002, mass mortality of fishes occurred in a farmer's pond of Mymensingh, Bangladesh. At the time of fish kill, a massive bloom of cyanobacteria (210.5×10^3 cells ml^{-1}) was found in the pond. Microscopic study showed the dominance of *Aphanizomenon flos-aquae* (L.) Ralfs and *Microcystis aeruginosa*, Kütz representing 60.91 and 33.98% of the total phytoplankton population, respectively. Fish species affected were silver carp, *Hypophthalmichthys molitrix* (Valenciennes), tilapia *Oreochromis niloticus* (L.), catla *Catla catla* (Hamilton Buchanon) and common carp *Cyprinus carpio* (L.) and among these silver carp, tilapia and catla were severely affected. The gills of dead fishes were pale-white and the microscopic analysis of the gill squashed water showed the presence of large number of *A. flos-aquae* and *M. aeruginosa* cells. Gut content analysis of dead silver carp, tilapia and catla revealed the presence of 49.12, 43.5 and 19.35% *A. flos-aquae* and 30.37, 38.32 and 9.75% *M. aeruginosa,* respectively among the total consumed phytoplankton. On the day of fish mortality, high concentration of PO_4-P (9.5 mg l^{-1}), high water temperature (31^0C) and low dissolved oxygen concentration (0.95 mg l^{-1}) were found. The fish mortality was possibly caused either by oxygen deficiency or toxins secreted by cyanobacteria or by combination of both.

Key words: Cyanobacterial bloom, fish mortality, farmer's pond, Bangladesh

Introduction

Toxic blooms of cyanobacteria have been detected in freshwater lakes all over the world (World Health Organization, 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). The species responsible for most of the poisonous outbreaks are *Microcystis aeruginosa* Kütz, *Anabaena flos-aquae* (Lyngb.) Bréb and *Aphanizomenon flos-aquae* (L.) Ralfs (Carmichael and Bent, 1981).

Freshwater aquaculture plays a significant role in the national economy and poverty alleviation of Bangladesh. For getting higher fish production fish farmers apply high dozes of fertilizers and feeds in their ponds. As a result, the confined waters of the ponds have become eutrophicated due to sedimentation of nutrients from fertilizers and from decomposed organic matters which induce toxic and noxious blooms of cyanobacteria. These blooms are hampering aquaculture as well as public health in different ways.

Cyanobacterial blooms have become common phenomenon in ponds, lakes and reservoirs in Bangladesh. Some of the species, e.g., *Microcystis aeruginosa, Anabaena flos-aquae, Aphanizomenon flos-aquae* are ubiquitous and among them *M. aeruginosa* and *Anabaena flos-aquae* are found to dominate continuously in warmer, shallow and eutrophic ponds and lakes of this country. The mortality of fishes and irritative bad odour from decayed algae in the fish culture ponds are very common in this country. A critical time during bloom condition occurs when dense cell masses decompose naturally and this decomposed products plus toxic cellular materials released into the water when the cells lyse may cause death or illness of mammals, birds and fishes and may also reduce water quality for animal (including human) and recreational purposes (Plamer, 1964; Schwimmer and Schwimmer, 1964; Collins, 1978). In some areas, death of cattle, goats and ducks are being reported frequently, where people supply pond water to their cattle for drinking but the etiology of these deaths has not yet been studied.

In April 2002, in Mymensingh, Bangladesh, a mass mortality of fishes occurred in a farmer's fish culture pond having cyanobacterial bloom. The fish farmer also reported that two goats were died after drinking water from the same pond. This paper deals with the species composition and abundance of cyanobacteria and their relation to fish mortality.

Materials and Methods

Plankton and water samples were collected directly in one litre plastic bottles on 6 April 2002, the day of fish kill, from the pond in Mymensingh. Samples were collected from both bottom and surface water at different sites of the pond.

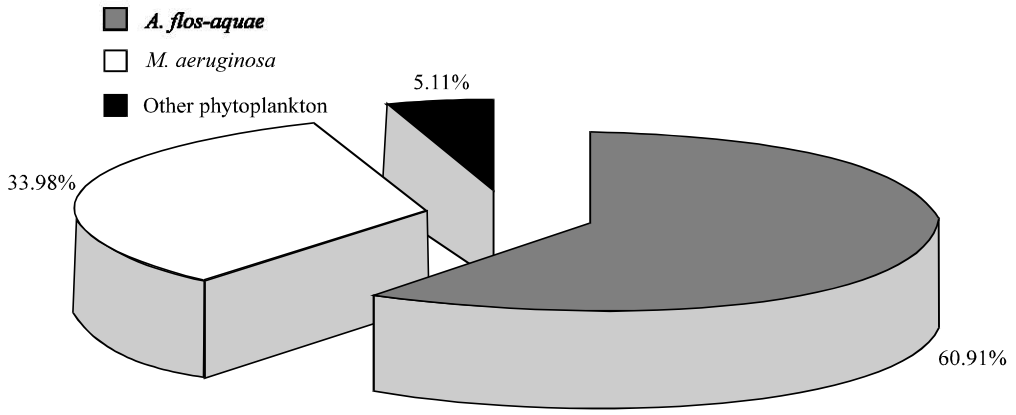

Fig. 1: Percent composition of total phytoplankton population in the fish kill pond

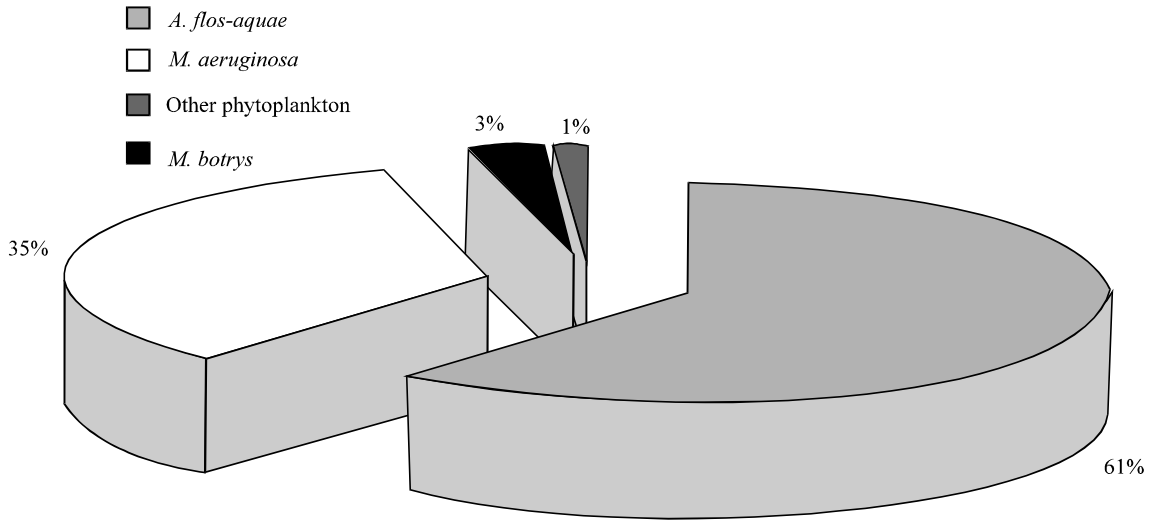

Fig. 2: Percent composition of cyanobacterial population in the fish kill pond

Analysis of water quality parameters: Surface water temperature, pH and dissolved oxygen were determined by using Celsius thermometer, electronic pH meter (Jenwary, 3020) and digital electronic oxygen meter (YSI, 58), respectively. Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) were measured by HACH kit (DR/2010, a direct reading spectrophotometer) using high range chemicals (NO_3-N by NitraVer 5 Nitrate Reagent Powder Pillows for 25 ml sample and PO_4-P by PhosVer 3 Phosphate Reagent Powder Pillows for 25 ml sample).

Phytoplankton study: For species identification, sample was gently shaken to resuspend all materials. It was allowed to settle for one minute, then 1-2 drops were removed from the middle of the sample and placed on a glass slide. Taxonomic determination of cyanobacteria was performed with an Olympus phase-contrast microscope at 100 to 400 X, with brightfield and phase contrast illumination on living material and on samples preserved with formaldehyde. Taxonomic identification was based on Komarek (1958) and Skulberg and Skulberg (1985). The quantitative estimation of phytoplankton was done by Sedgewick-Rafter counting chamber (S-R cell) under the same microscope. Each colony of *Aphanizomenon* and *Microcystis* was counted as a single cell.

Gills and gut content analysis: Gill samples of dead silver carp, tilapia and catla were taken from 10 fishes of each species. Each of the gill samples was squashed with a known volume (50 ml) of water. The qualitative and quantitative estimation of phytoplankton in the squashed water was done under microscope. Gut content of fish was analysed following the methods of Hynes (1950).

Results

In the morning of 6 April 2002 most of the dead fishes were found to float on the surface water of the pond and some others were gulping. The affected fish species were silver carp (*Hypophthalmichthys molitrix*), tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*) and catla (*Catla catla*) and among these fishes silver carp, tilapia and catla were severely affected.

During the present study three species of cyanobacteria namely, *Aphanizomenon flos-aquae*, *Microcystis aeruginosa* and *M. botrys* Teil, were identified and among these species *A. flos-aquae* and *M. aeruginosa* were dominant. During fish kill, a green paint like bloom was observed and the microscopic study revealed that the cyanobacterial cell density was 210.5×10^3 cells ml^{-1}, representing 98.25% among total phytoplankton (214.25×10^3 cells ml^{-1}). The cell density of *A. flos-aquae* and *M. aeruginosa* were 130.5×10^3 and 72.80×10^3 cells ml^{-1} which contributed 60.91 and 33.98% among total phytoplankton (Fig. 1) and 61 and 35% among Cyanophyceae (Fig. 2).

During collection the gills of the dead fishes were found pale-white. Microscopic analysis of the gill squashed water showed the presence of large number of *A. flos-aquae* and *M. aeruginosa* cells in silver carp (8.5×10^3 *A. flos-aquae* and 4.5×10^3 *M. aeruginosa* cells g^{-1} of gill), tilapia (6.4×10^3 and 3.5×10^3 cells g^{-1} of gill) and catla (4.3×10^3 and 2.1×10^3 cells g^{-1} of gill). Gut content analysis of dead silver carp, tilapia and catla revealed the presence of 49.12, 43.5 and 19.35% *A. flos-aquae* and 30.37, 38.32 and 9.75% *M. aeruginosa,* respectively among the total consumed phytoplankton.

On the day of fish kill, the water temperature and pH were 31°C and 7.9 and the recorded dissolved oxygen concentration was low (0.95 mg l^{-1}). The PO_4-P concentration was 9.5 mg l^{-1} which was very high in comparison to NO_3-N concentration (0.9 mg l^{-1}). The fish farmer reported that the people who bathed in that pond suffered from skin rashes and eye and ear irritations.

Discussion

Oxygen depletion in eutrophic ponds at night is a well known consequence of "excess" algal biomass. Mass mortality of fish in the studied pond may be associated with the vigorous bloom of *Aphanizomenon flos-aquae* and *Microcystis aeruginosa*. Two hypotheses have been proposed to explain the causes of fish mortality. The first hypothesis suggests that the fish kill was caused by gill clogging and low dissolved oxygen condition, induced either by death, sinking and decomposition of bloom or diurnal vertical migration of the bloom forming organisms and its respiration in waters at night. Similarly Dahl *et al.* (1989) reported that oxygen deficits resulting from decomposition of algal matter, with the ensuing death of fish and other animals, constitute a regular environmental problem in the southern Kattegat between Denmark and southern Sweden. The presence of higher number of cyanobacterial cells (*A. flos-aquae* and *M. aeruginosa.*) in the gills of the dead silver carp, tilapia and catla indicate that gill clogging by cyanobacteria may be a possible cause of fish mortality. Supporting evidence can be drawn from the findings of White (1988) who reported that the massive mortalities of farmed yellowtail (*Seriola quinqueradiata*) Temminck and Schlegel, occurred in the Seto Inland Sea of Japan due to gill damage by the chloromonad *Chattonella* and by the highly unsaturated fatty acids produced by the algae which decreased the pH of the fish's blood and made gas exchange difficult.

The second hypothesis is the production of potent toxins by *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* which may be the cause of fish mortality. Supporting evidences to our hypotheses can also be drawn from some other studies (Schwimmer and Schwimmer, 1964; Collins, 1978) which suggest that a critical time during bloom condition occurred when dense cell masses of cyanobacteria decomposed naturally and this decomposed products plus toxic cellular materials released into the water during cell lysis might have caused death of fishes. In two other reports (Carmichael *et al.*, 1990; Affan, 2001) the cyanobacteria in natural waters in Bangladesh have been reported to be toxic. We can assume that the bloom forming *A. flos-aquae* and *M. aeruginosa* in the studied pond might be toxic which might have caused mortality of fishes.

Fish gut content analysis showed the presence of broken *A. flos-aquae* and *M. aeruginosa* cells indicating partial digestion of the algal materials. Colman and Edwards (1987) conducted an experiment where fishes exhibited erratic behaviour and mortality when fishes were fed a mixture of live *Aphanizomenon* and *Microcystis*. They also found mortality of golden shiner (*Notemigonus crysoleucas*) when toxin from *A. flos-aquae* was added to the water. Supporting evidence can also be drawn from the findings of Tabthipwon *et al.* (1988) who reported that *Oreochromis niloticus* seemed to be retarded in its growth when *M. aeruginosa* was a significant part of the diet and indeed, liver deterioration of the fish was found at higher levels of *Microcystis* in the feed.

The owner of the fish mortality pond reported that the people who used this pond water for bathing were affected by skin rashes and eye inflammation. Beside aquaculture, the rural people in Bangladesh use pond water for bathing and other domestic purposes. Most of the ponds are contaminated with cyanobacteria and

peoples who used these waters for bathing are facing skin rashes and other allergic problems. Turner *et al.* (1990) reported that 10 of 20 recruited army showed symptoms like, vomiting, diarrhoea, central abdominal pain, blistering of the lips, sore throats after swimming and canoe training in water with a dense bloom of *Microcystis* spp and two of the recruits developed severe pneumonia attributed to the aspiration of *Microcystis* toxin which was the indication of intoxication.

A heavy rainfall occurred ten days before the incidence of the fish mortality and during the rainfall, run-off water from the adjacent paddy fields where the farmers used fertilizers (especially, Triple Super Phosphate and Urea) entered directly into the pond through broken embankment. The run-off water increased the nutrients level of the pond water and provided favourable conditions for the outbreak of cyanobacterial bloom. During fish mortality, PO_4-P concentration was very high (9.5 mg l^{-1}) with high temperature (31^{0}C). So, it can be assumed that high PO_4-P concentration coupling with high temperature might have created favourable condition for the occurrence of cyanobacterial (*A. flos-aquae* and *M. aeruginosa*) bloom. Hadas *et al.* (1999) found *Aphanizomenon* bloom in Lake Kinneret during the sudden increase of dissolved phosphorus concentration following a decline in total nitrogen concentration. Furthermore, in nutrient enrichment experiments, the addition of phosphorus has been noticed to increase the growth of nitrogen fixing species, *A. flos-aquae* (Rinne and Tarkiainen, 1978; Tamminen *et al.*, 1985).

Incidence of fish mortalities in hypernutrified ponds and lakes associated with cyanobacterial blooms elsewhere in the country are frequently reported and the poor people are found to collect the dead fishes for their consumption. Since the consequence of the toxic cyanobacterial blooms in natural waters are mostly unknown in Bangladesh, so we urgently need to conduct thorough survey on the prevalence of toxic cyanobacteria throughout the country and develop public awareness about harmful cyanobacteria. Due to lack of required laboratory facilities we could not test the toxicity of the cyanobacterial samples of the affected pond.

Acknowledgements

We are grateful to the fish farmer for informing us about the fish mortality and allowing to collect samples from his pond. This study was conducted as a part of the BAURES (Bangladesh Agricultural University Research System) funded research project on A study of the causes of noxious and toxic phytoplankton blooms in ponds to the last author of this paper.

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