J. Agrofor. Environ. 7 (1): 65-70, 2013 ISSN 1995-6983

Effects of water treatment chemicals on plankton biomass in aquaculture

J. Ferdous, M.S. Reza, M.N.A. Khan[1], S. Saha[2], M. Alamgir[4], J.N. Akhter[3] and M.K. Rahman[3]
Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh-2202; [1]Department of Fishing and Post-Harvest Technology, Chittagong Veterinary and Animal Sciences University, Chittagong-4225; [2]Department of Microbiology and Hygiene, Bangladesh Agricultural University, Mymensingh-2202, [3]Bangladesh Fisheries Research Institute, Mymensingh-2201, E-mail: rezams@gmail.com / msreza@bau.edu.bd

Abstract: In an effort to determine the influence of three important water treatment chemicals (viz., lime, oxy-more and zeolite) in aquaculture, studies were undertaken to determine changes in physico-chemical parameters and plankton biomass in pond and aquaria systems for a periods of 21 days. The results showed that lime had a negative impact on the growth and survival of plankton. Lime treatment significantly increased water pH from 7.3±0.5 to 8.2±0.2 in both aquarium and transparency from 21±2.9 cm to 29±0.7 cm in pond condition with a corresponding increase in hardness from 960±22 to 1250±23.0 (p<0.05). The highest value of total alkalinity (160±3.6 mg/L) was recorded for lime treatment under aquarium condition. DO content increased significantly after oxy-more (from 3.5±0.3 to 6.2±0.2 ppm, p<0.05) and zeolite (3.5±0.5 to 4.2±2.3 ppm, p<0.05) treatment and there was no significant variation for lime treatment. The mean values of phytoplankton before treatments were 2.24±0.6, 0.52±0.2, 0.48±0.0×10^4 cells/L for lime, oxy-more and zeolite respectively which showed a little or no change after treatment with a value of 1.66±0.2, 1.58±0.5 and 0.86±0.3×10^4 cells/L respectively. Phytoplankton density of the aquarium and pond showed significant reduction for lime treatment and a sharp increase for zeolite treatment. Density of Chlorophyceae of aquarium water showed no significant difference for different treatments but in pond after liming the density reduced significantly from 2.58±0.5 to 0.86±0.0×10^4 cells/L (p<0.05). The study also showed that Cyanophyceae density of the aquarium and pond increased greatly per liter after zeolite and oxy-more treatment whereas it decreased for lime treatment.
Key words: Cyanophyceae, Chlorophyceae, Lime, Oxy-more, Transparency, Zeolite.

Introduction

In aquaculture, one of the major inputs required for successful fish production is chemical. Chemicals are important components in health management of aquatic animals, soil and water management, improve aquatic productivity, transportation of live fish, feed formulation, manipulation of reproduction, growth promotion and processing and value addition of the final products (GESAMP, 1997; Subasinghe *et al.*, 1996). Some common chemicals include sodium chloride, formalin, malachite green, methylene blue, potassium permanganate, and hydrogen per–oxide, copper compounds, glutaraldehyde and trifluralin (Plumb, 1992).
With the expansion of aquaculture in Bangladesh, there has been increasing trend in using chemicals in aquatic animal health management. Commonly used chemicals in Bangladesh aquaculture are lime, rotenone, various forms of inorganic and organic fertilizers, various oxygen enhancers, phostoxin, salt, zeolite, dipterex, antimicrobials, potassium permanganate, copper sulphate, formalin, sumithion, melathion etc. (Brown and Brooks, 2002; DoF, 2011; Faruk *et al., 2005*). Chemicals used in aquaculture can be classified as purpose of use, the type of organisms under culture, the life cycle stage for which they are used, the culture system and intensity of culture, and the type of people who are using them. A variety of other chemicals are also used in aquaculture for health management of fish apart from antibiotics. Some common chemicals include sodium chloride, formalin, malachite green, methylene blue, potassium permanganate, hydrogen per oxide, copper compounds, glutaraldehyde and trifluralin (Plumb, 1992). Fertilizers are widely used in the management of fish ponds to stimulate phytoplankton bloom. Although fertilizers pose minimal risk to food safety in aquaculture, when used appropriately, any misuse could lead to hazard in aquaculture products (Reilly and Twiddy, 1992). Pesticides are also used in aquaculture for disease treatment, such as organophosphates, organotin compounds, rotenone and saponin. dichlovos, trichlorfon, diptarex, melathion, dursban are the widely used organophosphate applied to control ectoparasitic crustacean infections in finfish culture. Many chemicals may persist for many months in aquatic system, retaining their biocide properties. Some antibacterial, notably oxytetracycline, oxolinic acid and flumequine, can be found in sediments at least six months following treatment (Weston, 1996).
With the expansion of aquaculture in Bangladesh, there has been increasing trend in using chemicals in aquatic animal health management, mainly during pond preparation, soil and water management, enhancement of natural aquatic productivity, feed formulation, growth promotion and health management. In most cases, drugs in the fish and shrimp ponds are applied indiscriminately and without proper consultation with the fish specialists. Even banned antibiotics and chemicals like nitrofuran and chloramphenicol are applied in the ponds via fish/shrimp feeds which have already caused a serious problem in the growing shrimp export sector of the country (Khan *et al.*, 2009). Such types of antibiotic contamination/exposure of the environment probably have more intense affect on the microbial flora residing in the water and sediment of the water body concerned. For the success of aquaculture, chemicals must be judiciously and responsibly used.
Farmers in Bangladesh used various chemicals in their aqua–farms in different stages of the culture system from pond preparation up to harvesting. It was found that lime, rotenone, phostoxin were mainly used chemicals during pond preparation, whereas salt, lime, potassium permanganate, dipterex and some antimicrobial drugs like oxytetracycline and oxolinic acid were used by a few farmers to treat diseases like EUS (ADB/NACA 1996/98).
Water is one of the most important compounds to the ecosystem. Better quality of water described by its physical, chemical and biological characteristics. But some correlation was possible among these parameters and the significant one would be useful to indicate quality of water. The natural aquatic resources are causing heavy and varied pollution in aquatic environment leading to water quality and depletion of aquatic biota. It is therefore

necessary that the quality of water should be checked at regular time interval. Nevertheless, for many aquaculture chemicals, we have very little of the data needs identified. In most developed countries, such information is now required before new aquaculture chemicals are approved for use. However, no comparable data are available for many chemicals already in widespread commercial use. The present study was therefore, designed to determine the effects of some widely used chemicals such as lime, oxy–more and zeolite on the water quality parameters in terms of changes in physico–chemical parameters, and plankton biomass under both laboratory and pond condition.

Materials and Methods

Selection of water treatment chemicals: A survey was conducted among 150 respondent farmers in Fulpur, Bhaluka and Gouripur upazillas of Mymensingh district, Bangladesh to identify the most widely used chemicals in aquaculture used for treating water. The survey revealed that for water quality management, farmers mostly used lime (95%), salt (63%), potash (37%), zeolite (45%) and oxy–more (68%). Based on the survey result, three different water treatment chemicals were selected for the study. They were:

Sl. no.	Name of the chemical	Chemical composition	Producing company
1	Lime	Oxides, hydroxides and silicates of calcium or magnesium	-
2	Oxy-more	Hydrogen peroxide	Eskayef Bangladesh Ltd
3	Zeolite	Silicate, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide, potassium oxide, etc.	Eskayef Bangladesh Ltd

Experimental design

Location and sampling: Nine glass aquaria (size 37cm×30cm×60cm) were set at the Laboratory of Fish Harvesting, Department of Fisheries Technology, BAU in three sets (every set contain 3 aquarium). These aquaria were filled to a depth of 15 cm with water collected from earthen experimental ponds located at the vicinity of the Faculty of Fisheries, BAU. Physico–chemical characteristics of the water of every aquarium were determined separately for every treatment before and after the treatment. Aquaria were treated with lime at the rate of 0.27 g/m^3, oxy–more at the rate of 0.07 g/ m^3 and zeolite at the rate of 0.07 g/m^3 in triplicates. Water samples were collected from all aquaria before treatment to determine physico–chemical parameters and plankton biomass analysis, data of which were regarded as control. Similarly samples were collected from aquaria after treatment for consecutive 7 days and analysis of water quality parameters and plankton biomass study were conducted.

As for pond treatment, nine experimental ponds located at the vicinity of Faculty of Fisheries, were used where water was treated with lime at the rate of 1 kg/decimal, Oxy–more at the rate of 3g/decimal and zeolite at the rate of 200 g/decimal in triplicates. Water samples were collected from ponds before treatment to determine physico–chemical parameters and plankton biomass analysis, data of which were regarded as control. Similarly samples were collected from ponds after treatment for consecutive 7 days and analysis of water quality parameters and plankton biomass study was conducted. The water quality parameters were recorded as the same method used for aquarium.

Water quality monitoring: The water quality parameters were recorded daily throughout the experimental period. Water quality measurements and sample collection were made between 9.00 am to 11.00 am on each sampling day. Water quality parameters such as temperature, dissolved oxygen, total alkalinity, phosphate–phosphorous, nitrate–nitrogen, ammonia–nitrogen, and pH were measured.

Physical factors determination: Water temperature was recorded in the field with the help of a centigrade thermometer (div=0.1°C). Other Parameters such as dissolved oxygen, total alkalinity, phosphate–phosphorous, nitrate–nitrogen, ammonia–nitrogen, and pH were measured using HANNA Test kit, Hanna Instruments Ltd., Germany.

Collection of plankton samples and preservation: Plankton samples were collected daily from each aquarium. Half liter of water sample was taken from each aquarium and passed through fine (25µ) mesh plankton net. Filtered samples was taken into a measuring cylinder and carefully made up to a standard volume of 50 ml. Then the collected plankton samples were preserved in 5% buffered formalin in small plastic bottles for qualitative and quantitative studies.

Qualitative and Quantitative Study of Plankton: From each 50 ml preserved sample, 1ml sub–sample was examined using a Sedge Wick–Rafter cell (S–R cell) and a binocular microscope (Olympus CH–40) with phase contrast facilities at the laboratory of water quality, Department of Fisheries Management, BAU. The Sedge Wick–Rafter counting cell as a special type of slide having a counting chamber which is 50 mm long, 20 mm wide and 1 mm deep; the volume of the chamber is 1 mm. the counting chamber is equally divided into 1000 fields, each having a volume of 0.001 ml. One ml sub–sample from each sample was transferred to the cell and then all planktonic organisms present in 10 squares of the cell chosen randomly were identified and counted. Plankton identification was performed following APHA (1995). For each aquarium, mean number of plankton was recorded and expressed numerically per liter of water. The quantitative estimation of plankton was done using the following formula for quantitative estimation.

$$N= \frac{A \times C \times 100}{L}$$

where, N=Number of plankton cells or units per liters of original water, A=Total number of plankton counted in 10 fields, C= volume of final concentrate of the sample in ml, L= Volume of the water sample in liter. For each pond, mean number of plankton was recorded and expressed numerically per liter of water.

Statistical Analysis: The data obtained in the experiment were recorded and preserved in computer. The data obtained in the experiment were analyzed by using SPSS version 11.5 (Chicago. USA). Significant differences were determined among treatments at the 5 % level (p < 0.05).

Results and Discussion

Water quality parameters were determined for lime, oxy–more and zeo–prime under aquarium and pond condition. Changes in water temperature and other water quality parameters due to the effect of major water treatment chemicals in aquarium condition are summarized in Table 1 and 2. Water quality parameters were within the recommended optimum ranges required for the culture of freshwater fish species, except for total hardness which was much higher than the recommended level of 40 – 60 mg/l. Water temperature was within the range of 25 – 26 ºC while dissolved oxygen ranged from 3.5 ppm to 8.5 ppm.

Table 1. Changes in water quality parameters in aquarium treated with three chemicals

Parameter	Control	Days after treatment							Level of significance
		1	2	3	4	5	6	7	
Lime									
Temp. (ºC)	26ºC	25ºC	26ºC	26ºC	26ºC	27ºC	27ºC	26ºC	NS
pH	7.9±0.10^{a}	8.2±0.10^{b}	8.2±0.10^{b}	8.2±0.10^{b}	8.2±0.10^{b}	8.2±0.10^{b}	8.2±0.10^{b}	8.2±0.10^{b}	*
DO (ppm)	4.5±0.01	4.5±0.01	6.5±0.01	5.13±0.14	3.93±0.2	3.73±0.03	3.50±0.0	3.38±0.14	NS
Alkalinity (ppm)	110±11.2^{a}	160±3.6^{b}	160±3.6^{b}	150±2.5^{a}	150±2.5^{b}	150±3.5^{b}	140±3.5^{b}	140±3.3^{b}	*
NH_3–N (mg/l), NO_3–N (mg/l), NO_2–N (mg/l)	no	no	no	no	no	no	no	no	–
Hardness (ppm)	960±22^{a}	1200±0.0^{b}	1130±0.0^{a}	1145±1.7^{b}	1244±1.2^{a}	1165±2.3^{b}	1132±2.0^{b}	1210±0.0^{b}	*
Oxy–more									
pH	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	NS
DO (ppm)	3.5±0.3^{a}	6.0±0.2^{b}	8.2±0.4^{a}	8.1±0.4^{b}	5.5±0.5^{a}	5.0±0.1^{b}	4.5±0.2^{b}	4.3±0.6	*
Alkalinity (ppm)	110±5.3	110±5.3	130±4.8	120±1.8	110±5.3	110±5.3	120±1.8	130±8.8	NS
NH_3–N (mg/l), NO_3–N (mg/l), NO_2–N (mg/l)	no	no	no	no	no	no	no	no	
Hardness (ppm)	960±22^{a}	1080±20^{b}	1060±34.3^{b}	1060±34.3^{b}	1170±23.5^{a}	1130±26^{b}	1230±26^{a}	1180±20^{b}	*
Zeolite									
pH	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	NS
DO (ppm)	3.5±0.5^{a}	4.2±2.3^{b}	8.5±2.3^{a}	7.3±1.9^{b}	6.6±1.6^{b}	6.5±1.5^{b}	6.0±0.2^{b}	6.3±0.5^{b}	*
Alkalinity (ppm)	120±8.0	140±6.2	140±5.2	137±3.2	134±1.0	120±8.0	130±1.0	130±1.0	NS
NH_3–N (mg/l), NO_3–N (mg/l), NO_2–N (mg/l)	no	no	no	no	no	no	no	no	
Hardness (ppm)	1230±7.9^{a}	1170±24.5^{b}	1240±0.1^{a}	1227±2.9^{b}	1230±1.9^{b}	1200±14.9^{b}	1200±13.2^{b}	1230±7.9^{b}	*

Values are mean ± SE**;** NS= Values are not significantly different (*p>0.05*), *Values with different superscript indicate a significant difference at 5% significance level based on Tukey's test

Table 2. Changes in water quality parameters in ponds treated with three chemicals

Parameter	Control	Days after treatment							Level of significance
		1	2	3	4	5	6	7	
Lime									
Temp. (ºC)	32ºC	32ºC	30ºC	32ºC	29ºC	27ºC	30ºC	29ºC	NS
pH	7.3±0.5^{a}	7.9±0.1^{b}	8.2±0.1^{a}	8.2±0.3^{b}	8.2±0.1^{b}	8.2±0.2^{b}	8.2±0.2^{b}	8.2±0.1^{b}	*
DO (ppm)	4.5±2.0^{a}	6.5±0.5^{b}	7.0±1.2^{b}	7.0±1.2^{b}	5.5±0.8^{a}	5.0±0.5^{b}	4.0±0.5^{b}	4.5±1.3^{b}	*
Alkalinity (ppm)	100±5.0^{a}	110±7.9^{b}	140±1.2^{a}	140±13.2^{b}	130±6.2^{b}	120±0.9^{b}	120±0.9^{b}	110±8.0^{b}	*
NH_3–N (mg/l), NO_3–N (mg/l), NO_2–N (mg/l)	no	no	no	no	no	no	no	no	–
Hardness (ppm)	1130±12.4^{a}	1245±21.0^{b}	1230±8.8^{b}	1180±24.8^{a}	1220±16.0^{b}	1160±40.6^{b}	1250±23.0^{b}	1250±14^{b}	*
Transparency (cm)	21±2.9^{a}	28±0.0^{b}	29±2.1^{b}	29±0.7^{b}	30±1.4^{b}	29±0.7^{b}	28±0.0	29±0.7^{b}	*
Oxy–more									
pH	7.8	7.8	7.8	7.9	7.8	8.0	7.9	8.0	NS
DO (ppm)	3.8±1.2^{a}	6.5±1.4^{b}	8.0±0.2^{a}	9.2±1.1^{b}	9.5±0.8^{b}	8.4±0.2^{b}	8.0±0.2^{b}	6.5±1.0^{a}	*
Alkalinity (ppm)	100±7.0^{a}	110±5.9^{b}	110±1^{b}	110±3.2^{b}	120±6.2^{b}	120±0.7^{b}	120±1.9^{b}	120±4.0^{b}	*
Transparency (cm)	24±2.9^{a}	27±2.0^{b}	27±2.3^{b}	28±0.7^{b}	28±0.4^{b}	28±0.7^{b}	28±0.9^{b}	28±1.7^{b}	*
Hardness (ppm)	1060±15.4^{b}	1068±11.0^{b}	1080±5.8^{b}	1180±24.8^{a}	1180±13.0^{b}	1160±20.6^{b}	1150±20.0^{b}	1150±13^{b}	*
Zeolite									
pH	8.0	8.0	7.8	8.0	8.0	8.0	7.9	8.0	NS
DO (ppm)	3.5±1.0^{a}	6.6±1.2^{b}	9.0±0.2^{a}	9.0±1.1^{b}	8.2±1.3^{b}	8.4±0.5^{b}	6.6±0.7^{a}	5.0±0.3^{b}	*
Alkalinity(ppm)	110±4.0^{a}	130±3.6^{b}	140±3.2^{a}	140±3.2^{b}	140±6.2^{b}	135±1.9^{b}	130±0.7^{b}	120±5.0^{b}	*
Transparency (cm)	24±2.3^{a}	28±0.6^{b}	30±2.2^{b}	30±1.4^{b}	30±1.4^{b}	30±0.5^{b}	26±1.0^{b}	26±0.7^{b}	*
Hardness (ppm)	1180±13.4^{a}	1230±11.0^{b}	1230±3.8^{b}	1240±14.8^{b}	1220±12.0^{b}	1160±20.6^{a}	1150±23.0^{b}	1150±14^{b}	*

Mean ± SE**;** NS= Values are not significantly different (*p>0.05*), *Values with different superscript indicate a significant difference at 5% significance level based on Tukey's test

Physical parameters

Temperature: Water temperatures measured in different aquarium were between 25 – 26 ºC, which was more or less similar to the suitable range of 26 – 28 ºC for tropical and subtropical species (Boyd, 1990). For pond water, temperature ranged from 23.6 to 36 ºC in nine ponds at the Faculty of Fisheries, Mymensingh. Rahman (1992) also reported water temperature of culture ponds at BAU ranged from 26.2 to 34.5 ºC during the summer period.

Transparency (cm): During the study period, water transparency in pond water varied from 21 cm before treatment to 31 cm after treatment. The mean value of transparency of the pond was 28 cm. The highest value of transparency (30 cm) was recorded both for lime and zeolite treatment. Difference among the treatments was significant (p<0.05) during the experimental period where variations ranged from 21±2.9 to 30±2.2 cm.

Chemical Parameters

pH: pH is an important factor in fish culture. It is also called the productivity index of a water body. The almost neutral pH or slightly alkaline pH is most suitable for fish culture. During the study period, the values of pH ranged from 7.9 to 8.2 in aquarium condition (Table 1). Changes in the pH were not significant in different treatments except for lime treatment. After lime treatment aquarium pH significantly increased from 7.9±0.10 to 8.2±0.10, which denote that lime has a significant effect on water pH. In pond condition as well, lime treatment raised pH from 7.3 to 8.2 (Table 2), which denote that lime has a significant effect on water pH which is similar to that observed for aquarium treatment.

Table 3. Generic status of plankton under different groups as found in the aquarium experiment

Plankton Genus						
Phytoplankton				Zooplankton		
Bacillariophyceae	Cyanophyceae	Chlorophyceae	Euglenophyceae	Rotifera	Crustacea	Copepoda
Cosmarium	*Anabaena*	*Ankistrodesmus*	*Euglena*	*Asplanchna*	*Notolca*	*Cyclops*
Cycotella	*Microcystis*	*Chlorella*	*Phacus*	*Brachionus*	*Nauplius*	*Diaptomous*
Navicola	*Oscillatoria*	*Closterium*				
Nitzchia	*Spirulina*	*Pediastrum*				
Surirella	*Gomphosphaeria*	*Scenedesmus*				
		Tetraedon				
		Volvox				
		Ulothrix				
		Pleurococcum				
		Stichococcus				

Dissolved oxygen (DO): Dissolved oxygen of water body is very important factor for fish culture. During the experimental period the mean value of dissolved oxygen content in aquarium ranged between from 3.38±0.14 to 6.5±0.01 ppm in lime, 3.5±0.3 to 6.2±0.4 ppm in oxy–more, 3.5±0.5 to 8.5±2.3 ppm in zeolite treatments. The experiment showed that the DO content enhanced greatly after zeolite treatment indicating improved water quality under aquarium condition. DO in pond was also raised from 3.8±1.2 to 9.5±0.8 ppm for oxy–more and 3.5±1 to 9.0±1.1 for zeolite treatment.

Nitrate–nitrogen (mg/L), ammonia nitrogen (mg/L) and phosphate (mg/L): Nitrate is extremely important as a nutrient in fish pond. Nitrate nitrogen usually occurs in relatively small concentrations in unpolluted freshwaters. The lower value of total ammonia and phosphate in water, the better the quality of water for fish. In the present study there is hardly any presence of nitrate, ammonia and phosphate in pond and aquarium water.

Total alkalinity (mg/L): During the study period, total alkalinity was varied from 110±11.2 to 160±3.6 mg/l and 120±8.0 to 140±6.2 mg/l in aquarium with lime and zeolite, respectively. The highest value of total alkalinity content (160±3.6 mg/L) was recorded on lime treatment under aquarium condition and showed no significant variation for oxy–more. As for pond condition, total alkalinity varied from 100±15.0 to 140±13.2 mg/L in pond with liming and 110±4.0 to 140±6.2 for zeolite, respectively. The highest value of total alkalinity content (160±3.6 mg/L) was recorded for liming and showed no significant variation for oxy–more treatment condition (Table 1 and 2).

Total hardness (ppm): Total hardness is an important factor for fish pond. In the study total hardness was above 960 ppm in aquarium water. Also the study showed that significant change in hardness under lime treatment in aquarium (960±22 to 1244±1.2) (Table 1). Similar change was also observed in pond condition with lime treatment (1130±12.4 to 1250±23.0) (Table 2).

Plankton populations: Plankton populations (phytoplankton and zooplankton) in water of the experimental aquariums were enumerated and identified up to genus level. It consists of 28 genera belonging to 7 planktonic groups. Twenty two genera of Phytoplankton belonging to Bacillariphyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Six genera of zooplankton belonging to Rotifer, Copepoda and Crustacean were identified. Mean abundance of phytoplankton with their different groups are shown in Table 4 and 5.

Changes in Bacillariophyceae: Under this group 5 genera were identified in three treatment conditions, respectively. Among these *Navicola, Nitzchia, Surirella* and *Cycotella* were predominant. The mean values before treatments were 2.24×10^4, 0.52×10^4, 0.48×10^4 cells/l which were changed to 1.66×10^4, 1.58×10^4 and 0.86×10^4 cells/l, respectively after treatment with lime, oxy–more and zeolite. Density of the Bacillariophyceae in aquarium showed significant difference for lime and zeolite treatment (Table 4). After lime treatment the plankton density reduced whereas for other treatments density was found to have increased. Similar condition was also observed for pond treatment (Table 5).

Changes in Chlorophyceae: Under this group 10 genera were identified in three treatment conditions, respectively. Among these A*nkistrodesmus, Chlorella, Clostridium,* and *Tetradon* were predominant (Table 3). Density of Chlorophyceae of aquarium showed significant difference for lime treatment and the density reduced significantly from 2.58×10^4 to 0.42×10^4 cells/l (Table 4). There were similar conditions for pond treatment also (Table 5).

Changes in Cyanophyceae: Under this group 5 genera were identified in three treatment condition respectively. Among these Anabaena, Microcystis, and Oscillatoria were predominant (Table 3). The study showed that

Cyanophyceae density of the aquarium increased greatly per liter after zeolite and oxy–more treatment whereas it decreased for lime treatment.

Changes in Euglenophyceae: Under this group 2 genera were identified in three treatment condition respectively. Among these *Eeuglena* was predominant. The study showed that the community remains almost unchanged after different treatments (Table 4 and 5).

Table 4. Changes in plankton groups treated with lime, oxy–more and zeolite under aquarium condition

Water treatment chemicals	Control	Days after treatment							Level of significance
		1	2	3	4	5	6	7	
Lime									
Bacillariophyceae (×10^4 cells/L)	2.24 ± 0.6^{b}	2.14 ± 0.6^{b}	1.66 ± 0.2^{a}	1.06 ± 0.0^{b}	0.86 ± 0.04^{b}	0.92 ± 0.06^{b}	0.32 ± 0.0^{a}	0.42 ± 0.7^{b}	*
Cyanophyceae (×10^4 cells/L)	0.9 ± 0.2^{b}	1.0 ± 0.2^{b}	0.78 ± 0.03^{b}	0.62 ± 0.0^{b}	0.78 ± 0.03^{b}	0.46 ± 0.01^{b}	0.52 ± 0.1^{b}	0.36 ± 0.2^{b}	NS
Euglenophyceae (×10^4 cells/L)	0.2 ± 0.0	0.2 ± 0.0	0.14 ± 0.04	0.18 ± 0.01	0.12 ± 0.01	0.12 ± 0.01	0.16 ± 0.02	0.14 ± 0.02	
Chlorophyceae (×10^4 cells/L)	2.58 ± 0.8^{b}	2.3 ± 0.8^{b}	2.24 ± 0.2^{b}	1.76 ± 0.2^{a}	1.28 ± 0.02^{b}	0.66 ± 0.0^{a}	0.52 ± 0.2^{b}	0.52 ± 0.3^{b}	*
Rotifera (×10^4 cells/L)	0.12	1.02	0.14	0.14	0.02	0.04	0.02	0.02	
Copepoda (×10^4 cells/L)	0.04	0.03	0.08	0.12	0.03	0.05	0.04	0	
Crustacea (×10^4 cells/L)	0	0	0	0.02	0.04	0	0.08	0.05	
Total (×10^4 cells/L)	6.08 ± 1.7^{a}	5.7 ± 1.6^{b}	5.0 ± 0.5^{a}	4.04 ± 0.3^{b}	4.13 ± 1.0^{b}	2.45 ± 0.8^{a}	1.7 ± 0.3^{b}	1.5 ± 1.2^{b}	*
Oxy–more									
Bacillariophyceae (×10^4 cells/L)	0.52 ± 0.2^{b}	0.52 ± 0.2^{b}	0.9 ± 0.0^{a}	0.9 ± 0.0^{b}	1.58 ± 0.5^{a}	0.78 ± 0.1^{a}	0.52 ± 0.2^{b}	1.12 ± 0.2^{a}	*
Cyanophyceae (×10^4 cells/L)	0.3 ± 0.2^{b}	0.3 ± 0.2^{b}	0.46 ± -0.1^{b}	0.78 ± 0.1^{b}	0.86 ± 0.2^{b}	0.86 ± 0.2^{b}	0.44 ± 0.1^{a}	0.6 ± 0.0^{b}	*
Euglenophyceae (×10^4 cells/L)	0.12 ± 0.0^{b}	0.12 ± 0.0^{b}	0.14 ± 0.0^{b}	0.32 ± 0.1^{b}	0.14 ± 0.0^{b}	0.14 ± 0.0^{b}	0.18 ± 0.0^{b}	0.14 ± 0.0^{b}	NS
Chlorophyceae (×10^4 cells/L)	1.06 ± 0.1^{b}	1.06 ± 0.1^{b}	0.92 ± 0.2^{b}	1.66 ± 0.3^{a}	1.34 ± 0.1^{b}	1.22 ± 0.0^{b}	0.86 ± 0.2^{b}	1.22 ± 0.1^{b}	*
Rotifera (×10^4 cells/L)	0.04	0.04	0.14	0.04	0.02	0.02	1.5	0.02	
Copepoda (×10^4 cells/L)	0	0	0.04	0	0.04	0	0.02	0.02	
Crustacea (×10^4 cells/L)	0.04	0.04	0	0.04	0.02	0.04	0.02	0.06	
Total (×10^4 cells/L)	1.8 ± 0.5^{a}	2.08 ± 0.5^{b}	2.6 ± 0.3^{a}	3.7 ± 0^{b}	4.6 ± 0.8^{a}	2.8 ± 0.3^{b}	4.16 ± 0.5^{a}	3.2 ± 0.3^{b}	*
Zeo–prime									
Bacillariophyceae (×10^4 cells/L)	0.48 ± 0.0^{b}	0.48 ± 0.0^{b}	0.46 ± 0.0^{b}	0.32 ± 0.1^{b}	0.86 ± 0.3^{a}	0.78 ± 0.2^{b}	0.78 ± 0.2^{b}	0.6 ± 0.0^{b}	*
Cyanophyceae (×10^4 cells/L)	0.46 ± 0.0^{b}	0.66 ± 0.0^{b}	0.28 ± 0.2^{b}	0.3 ± 0.1^{b}	0.44 ± 0.0^{b}	0.86 ± 0.3^{b}	0.6 ± 0.0^{b}	0.5 ± 0.0^{b}	NS
Euglenophyceae (×10^4 cells/L)	0.28 ± 0.0^{b}	0.32 ± 0.0^{b}	0.32 ± 0.0^{b}	0.3 ± 0.0^{b}	0.42 ± 0.0^{b}	0.26 ± 0.0^{b}	0.14 ± 0.1^{b}	0.22 ± 0.0^{b}	NS
Chlorophyceae (×10^4 cells/L)	1.38 ± 0.2^{b}	1.44 ± 0.2^{b}	1.66 ± 0.4^{b}	1.28 ± 0.1^{b}	0.96 ± 0.1^{b}	0.86 ± 0.2^{b}	0.88 ± 0.2^{b}	0.78 ± 0.2^{b}	NS
Rotifera (×10^4 cells/L)	0.14	0.14	0.16	0.32	0.22	0.16	0.12	0	
Copepoda (×10^4 cells/L)	0	0	0	0.04	0.02	0.04	0	0	
Crustacea (×10^4 cells/L)	0.03	0.03	0	0.04	0.04	0.08	0.06	0.08	
Total (×10^4 cells/L)	2.7 ± 0.2^{a}	3.01 ± 0.2^{b}	2.9 ± 0.6^{b}	2.6 ± 0.3^{b}	3.0 ± 0.4^{a}	3.0 ± 0.7^{b}	2.7 ± 0.5^{b}	2.2 ± 0.2^{a}	*

Values are Mean ± SE (×10^4 cells/l**);** * Values with different superscript indicate a significant difference at 5% significance level based on Tukey's test.

Table 5. Changes in plankton groups treated with lime, oxy-more and zeolite under pond condition

Water treatment chemicals	Control	Days after treatment							Level of significance
		1	2	3	4	5	6	7	
Lime									
Bacillariophyceae (×10^4 cells/L)	2.34 ± 0.5^{b}	2.22 ± 0.4^{b}	2.22 ± 0.4^{b}	1.66 ± 0.1^{a}	1.36 ± 0.0^{b}	0.92 ± 0.0^{a}	0.32 ± 1.0^{b}	0.82 ± 0.6^{a}	*
Cyanophyceae (×10^4 cells/L)	1.6 ± 0.2^{a}	1.2 ± 0.1^{a}	1.08 ± 0.0^{b}	0.92 ± 0.2^{b}	0.88 ± 0.0^{b}	1.16 ± 0.0^{b}	1.22 ± 0.1^{b}	1.36 ± 0.0^{b}	*
Euglenophyceae (×10^4 cells/L)	0.9 ± 0.4^{a}	0.3 ± 0.4^{a}	0.14 ± 0.0^{b}	0.18 ± 0.0^{b}	0.12 ± 0.0^{b}	0.12 ± 0.0^{b}	0.16 ± 0.0^{b}	0.14 ± 0.0^{b}	*
Chlorophyceae (×10^4 cells/L)	2.58 ± 0.5^{b}	2.58 ± 0.5^{b}	2.24 ± 0.2^{b}	2.24 ± 0.2^{b}	2.28 ± 0.2^{b}	0.86 ± 0.0^{a}	0.52 ± 0.0^{b}	0.52 ± 0.0^{b}	*
Rotifera (×10^4 cells/L)	0.24 ± 0.1^{b}	0.26 ± 0.1^{b}	0.16 ± 0.2^{b}	0.18 ± 0.2^{b}	0.14 ± 0.3^{b}	0.16 ± 0.1^{b}	0.2 ± 0.1^{b}	0.24 ± 0.02^{b}	NS
Copepoda (×10^4 cells/L)	0.04	0.04	0.08	0.08	0.06	0	0.04	0	
Crustacea (×10^4 cells/L)	0.2	0.14	0.14	0.04	0.02	0.10	0.12	0.16	
Total (×10^4 cells/L)	7.2 ± 1.7^{a}	6.64 ± 1.5^{a}	6.06 ± 0.8^{a}	5.3 ± 0.7^{a}	4.9 ± 0.5^{a}	3.3 ± 0.1^{a}	2.6 ± 0.3^{a}	3.2 ± 0.6^{a}	*
Oxy–more									
Bacillariophyceae (×10^4 cells/L)	1.52 ± 0.2^{a}	1.62 ± 0.2^{b}	1.9 ± 0.0^{b}	2.3 ± 0.0^{a}	1.58 ± 0.5^{a}	1.38 ± 0.1^{b}	0.92 ± 0.2^{a}	1.12 ± 0.2^{b}	*
Cyanophyceae (×10^4 cells/L)	1.2 ± 0.2^{a}	1.6 ± 0.2^{a}	1.3 ± -0.1^{b}	1.8 ± 0.1^{a}	1.7 ± 0.2^{b}	1.9 ± 0.2^{b}	1.5 ± 0.1^{a}	1.4 ± 0.0^{b}	*
Euglenophyceae (×10^4 cells/L)	0.82 ± 0.0^{b}	0.8 ± 0.0^{b}	0.94 ± 0.0^{b}	0.92 ± 0.1^{b}	0.94 ± 0.0^{b}	1.24 ± 0.0^{b}	1.18 ± 0.0^{b}	1.4 ± 0.0^{b}	NS
Chlorophyceae (×10^4 cells/L)	2.06 ± 0.1^{b}	2.3 ± 0.1^{b}	1.92 ± 0.2^{a}	1.7 ± 0.3^{b}	1.34 ± 0.1^{a}	1.22 ± 0.0^{b}	0.8 ± 0.2^{a}	1.14 ± 0.1^{b}	*
Rotifera (×10^4 cells/L)	0.16^{b}	0.1^{b}	0.26^{b}	0.24^{b}	0.72^{a}	0.5^{b}	0.5^{b}	0.6^{b}	*
Copepoda (×10^4 cells/L)	0.04	0.4	0.24	0	0.53	1.1	1.02	1.22	
Crustacea (×10^4 cells/L)	1.04	0.94	1.04	1.3	1.42	1.44	1.24	1.06	
Total (×10^4 cells/L)	6.8 ± 0.5^{a}	7.7 ± 0.5^{a}	7.6 ± 0.3^{b}	8.3 ± 0.5^{a}	8.0 ± 0.8^{b}	8.8 ± 0.3^{a}	7.2 ± 0.5^{a}	8.0 ± 0.3^{a}	*
Zeo–prime									
Bacillariophyceae (×10^4 cells/L)	2.42 ± 0.0^{b}	2.28 ± 0.0^{b}	2.46 ± 0.0^{b}	2.62 ± 0.1^{b}	3.16 ± 0.3^{a}	3.18 ± 0.2^{b}	3.52 ± 0.2^{a}	3.3 ± 0.0^{b}	*
Cyanophyceae (×10^4 cells/L)	1.5 ± 0.0^{a}	1.11 ± 0.0^{a}	1.28 ± 0.2^{b}	1.3 ± 0.1^{b}	1.14 ± 0.0^{b}	0.86 ± 0.3^{b}	0.6 ± 0.0^{b}	0.7 ± 0.0^{b}	*
Euglenophyceae (×10^4 cells/L)	0.98 ± 0.0^{b}	1.0 ± 0.0^{b}	0.93 ± 0.0^{b}	0.8 ± 0.0^{b}	0.82 ± 0.0^{b}	0.86 ± 0.0^{b}	0.64 ± 0.1^{b}	0.52 ± 0.0^{b}	NS
Chlorophyceae (×10^4 cells/L)	2.28 ± 0.2^{b}	2.34 ± 0.2^{b}	2.2 ± 0.4^{b}	1.83 ± 0.1^{a}	1.6 ± 0.1^{b}	1.5 ± 0.2^{b}	1.9 ± 0.2^{a}	1.9 ± 0.2^{b}	*
Rotifera (×10^4 cells/L)	0.64^{b}	0.62^{b}	0.54^{b}	0.42^{b}	0.22^{b}	0.16^{b}	0.12^{b}	0.08^{b}	NS
Copepoda (×10^4 cells/L)	0	0.4	0.08	0.14	0.12	0.34	0.38	0.6	
Crustacea (×10^4 cells/L)	0.22	0.13	0	0.14	0.14	0.3	0.5	0.5	
Total (×10^4 cells/L)	8.0 ± 0.2^{b}	7.9 ± 0.2^{b}	7.5 ± 0.6^{a}	7.3 ± 0.3^{b}	7.2 ± 0.4^{b}	7.2 ± 0.7^{b}	7.7 ± 0.5^{a}	7.6 ± 0.2^{b}	*

Mean ± SE**;**, *Values with different superscript indicate a significant difference at 5% significance level based on Tukey's test

Zooplankton population: Mean abundance of zooplankton with their different groups are shown in Table 3. Zooplankton population of both aquarium and pond water was composed of three major groups: Rotifera, Crustacea, and Copepoda.

Changes in Rotifera: Under this group 2 genera were identified in three treatment condition respectively. These are Asplanchna and Brachionus. This group of plankton community was present in little amount than the phytoplankton. In aquarium condition this community reduced considerably for lime treatment in the consecutive day of experiment (Table 4). However, in pond condition at first the density was reduced for 4 consecutive days but again increased later on (Table 5).

Changes in Crustacea: Under this group 2 genera were identified in three treatment condition respectively. Among these Notolca was predominant. This group of zooplankton presents so much little amount for the observation of the influence of chemicals on them (Table 3).

Changes in Copepoda: Under this group 2 genera were identified in three treatment condition respectively. Among these Cyclops was predominant. This group of zooplankton also presents so much little amount for the observation of the influence of chemicals on them (Table 3). This result indicates that copepods are much resistant to these three water treatment chemicals.

Our study on the effect of lime, oxy-more and zeolite on planktonic community in the tropical aquaculture pond condition is the first report especially in the context of Bangladesh. All of these chemicals in the present study was found to be suitable and effective in managing different water quality parameters including pH, DO, hardness. However, special attention need to be taken while using and applying these chemicals in water. Proper doses and appropriate application procedure need to be followed in all steps and SOPs should be followed by the aqua-farm operators.

Acknowledgement: The research was funded by Bangladesh Fisheries Research Institute (BFRI) under the core research project *Impact of Aquaculture Drugs and Chemicals on Aquatic Ecology and Productivity.*

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