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Article

Evaluation of the growth performance of fishes in industrial waste fed ponds under Rajshahi City Corporation

Md. Rayhan Hossain[1*], Md. Akhter Hossain[3], Shishir Kumer Dey[1], Sayeeda Sultana[2] and Rubia Akter[2]

[1]Bangladesh Fisheries Research Institute, Freshwater Station, Mymenshing 2201, Bangladesh
[2]Bangladesh Fisheries Research Institute, Head Quater, Mymenshing 2201, Bangladesh
[3]Rajshahi University, Fisheries Department, Rajshahi 6205, Bangladesh

[*]Corosponding author: Md. Rayhan Hossain, Scientific Officer, Bangladesh Fisheries Research Institute, Freshwater Station, Mymenshing 2201, Bangladesh. Phone: +8801735851266. E-mail: rfaa_hossain@yahoo.com

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Abstract: Growth performance of fishes was evaluated for a period of six months (May to October, 2007) in industrial waste fed ponds located at Rajshahi City under three different treatments of species variation namely T_1 *(Labeo rohita, Catla catla, Cirrhinus mrigala, Hypophthalmichthys molitrix, Cyprinus carpio)* in non waste pond, T_2 *(L. rohita, C. catla, C. mrigala, H. molitrix, C. carpio, Labeo bata)* in industrial waste fed pond and T_3 *(L. rohita, C. catla, C. mrigala, H. molitrix, C. carpio, L. bata, Oreochromis nilotica)* in waste fed pond. All the treatments were replicated twice. Stocking density 14,000 individuals/ha was same for all the treatments. The average initial weight of fish was 28.9g. Treatments had no significant effect on the mean SGR and survival rate of fishes except C. *carpio.* Mean SGR (%, bwd^{-1}), weight gain (g), final weight (g) and survival rate (%) varied from 1.14±0.26 (T_2) to 1.67±0.44 (T_1), 34.00±2.81 (T_2), to 114.22±12.37 (T_1), 235.75±2.59 (T_3) to 752.50±4.50 (T_1), 60.50±4.50 (T_3) to 82.50±2.50% (T_2), respectively. Total fish yield (Kg/ha) significantly ($P<0.05$) varied from 2234.50±24.40 (T_2), to 2532.50±1.50 (T_1). Mean water temperature [(27.73±0.50 (T_1) to 28.09±0.53°C (T_2)], dissolved oxygen [(4.45±0.18 (T_3) to 6.00±0.22 mg/l (T_2)], pH (7.73±0.11 (T_1) to 8.32±0.15 (T_3)], ammonia-nitrogen [(0.0069±0.0018 (T_1) to 0.039±0.0029 mg/1 (T_3)] and total alkalinity (95.09±3.22 (T_1) to 160.49±18.97 mg/I (T_2) significantly ($P<0.05$) varied under the different treatments.

Keywords: waste fed; growth performance; weight gain; dissolved oxygen; alkalinity

1. Introduction

Aquaculture in ponds and lakes in urban waters, fishing and fishery activities in peri-urban, both in public and private sector are distinctly variable and it contributes in livelihood and food security of people living around the city areas.

The textile industry is the largest consumer of dye stuffs. During the coloration process a large percentage of the synthetic dye does not bind and is lost to the waste stream (Weber and Adams, 1995). Approximately 10-15% dyes are released into the environment during dyeing process making the effluent highly colored and aesthetically unpleasant. The effluent from textile industries thus carries a large number of dyes and other additives which are added during the colouring process (Wang *et al*., 2002).

Industrialization is the result of urbanization. The textile industry uses vegetable fibres such as cotton, animal fibres such as wool and silk and a wide range of synthetic materials such as nylon, polyester, and acrylics materials (of which polyester accounts for about half) (Commission, 2002). Pollutants in wastewater from textile factories vary greatly and depend on the chemicals and treatment processes used. Pollutants which are likely to be present include suspended solids, biodegradable organic matter, toxic organic compounds (e.g. phenol) and heavy metals. Industrial pollution may pose a greater threat to public health than pathogens and parasites. Hundreds of factories discharge effluents into Calcutta's waste waters, including highly toxic chromium from tanneries. One waste water fed fish pond system in Calcutta receives 70% industrial waste. Hanoi sewage also contains about 30% industrial waste (IUCN, 1990). Brown and Anliker (2000) summarized the effects of textile effluents on the environment and the toxicity with respect to fish and other aquatic organisms. For example, suspended solids can clog fish gills, either killing them of reducing their growth rate. Other important impact, they also reduce light penetration. This reduces the ability of algae to produce food and oxygen.

Textile industry is one of the most important and rapidly developing industrial sectors in Bangladesh. Silk industry is the pride of Rajshahi. The silk industry discharge huge amount of effluent in the adjacent water bodies which mainly consists of dye, grease, $FeSO_4$, polyethylene, Alum, lime etc. Because of the mandatory use of so_4-^{2} based chemicals in several processes of textile industry, high sulphate concentration in effluent cause the water quality deteriorated (Shahin, 1996).The surrounding water bodies near the silk industry have great potentialities in terms of fish culture. The quality of water could be maintained if relatively less harmful chemicals (like chloride salt instead of sulphate) will be used. According to Barclay and Buckley (2000), in the European countries, many firms in textile industry are concentrated on the use of environmentally friendly chemicals and processes that require less water.

Utilization of the industrial waste-fed water for aquaculture is primarily based on degradation process. Waste water is reused instead of disposed of industrial waste-fed aquaculture is a new and nevertheless innovative and successful way to treat and recycle wastewater. Many developed countries had well adopted different industrial waste-water treatment plants. As Bangladesh is a developing country, it is not possible for us to adopt such expensive methods as a short time basis. Utilization of industrial wastewater for aquaculture is an initial attempt to understand the actual productivity and prospects of industrial waste-fed aquaculture. Actually almost all sorts of aquaculture have potentials in Bangladesh.

However we get only 16.48g/day of fish for consumption. We need 18.24 g /day fish protein per capita. So aquaculture is effective solution to recover protein demand. Fisheries sector can also an important role to improve economy of Bangladesh. Water resources is 49 million hector. It covers 34% of total area of Bangladesh. All most 1.2 crore people depend on fisheries sector direct or indirectly for their livelihood (DoF, 2005). It is necessary to improve the different aquaculture practices already developed for proper utilization of the water resources and meeting up the protein gap in Bangladesh. Maximum research efforts are taken for the development of rural aquaculture with little emphasis in urban and per urban aquaculture in Bangladesh. Since industrial waste fed ponds are mainly located in urban and peri urban areas, there is a necessity for the development of aquaculture in this area. On the other hand poor emphasis is also given for the development of aquaculture in different climatic zones.

2. Materials and Methods

2.1. Time and location of the study

The experiment was conducted for a period of 12 fortnights from May, 2007 to October, 2007 in six farmer's ponds located at Sopura of Boalia thana in Rajshahi City corporation. The average size and depth of the ponds are l.lha and 1.5m, respectively. All the ponds were rain-fed and well exposed to sunlight.

2.2. Experimental design

The present experiment was conducted with three treatments namely T_1, T_2 and T_3 each with two replications. The treatment assignments are as follows

T_I: Carp culture in freshwater
(Labeo rohita, Catla catla, Cirrhina mrigala, Hypopthalmichthys molitrix, Labeo bata and Cyprinus carpio)

T_2: Carp culture in industrial waste water
(Labeo rohita, Catla catla, Cirrhina mrigala, Hypopthalmichthys molitrix, Labeo bata and Cyprinus carpio)

T_3: Carp-Tilapia mixed culture in industrial waste water
(Labeo rohita, Catla catla, Cirrhina mrigala, Hypopthalmichthys molitrix, Labeo bata, Cyprinus carpio and Oreochromis niloticus)

2.3. Pond preparation

Aquatic weeds were removed from all the ponds manually. Predatory fish and other unwanted species were removed through repeated netting. Liming was done at a rate of 250 kg/ha before 7 days of fertilization. All the ponds were fertilized with cowdung (2000 kg/ha), urea (50 kg/ha) and TSP (50 kg/ha) as basal dose.

2.4. Stocking

One week after basal fertilization all the ponds are stocked with the different species. The stocking density (14000 individuals/ha) was same for all the treatments.

2.5. Post stocking fertilization and feeding

All the ponds were fertilized with cowdung (1400 kg/ha), urea (25 kg/ha) and TSP (12 kg/ha) as a fortnightly basis.

2.6. Sampling

Sampling for monitoring the water quality parameters were done as a fortnightly basis within 9:00 am to 10:00 am. Samplings for the growth performance of fishes were also done as a monthly basis. In each fortnight 10% of the stocked fishes were caught from each pond with the help of a seine net for the study of growth performance of fishes.

2.7. Physico-chemical parameters

2.7.1. Water temperature

A centigrade thermometer within the range of 0°C to 120°C was used to record the water temperature.

2.7.2. Water transparency

The transparency of water was recorded with the help of a secchi disc and it was expressed as cm.

2.7.3. Dissolved oxygen

The dissolved oxygen content of water was determined by the Winkler's titration method (APHA, 1976). Reagent used in determining the dissolved oxygen were manganese sulphate ($MnSO_4$) solution, alkaline iodide solution, concentrated sulfuric acid, 0.025 N sodium thiosulfate solution and starch solution. The concentration of dissolved oxygen thus estimated was expressed in milligram per liter (mg/ l) of water.

2.7.4. Hydrogen ion concentration (pH)

The negative logarithm of the hydrogen ion concentration or pH of pond water was measured by the help of a pH indicator paper (LOGAK, Korea).

2.7.5. Ammonia-Nitrogen

Ammonia-Nitrogen was determined by the help of a water quality test kit (HACH kit, FF-2, USA). The concentration of ammonia-nitrogen was expressed in milligram per liter (mg/l) of water.

2.7.6. Alkalinity

Alkalinity was determined by titration method. The reagents used were N/50 sulfuric acid, phenolphthalein indicator solution and methyl orange indicator solution. It was also expressed as mg/l.

2.8. Study of plankton

For plankton study 20 liters of water sample from each pond was collected in a plastic bucket and passed through plankton net of SSµ mesh size. Then the concentrated plankton samples were preserved in plastic vials with 5% formalin for subsequent studies.

2.8.1. Study under microscope

For the qualitative and quantitative study of plankton 1ml of the concentrated plankton samples was taken by a dropper and then put on the S-R (Sedgewick-Rafter) counting cell. The S-R cell is a special type of slide having a counting chamber of 55mm in length, 20mm in width and lmm in depth. The volume of chamber is lml. The counting chamber is equally divided into 1000 fields each having a volume of 0.001 ml. Finally, the S-R counting cell was placed under a light microscope (Olympus, Japan) for phytoplankton and zooplankton identification.

2.8.2. Qualitative study of plankton
The qualitative study of phytoplankton and zooplankton were done after Ward and Whipple (1954), Needham and Needham (1962) and Prescott (1964). Different groups of phytoplankton and zooplankton were identified up to genus level.

2.8.3. Quantitative study of plankton
The quantitative abundance of plankton was expressed as cells/1 of pond water using the following formula

$$N = \frac{A \times 100 \times C}{V \times F \times L} \quad \text{(Stirling, 1985)}$$

where,

N= Number of plankton cells per liter of original water.
A = Total number of plankton counted.
C = Volume of final concentration of the sample in liter.
V = Volume of a field.
F = Number of the field counted.
L= Volume of original water in liter.

2.9. Fish growth parameters
The following parameters were used to evaluate the growth performance of fishes under different treatments.
1. Specific Growth Rate (SGR, % bwd^{-1})

$$= \frac{L_n \text{ final weight} - L_n \text{ initial weight}}{\text{Culture period}} \times 100 \quad \text{(Brown, 1957).}$$

2. Weight gain (g) = Mean final weight - Mean initial weight.
3. Survival rate (%)

$$= \frac{\text{No of fish harvested}}{\text{No of fish stocked}} \times 100$$

4. Final weight (g) = Weight of fish at harvest
5. Yield: Yield was calculated based on the average final weight of the harvested fishes and was expressed as kg/ha.
SGR and weight gain were calculated in each fortnight whereas the survival rate and yield were calculated during harvesting of the fishes.

2.10. Statistical analysis
All the data were subjected to ANOVA (Analysis of Variance) using a computer software SPSS (Statistical Package for Social Science). The mean values were also compared to see the significant difference through DMRT (Duncan Multiple Range Test) after Zar (1984).

3. Results
3.1. Mean variation physico-chemical parameters
The mean values of different physico-chemical parameters under different treatments by the total of all fortnights are presented in Table1.

3.1.1. Water temperature
The mean values of water temperature were found to be ranged from 27.73±.50 to 28.09±.53°C. The minimum value was recorded with the treatment T_1 whereas the maximum value was recorded with the treatment T_2. No significant difference was found among the treatments for the mean values of water temperature.

3.1.2. Water transparency
The mean values of water transparency were found to be ranged from 29.15±0.58 to 31.69f.26 cm. The minimum value recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_2. There was significant different among 1st, 2nd , 3rd for mean value of transparency.

3.1.3. pH

The mean values of pH were found to be ranged from 7.73±0.11 to 8.32±.15. The minimum value was recorded with the treatment T2 whereas the maximum value was recorded with the treatment T_3. Significant difference was found among the treatments 1st, 2nd , 3rd for the mean values of pH.

3.1.4. Dissolved oxygen morning

The mean values of dissolved oxygen was found to be ranged from .94±.00 to2.57±.23. mg/l. The minimum value was recorded with the treatment T_2 whereas the maximum value was recorded with the treatment T_3. significant difference was found among the treatments 1st, 2nd, 3rd for the mean values of dissolved oxygen.

3.1.5. Dissolved oxygen afternoon

The mean values of dissolved oxygen was found to be ranged from 4.45±.18 to 6.00±.22mg/l. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_Z. Significant difference was found among the treatments 1st, 2nd, 3rd for the mean values of dissolved oxygen

3.1.6. Ammonia-Nitrogen (NH_3-N)

The mean values of dissolved oxygen was found to be ranged from .00±0.0028 to 0.36+0.29 mg/l. The minimum value was recorded with the treatment T_2 whereas the maximum value was recorded with the treatment T_1. No significant difference was found among the treatments for the mean values of ammonia-nitrogen (NH_3-N).

3.1.7. Alkalinity

The mean values of alkalinity was found to be ranged from 95.09±3.22 to160.49±95.09 mg/l. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T1. No significant difference was found among the treatments for the mean values of alkalinity.

3.1.8. Free Co_2

The mean values of Co_2 was found to be ranged from 4.49 ±.30 to 5.04±.18 mg/l. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_1. No significant difference was found among the treatments for the mean values of CO_2.

3.2. Phytoplankton

The mean values of phytoplankton concentration under different treatments by the total of all fortnights are presented in Table 2. The mean value of Euglenophyceae was found to be ranged from 4169.33±227.23 to 4675.17±354.26 cells/l. The minimum value was recorded with treatment T_2 whereas the maximum value was recorded with the treatment T_i. No significant difference found among the treatments for the mean values of Euglenophyceae. The mean value of Bacillariophyceae was found to be ranged from 842.33±406.85 to 1083.25±469.14 cells/I. The minimum value was recorded with treatment T_l whereas the maximum value was recorded with the treatment T_3. No significant difference found among the treatments for the mean values of Euglenophyceae. The mean value of Cyanophyceae was found to be ranged from 2017.00±326.46 to 3991.67±194.69 cells/I. The minimum value was recorded with treatment T_2 whereas the maximum value was recorded with the treatment T_3. Significant difference found among the treatments 1st, 2nd, 3rd for the mean values of Cyanophyceae. The mean value of Myxophyceae was found to be ranged from 1090.42±385.61 to 1496.33±521.38 cells/I. The minimum value was recorded with treatment T_i whereas the maximum value was recorded with the treatment T_3. No significant difference found among the treatments for the mean values of Myxophyceae. The mean value of Chlorophyceae was found to be ranged from 18220.58±398.24 to20150.42±174.78 cells/I. The minimum value was recorded with treatment T2 whereas the maximum value was recorded with the treatment T_3. Significant difference found among the treatments 1st, 2nd, 3rd for the mean values of Chlorophyceae. The mean value of total phytoplankton concentration was found to be ranged from 38958.75±4018.50 to 39908.50±4276.90 cells/I. The minimum value was recorded with treatment T_2 whereas the maximum value was recorded with the treatment T_1.

3.3. Zooplankton

The mean values of zooplankton concentration under different treatments by the total of all fortnights are presented in Table-3. The mean value of Rotifera was found to be ranged from 4860.08±70.84 to 5632.33±178.74 cells/I. The minimum value was recorded with treatment T_2 whereas the maximum value was recorded with the treatment T_3. Significant difference found among the treatments 1 st, 2nd, 3rd for the mean values of Rotifera. The mean value of Cladosera was found to be ranged from 5000.00±318.21 to 5490.08±368.40 cells/I. The minimum value was recorded with treatment T_3 whereas the maximum value was recorded with the treatment T_2. No significant difference found among the treatments for the mean values of Cladosera. The mean value of Copepoda was found to be ranged from 4526.84±172.47 to 4717.92±224.94 cells/I. The minimum value was recorded with treatment T_2 whereas the maximum value was recorded with the treatment T1. No significant difference found among the treatments for the mean values of Copipoda. The mean value of Naupli was found to be ranged from 2703.75±89.25 to 3293.42±373.19 cells/1. The minimum value was recorded with treatment T_3 whereas the maximum value was recorded with the treatment T_1. No significant difference found among the treatments for the mean values of Naupli.

3.4. Growth parameters

Variations in the mean values of growth parameters (weight gain and SGR) under different treatments are shown in Tables 4,5,6,7 and 8.

3.3.1. Weight gain

In case of *L. rohita,* weight gain (g) varied from 64.08±5.64g (T_2) to 67.42±7.08g (T_I). No significant difference was found among the treatments for the mean values of weight gain of *L. rohita.* In case of C. *catla,* weight gain (g) varied from 51.50±4.31 g(T_2) to 74.42±14.35g (T3). No significant difference was found among the treatments for the mean values of weight gain of C. *catla.* In case of C. *mrigal,* weight gain (g) varied from 55.20±7.80g (T_2) to 56.48±7.60g (T3). No significant difference was found among the treatments for the mean values of weight gain of C. *catla.* In case of, C. *carpio* weight gain (g) was found 54.75±8.47 g (T_2) and 113.83±14.10 g(T_1) respectively. Significant difference found among the treatments 1 st, 2nd, 3rd for the mean values of C. *carpio.* In case of, *L. bata* weight gain (g) was found 34.00±2.81 g (T_2) and 34.50±3.06 g (T_3) respectively. Significant difference found among the treatments, 2nd, 3rd for the mean values of C. *carpio.* In case of, O. *nilotica* weight gain (g) was found 34.25±4.52g (T_3) and 34.42±4.07 g (T_2) respectively. Significant difference found among the treatments, 3rd for the mean values of Silver carp.

3.3.2. SGR (%, bwd^{-1})

In case of *L. rohita,* SGR varied from 1.14±.26 g (T_2). To 1.39±.34g (T_I).).No significant difference was found among the treatments for the mean values of SGR of *L. rohita.*In case of C. *catla* SGR varied from 1.19±.29 g (T_2). To 1.37±.36g (T_I). No significant difference was found among the treatments for the mean values of SGR of C. *catla.* In case of C. *mrigal* SGR varied from 1.19±0.30 g (T_3) to 1.30f0.35g (T_1). No significant difference was found among the treatments for the mean values of SGR of C. *mrigal.* In case of *H. molitrix* and, SGR was found 1.35±0.33 g (T_3) to 1.±0.44g (T_1).). No significant difference was found among the treatments for the mean values of SGR of *H. molitrix.* In case of Carpiu and, SGR was found 1.25±0.30 g (T_3) to 1.67±0.44g (T,).). No significant difference was found among the treatments for the mean values of SGR of C. *carpio.* In case of *L. bata* and, SGR was found 1.20±0.35 g (T_3) to 1.21±0.30g (T_2).). Significant difference was found among the treatments Ist, 2n^{d}, for the mean values of SGR of *L. bata.* In case of O. *nilotica* and, SGR was found 1.19±0.30 g $_{(T2)}$ to 1.23±0.40g (T_3). Significant difference was found among the treatments Ist, 2n^{d}, for the mean values of SGR of O. *nilotica.*

3.3.3. Final Weight (g)

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The final weight of *L. rohita* varied from 45.00±10.00 g(T_3) to 475.00±15.00 g(T_2). No significant difference was found among the treatments for the first final weight of *L. rohita.* The final weight of *H. molitrix* varied from 415.00±5.00 g(T_2) to 752.50±4.50 g(T_1). Significant difference was found among the treatments for the final weight of *H. molitrix.* The final weight of C. *catla* varied from 370.00±10.00g (T_2) to 505.00±5.00 g(T_3). Significant difference was found among the treatments for the final weight of C. *catla.* The final weight of C. *mrigala* was found 374.50±19.50 g(T_I) to 395.00±3.00 (T_3).No significant difference was found among the treatments for the first final weight of C. *mrigala.* The final weight of C. *carpio* was found 365-00±5-00 g (T_2) to 680.00±28.00 (T_I). Significant difference was found among the treatments for the first final weight of C. *carpio.*

The final weight of *L. bata* was found 235.75±2.59 g(T_3) to 40.50±.50 (T_2). No significant difference was found among the treatments for the first final weight of *L. bata.* The final weight of O. *nilotica* was found 240.50±.50 g (T_2) to 46.00±1.00 (T_3).No significant difference was found among the treatments for the first final weight of O. *nilotica.*

3.3.4. Yield (Kg/ha)

The yield of *L. rohita* varied from 404.50±9.50 Kg/ha/yr (T_3) to 422.50±1750 Kg/ha (T_2). No significant difference was found among the treatments for the yield of *L. rohita.* The yield of *H. molitrix* (*H. molitrix* carp) varied from 380.50±4.50 Kg/ha (T2) to 717.50±5.50 Kg/ha (T_2). Significant difference among the treatments was found at T_I, T2, T3 for the yield of *H. molitrix.* The yield of C. *catla* varied from 329.00±9.00 (T_2) to 461.50±4.50 Kg/ha (T_3). Significant difference among the treatments was found at T_I,T3 for the yield of C. *catla.* The yield of C. *mrigala* varied from 339.50±21.50 (T_1) to 351.00±2.00 Kg/ha (T_3). No significant difference was found among the treatments for the yield of C. *mrigal.* The yield of C. *carpio* varied from 336.00±6.00 (T_2) to 645.50±25.50 Kg/ha (T_I). Significant difference among the treatments was found at T_1, T3 for the yield of C. *carpio.* The yield of *Labeo bata* varied from 645.50±25.50 (T_I) to 336.00±6.00 Kg/ha (T_2). No significant difference was found among the treatments for the yield of *L. bata.* The yield of O. *nilotica* varied from 213.50±1.50 (T_2) to 220.50±.50 Kg/ha (T_3). No significant difference was found among the treatments for the yield of O. *nilotica*

3.3.5. Survival rate (%)

The survival rate of *H. molitrix* varied from 69.50±5.50% (T_3) to 77.50±2.50% (T_I). No significant difference was found among the treatments for the survival rate of *H. molitrix.* The survival rate of C. *catla* varied from 68.50±.50% (T_I) to 80.50±11.50% (T_2). No significant difference was found ‘among the treatments for the survival rate of C. *catla.* The survival rate of *L. rohita* varied from 64.00±10.00% (T_3) to 78.50±1.50% (T_2). No significant difference was found among the treatments for the survival rate of *L. rohita.* The survival rate of C. *mrigala* varied from 63.50±.50% (T_2) to 77.50±1.50% (T_1). Significant difference among the treatments was found at T_1,T_2, T3 for the survival rate of *C. mrigala.* The survival rate of C. *carpio* varied from 67.50±3.50% (T_3) to 81.50±.50% (T_Z). Significant difference among the treatments was found at T_I,T_2,T3 for the survival rate of *C. carpio.* The survival rate of *L. bata* varied from 60.50-±4.50% (T_3) to 75.50±.50% (T2). No significant difference was found among the treatments for the survival rate of *L. bata.* The survival rate of O. *nilotica* varied from 64.50±.50% (T_3) to 82.50±2.50% . No significant difference was found among the treatments for the survival rate of O. *nilotica*

Table 1. Variation in the mean values of water quality parameters under different treatments at the during the study period.

Water quality parameters	Treatment		
	T_1	**T_2**	**T_3**
Temperature (°C)	27.73±.50^a	28.09±.53^a	27.80±.49^a
Transparency (cm)	30.78±.15^b	31.69±.26^a	29.15±.58^c
p^H	7.73±.11°	7.78±.00^b	8.32±.15^a
DO (mg/1)-morning	2.52±.26^b	2.57±.23^a	.94±.00^c
DO (mg/l)-afternoon	5.84±.35^6	6.00±.22^a	4.45±.18^c
Free C02 (mg/l)	4.93±.23^a	4.49±.30^a	5.05±.18^a
NH3_N (mg/1)	0.0069±0.0018^a	0.0078±0.0025^a	0.039±0.0029^a
Alkalinity (mg/1)	95.09±3.22^c	160.49±18.97^a	119.00±19.33^b

Table 2. Variation in the mean concentration of different groups of phytoplankton under different treatments during the study period.

Phytoplankton group	Phytoplankton concentration (cells/1)		
	T_1	**T_2**	**T_3**
Myxophyceae	1090.42±385.61^a	1295.92±469.89^a	1496.33±521.38^a
Cyanophyceae	2484.67±248.93^b	2017.00±326.46^c	3991.67±194.49^a
Euglenophyceae	4675.17±354.26^a	4169.33±227.23^a	4520.25±234.57^a
Bacillariophyceae	842.33±406.85^a	947.42±409.76^a	1083.25±469.14^a
Chlorophyceae	19195.33±329.45^b	18220.58t398.24^c	20150.42±174.78^a

Table 3. Variation in the mean concentration of different groups of zooplankton under different treatments during the study period.

Zooplankton group	Zooplankton concentration (cells/1)		
	T_1	T_2	T_3
Rotifera	5020.SO±245.13[6]	4860.08±70.84[c]	5632.33±178.74[a]
Cladocera	5490.08±368.40[a]	5333.42±422.79[a]	5333.OO±318.21[a]
Copepoda	4717.92±224.94[a]	4526.84±172.47[a]	4605.59±222.21 [a]
Nauplius	3293.42±373.19[a]	2729.42±166.84[a]	2703.75±89.25[a]

Table 4. Variation in the mean values of weight gain under different treatments during the study period.

Species	Treatment		
	T_1	T_2	T_3
L. rohita	67.42±7.08[a]	64.08±5.64[a]	64.17±4.86[a]
C. catla	69.33±4.99[a]	51.50±4.31[a]	74.42±14.35[a]
C. mrigala	55.17±2.95[a]	55.20±7.80[a]	56.48±7.60[a]
H. molitrix	114.22±12.37[a]	61.42±9.29[c]	64.25±9.80[b]
C. carpio	113.83±14.10[a]	54.75±8.47 [c]	68.75±6.85[b]
L. bata	35.00±2.81 [a]	34.00±2.81 [b]	34.50±3.06 [a]
0. nilotica			34.25±4.52

Table 5. Variation in the mean values of specific growth rate (SGR) under different treatments during the study period.

Species	Treatment		
	T_1	T_2	T_3
L. rohita	1.39±.34[a]	1. 14±.26[a]	1.22±.33[a]
C. catla	1.37±.36[a]	L19±.29[a]	1.33±.27[a]
C mrigala	1.30±.35[a]	1.21±.32[a]	1.17±.30[a]
H. molitrix	1.66±.44[a]	1.36±.34[a]	1.35±.33[a]
C. carpio	1.67±.44[a]	1.30±.49[b]	1.25±.30[c]
L. bata	1.21±.30 [a]	1.21±.30 [b]	1.20±.35 [c]
O. nilotica			1.23±.40

Table 6. Variation in the mean values of final weight under different treatments during the study period.

Species	Treatment		
	T_1	T_2	T_3
L. rohita	452.50±12.50[a]	475.00±15.00[a]	450.00± .00[a]
C. catla	459.17±7.57[b]	370.00±10.00[°]	505.00±5.00[a]
C mrigala	374.50±19.50[a]	385.00±5.00[a]	395.00±3.00[a]
H. molitrix	752.50±4.50[a]	415.00±5 .00[b]	432.00±2.50[b]
C. carpio	680.00±28.00[a]	365.00±5.00[c]	380.00±5.00[b]
L. bata	242.50±.50 [a]	240.50±.50 [b]	235.75±2.59 [c]
O. nilotica			246.00± 1.00

Table 7. Variation in the mean values of yield under different treatments during the study period.

Species	Treatment		
	T_1	T_2	T_3
L. rohita	417.00±14.00[a]	422.50±17.50[a]	404.50±9.50[a]
C. catla	413.00±14 .00[b]	329.00±9.00[c]	461.50±4.50[a]
C mrigala	339.50±21.50[a]	343.50±6.50[a]	351.00±2. 50[a]
H. molitrix	717.50±5.50[a]	380.50±4.50[c]	395.50±1.50[b]
C. carpio	645.50±25.50[a]	336.00±6 .00[a]	339.00±4.50[a]
L. bata	209.50±4. 50[a]	209.50±4. 50[b]	214.00±.50[c]
O. nilotica			220.50±.50

Table 8. Variation in the mean values of survival rate under different treatments during the study period.

Species	Treatment		
	T_1	T_2	T_3
L. rohita	78.50±1.50[a]	74.50±.50[a]	64.00±1 0.00[a]
C. catla	68.50±.50[a]	80.50±11.50[a]	73.50±1.50[a]
C mrigala	77.50±50[a]	63.50±.50[c]	69.50±2.50[b]
H. molitrix	77.50±.50[a]	71.50±.50[a]	69.50±5.50[a]
C. carpio	79.50±.50[b]	81.50±.50[a]	67.50±3.50[c]
L. bata	75.50±50[a]	74.50±50[b]	60.50±4. 50[c]
O. nilotica			64.5±.50

4. Discussion

4.1. Mean variations physico-chemical factors

The water temperature was found to be ranged from 27.73±0.50 to 28.09±0.53°C, transparency 29.15±0.58 to 31.69±0.26cm, pH 7.73±0.11 to 8.32±0.25, DO-morning 0.94±0.00 to 2.57±0.23, NH_3-N 0.039±0.0029 to 0.0078±0.0025 mg/l and alkalinity 95.09±3.22 to 160.49±18.97 mg/1. These findings were almost similar with the findings of Hossain and Bhuiyan (2007). These findings are more or less similar with the findings of Rahman (1992). However, the mean variation in pH was agreed with Boyd (1998) who reported that the pH of most freshwater pond was between 6 to 9. Azad *et al.* (2004) reported that pH ranged from 6.8 to 8.4 was suitable for carp poly-culture. The maximum DO value was 5.20±0.10 mg/1 during winter which agreed with Saha *et al.* (1971) and was suitable for pond aquaculture according to Boyd (1998).According to BAFRU (1990), ammonia should be less than 0.025 mg/1 in culture pond. The NH_3-**N** value was found to be ranged from .00±.00 mg/1 to 0.20±0.00 mg/1 Results indicate that the free carbondioxide varied from 3.50±.50 to 7.05±.05. Alkalinity was found to' be ranged from 72.50±32.50 mg/1 to 232.50±32.50 mg/1 which agreed with Saha *et al.* (1971).

4.2. Phytoplankton during the study period

4.2.1. Phytoplankton

During the study period Euglenophyceae varied from 4169.63±174.78 to 4675.17±174.78 cell/l**,** Bacillariophyceae varied from 842.33±406.85 to 1083.25±469.14 cell/l**,** Cynophyceae varied from 2017.00±326.46 to 3991.67±194.49 cell/l**,** Myxophyceae varied from 1090.42±385.61 to 1496.33±521.31 cell/l**,** Chlorophyceae varied from 18220.58±398.24 to 20150.42±174.78 cell/l**,** and total phytoplankton varied from 26699.58±1008.20 to 31249.42±469.59 cell/l**.** Almost similar findings were also observed by Hossain *et al.* (1999). Phytoplankton concentration found in this study was composed of 5 groups (Euglenophyceae , Bacillariophyceae, Cynophyceae, Myxophyceae, and Chlorophyceae). Almost similar findings were also observed by Bhuiyan and Nessa (1998).

4.2.2. Zooplankton

During the study period mean value of Copepod was found to be raged from 4526.84±172-47 to 4717.92±224.94 cells/I, Rotifera 4860.08±70.84 to 5632.33±178.74 octbk Cladocera 5333.00±318.21 to 5490±368.40 cells/1, Nuplius 2703.75-±89.25 to 3293.42±373.19 cell /1 and total zooplankton 17058.50±1430.21 cells/1 to 17941.17±251.34 cells/l. These findings are more or less similar with the findings of Islam *et al.* (2000). Almost similar findings were also observed by Islam *et al.*, 1998. Zooplankton concentration found in this study was composed of 4 groups (Copepoda, Rotifera, Cladocera and Crustacean larvae). Almost similar findings were also observed by Rahmatullah (1983).

4.3. Growth parameters

4.3.1. Weight gain

During the study period it was found that weight gain (g) of Rui varied from 64.08±5.64g (T_2) to 67.42±7.08g (T_I), Catla 51.50±4.31 g (T_2) to 74.42±14.3 5g (T_3), Mrigel 55.20±7.80g (T_2) to 56.48±7.60g (T_3), Carpio54.75±8.47 g (T_2) to 113.83±14.10 g(T_1), Bata 34.00±2.81 g (T_2) and 34.50±3.06 g (T_3) and Nilotica 34.25±4.52g (T_3) and 34.42±4.07 g(T_2). These are more or less similar with Wahab *et al.* (1994).

4.3.2. SGR (%, bwd^{-1})

It was found that SGR of Rui varied from 1.14±.26 g (T_2) to 1.39±.34g (T_1), Catla 1.19±.29 g (T_2) to 1.37±.36g (T_1), Mrigel 1.19±0.30 g $_{(T3)}$ to 1.30±0.35g (T_1), Silver 1.350±.33 g(T_3) to 1.±0.44g (T_I), Carpio 1.25±0.30 g (T3) to 1.67±0.44g (T,), Bata 1.20±0.35 g $_{(T3)}$ to 1.21±0.30g (T_2) and Nilotica 1.19±0.30 g(T_Z) to 1.23±0.40g(T_3). These findings were agreed with the findings of Hasan *et al.* (1982).

4.3.3. Final Weight (g)

The final weight of *L. rohita* varied from 45.00± 10.00 (T_3) to 475.00±15.00 g (T_2), *H. molitrix 415.00±5.00* (T_2) to 752.50±4.50 g(T_1), *C. catla 370.00±10.00* (T_2) to 505.00±5.00 g(T_3), C. mrigala 374.50±19.50 (T_1) to 395.00±3.00 (T_3), C. *carpio* 365.00±5.00 (T_2) to 680.00±28.00 (T_1), L. *bata* 235.75±2.59 (T_3) to 40.50±.50 (T2) and *O. nilotica* 240.50±.50 (T_2) to 46.00±1.00 (T_3). These are more or less similar with Hossain *et al.* (2007).

4.3.4. Yield (Kg/ha)

The yield of Rui varied from 404.50±9.50 (T_3) to 422.50±1750 Kg/ha (T_2), *H. molitrix* 380.50±4.50 (T_2) to 717.50±5.50 Kg/ha (T_2), *C. catla* 329.00±9.00 (T_2) to 461.50±4.50 Kg/ha (T_3), *C. mrigala* 339.50+21.50 (T_1) to 351.00+2.00 (T_3), *C. carpio* 336.00±6.00 (T_2) to 645.50±25.50 (TI), *Labeo bata* 645.50±25.50 (TI) to 336.00±6.00 (T_2) and *O. nilotica* varied from 213.50±1.50 (T_2) to 220.50±.50 Kg/ha (T_3) which are agreed with the findings of Wahab *et al.* (1994).

4.3.5. Survival rate (%)

The survival rate of *H. molitrix* varied from 69.50±5.50 (T_3) to 77.50±2.50% (T_I), C. *catla* 68.50±.50 (T,) to 80.50±11.50% (T_2), *L. rohita* 64.00±10.00 (T_3) to 78.50±1.50% (T_2), C. *mrigala* 63.50±.50% $_{(T2)}$ to 77.50±1.50 (T,), C. *carpio* varied from 67.5t2t3.50 (T_3) to 81.50±.50% (T2), *L. bata* 60.50±4.50 (T_3) to 75.50±.50% (T_2) and *O. nilotica* 64.50±.50% (T_3) to 82.50±2.50% (T_2) which is more or less similar with the findings of Hossain *et al.* (2007).

The different concentration of phyloplsniton and zooplankton were found similar to no waste fed fish culture pond in Bangladesh. All physicochemical parameters were suitable for aquaculture. The better growths were found in Treatment T_1 (*H. molitrix + L rohita + C. catla+ C. carpio + C. mrigala).*

5. Conclusions

Comparatively lower fish yield was found in industrial waste fed pond than that of the non waste fed ponds. For the future research steps the economics of industrial waste fed aquaculture should be given emphasis.

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Conflict of interest

None to declare.

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