*J. Environ. Sci. & Natural Resources,* **6(2): 71 -78 , 2013** ISSN 1999-7361

# Study on Environmental Implications and Its Impact on Aquatic Productivity in the Southwest Coastal Region

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**Abstract:** An experiment was conducted on environmental implications and its impact on aquatic productivity in the southwest coastal region for a period of 2 months (May-June/2013). Five Rivers such as Pira River, Andarmanik River, Sonatala River, Khaprabhanga River and Rupsaha River were selected for sample collection and were treated as $T_1$, $T_2$, $T_3$ $T_4$ and $T_5$. Three sampling sites were selected from each River based on salinity. The overall mean values of water temperature were 28.17 ±0.98, 27.41 ±1.21, 28.12 ± 1.11 and 27.13 ± 1.26, 26.62 ± 1.01 $^0$C in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$, respectively. The mean values of water transparency of treatments $T_1$ $T_2$ $T_3$ $T_4$ and $T_5$ were 36.00±1.26, 31.0±0.0894, 34.00±1.94, 28.00±1.46 and 31.00±1.86cm, respectively. The overall mean values of water temperature were 6.56 ± 0.12, 6.47 ±0.23, 6.34 ± 0.12, 6.19 ± 0.22, and 6.67 ± 0.29 ppm in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. pH values were found to fluctuate from 6.72 to 7.64, 6.48 to 7.13, 6.95 to 7.35 and 6.86 to 7.6 in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. Mean values of total salinity were 2.17 ±0.12, 6.17 ±0.82, 7.17 ±0.92, 10.17 ±0.1.12 and 1.78 ±0.12 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. Mean values of total alkalinity were 187.5±2.25, 165.5±3.1, 185.5±2.15, 175±2.5 and 180.5±3 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. Mean values of total alkalinity were 187.5±2.25, 165.5±3.1, 185.5±2.15, 175±2.5 and 180.5±3 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. Mean values of total alkalinity were 187.5±2.25, 165.5±3.1, 185.5±2.15, 175±2.5 and 180.5±3 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. Total hardness of water was found to range from 37 mg/l to199 mg/l. The mean values of $NH_3$-N ($mgl^{-1}$) were found to vary from 0.23 ± 0.03 ,0.27 ±0.08, 0.23 ±0.03, 0.25 ±0.03 and 0.27 ± 0.05 $mgl^{-1}$ in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. The mean values of nitrite ($NO_2$) concentration were 0.63±0.06, 0.68 ±0.08, 0.67±0.09, 0.73±0.03 and 0.67±0.06 $mgl^{-1}$ in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. There were no significantly different of temperature, dissolved oxygen pH and alkalinity among the treatments but significance difference found in transparency, salinity, hardness, ammonia, nitrite using ANOVA ($P<0.05$). Ammonia and nitrite concentration of Rupsha River ($T_5$) higher than other four Rivers due to municipal waste product of Khulna city. A proportionally strong relationship was found among salinity, transparency and hardness. Highest concentration of phytoplankton was found in Rupsha River (lowest salinity) and lowest phytoplankton concentration was found in Khaprabhanga River (highest salinity).

**Key word:** Environment, Phytoplankton, River, Water quality

## Introduction

Worldwide ecosystems are exposed to an unprecedented global diversity loss and an increasing level of environmental stress, due to global warming (Caldeira and Wickett, 2003). Climate change influences fisheries production through its effects on primary production, food web interactions and the life history and distribution of target species (Julia et al, 2012); changes in primary production follow from changes in the physical and chemical environment (Sarmiento, 2004). Bangladesh is a low lying typical flat country with big inland water bodies including some of the biggest Rivers in the world and is extremely venerable to climate change effects because of its geophysical characteristics and hydrological influence (Matin and Kamal, 2010). Due to climatic sea level rising and declining fresh water flow from the Ganges (Mizanur, 1997), ingress of salinity put forward implications for ecosystem functions including productivity from plankton to fish (Duffy, 2003). Intrusion of salinity occurs in coastal freshwater aquifers when the different densities of both the saltwater and freshwater allow the ocean water to intrude into the freshwater aquifer.. Due to salinity intrusion with an increasing trend the southwest coastal region of Bangladesh poses a complicated situation regarding fresh water and saline water interaction and its role in primary productivity and fisheries sector. (Gain *et al.,* 2008). Moreover, climate change is modifying the distribution and productivity of marine and freshwater species and is already affecting biological processes and altering food webs (Soheila and Bahram, 2010).

Water quality is defined in terms of the chemical, physical and biological contents of water which may provide basic scientific information about water quality parameters and ecologically relevant and toxicological threshold values to protect specific water uses. Environmental water quality relates to any specific water body that determines supporting suitability of aquatic organisms. Important physical and chemical parameters influencing the aquatic environment are the limiting factors for the survival and growth of aquatic organisms. (Lawson, 2011). Physico-chemical characteristics of the partially mixed zones are largely influenced by the interaction of seawater and discharge of Riverine freshwater,

annual precipitation and surface runoff (Santosh *et al*., 2007).

South West region of Bangladesh hydro-biologically is one of the most variable place in which fresh water from upstream is continuously mixing with salt water from an oceanic source. A combination of diverse fluctuating parameters is responsible for occurrence and distribution of lives in different brackish waters. Phytoplankton distribution and abundance is also an index to the fertility of any water area which can provide indicative information on fishery potentiality. There must be some complex interrelationship among the flora and fauna and the different microorganisms in diverse brackish water ecosystem. Therefore objective of our research is to determine the threshold levels and establish optimal requirements.

## Materials and Methods

This experiment has been carried out in 5 Rivers have 3 sampling stations, varying salinities. Pira River, Andarmanik River, Sonatala River, Khaprabhanga River and Rupsaha River

| Treatment | Replication | Sampling site | Location | Symbol |
|---|---|---|---|---|
| $T_1$ (Pira River) | $R_1$ | Labokhali point | Dumki | $T_1 R_1$ |
| | $R_2$ | Amtoli point | Amtoli | $T_1 R_2$ |
| | $R_3$ | Taltoli point | Amtoli | $T_1 R_3$ |
| $T_2$ (Andarmanik River) | $R_1$ | Dhankali point | Kalapara | $T_2 R_1$ |
| | $R_2$ | Kalapara point | Kalapara | $T_2 R_2$ |
| | $R_3$ | West Hagipur point | Kalapara | $T_2 R_3$ |
| $T_3$ (Sonatala River) | $R_1$ | Baliatoli point | Kalapara | $T_3 R_1$ |
| | $R_2$ | Hagipur point | Kalapara | $T_3 R_2$ |
| | $R_3$ | West Hagipur point | Kalapara | $T_3 R_3$ |
| $T_4$ (Khaprabhanga River) | $R_1$ | West kuakata point | Kalapara | $T_4 R_1$ |
| | $R_2$ | Alipur Point | Kalapara | $T_4 R_2$ |
| | $R_3$ | Chapli point | Kalapara | $T_4 R_3$ |
| $T_5$ (Rupsaha River) | $R_1$ | Rupsha Bridge point | Khulna Sadar | $T_5 R_1$ |
| | $R_2$ | Chalna | Dakup | $T_4 R_2$ |
| | $R_3$ | Botiaghata | Botiaghata | $T_5 R_3$ |

***Determination of water quality parameters***

***Physical parameters***

1. Water temperature ($^0$c)

2. Transparency (cm)

***Chemical Parameters***

1. Hydrogen Ion Index ( $p^H$)

2. Salinity (%)

3.. Total hardness as $CaCO_3$(mg/l)

4. Alkalinity

6. Dissolved Oxygen (mg/l)

8. Total Nitrate- Nitrogen (mg/l)

9. Ammonia - Nitrogen (mg/l)

***Biological parameters***

1. Phytoplankton density (cells/l), (S-R cell/light microscope method)

***Collection of plankton sample and preservation***

Plankton samples were collected from each River and pond. A bucket contained two liters of water was used to collect 10 liters of water from five different places and depth of the pond and passed through fine mesh (25 µm) plankton net. The concentrated samples were transferred to a measuring cylinder and carefully made up to a standard volume of 50 ml with distilled water. Then the collected plankton samples were preserved in 10% buffered formalin in small plastic bottles each for subsequent studies.

***Qualitative and quantitative study of plankton***

From each 50 ml preserved sample, 1 ml sub-sample was examined by using a Sedge Wick-Rafter cell (S-R cell) and a binocular microscope (Olympus CH-40) with phase contrast facilities. The Sedge Wick-Rafter counting cell is a special type of slide having a counting chamber which is 50 mm long, 20 mm wide and 1mm deep, the volume of the chamber is 1 ml. 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 (1992) and Bellinger (1992). For each pond, mean number of plankton was

recorded and expressed numerically per liter of water. The quantitative estimation of plankton was done by using the following formula for quantitative estimation.

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$ (Rahman, 1992)

Where,

N = Number of plankton cells or units per liter of original water,

A = Total number of plankton counted,

C = Volume of final concentrate of the sample in ml,

V = Volume of field in cubic mm,

F = Number of field counted and

L = Volume of original water in liter.

For each pond, mean number of plankton was recorded and expressed numerically in per liter of water.

***Statistical analysis***

For the statistical analysis of data, one-way analysis of variance (ANOVA) and Tukeys Test was performed using the SPSS (Statistical Package for Social Science, version-12.0). Significant results ($P<0.05$) were further tested by using Duncan's multiple range test (DMRT) at 5% level of significance to identify significant differences among means.

## Results and Discussion

***Water Quality Parameters***

Water quality parameters such as water temperature (°C), transparency, dissolved oxygen (mg/L), pH, alkalinity (mg/L), hardness (mg/L), ammonia (mg/L), salinity and nitrite (mg/L) of the River were recorded. All parameters were measured in the laboratory of Faculty of Fisheries, PSTU and River site. The overall mean values of each water quality parameter in different treatments are presented in Table 1.

**Table. 1.** Water quality parameters (mean and range) during study period

| **Parameters** | **$T_1$** | **$T_2$** | **$T_3$** | **$T_4$** | **$T_5$** |
|---|---|---|---|---|---|
| Water Temperature (°C) | 28.17 ±0.98 (27-28.8) | 27.41 ±1.21 (26-28) | 28.12 ± 1.11 (27.5-28.9) | 27.13 ± 1.26 (26.-27.6) | 26.62 ± 1.01 (25.5-27) |
| Transparency (cm) | 31.00±1.86 (30-.33) | 32.00±1.66 (31-.32.5) | 34.00±1.94 (32-.35) | 36.00±1.26 (35-.38) | 28.00±1.46 (27-29) |
| Dissolved Oxygen (mg/L) | 6.56 ± 0.12 (5.65 –7.30) | 6.47 ±0.23 (5.67 –7.26) | 6.34 ± 0.12 (5.15 –7.23) | 6.19 ± 0.22 (5.07 – 7.34) | 6.67 ± 0.29 (5.98 –7.39) |
| pH | 7.18± 0.27 (6.72-7.64) | 7.55± 0.26 (6.48-7.13) | 7.19 ±0.16 (6.70-7.62) | 7.15 ±0.17 (6.8-7.65) | 7.35 ± 0.23 (6.86-7.6) |
| Salinity (ppt) | 2.17 ±0.12 (0-3) | 6.17 ±0.82 (3-8) | 7.17 ±0.92 (5-9) | 10.17 ±0.1.12 (9-11) | 1.78 ±0.12 (0-2) |
| Alkalinity | 187.5±2.25 (156-197) | 165.5±3.1 (162-197) | 185.5±2.15 (150-195) | 175±2.5 (166-191) | 180.5±3 (171-200) |
| Ammonia (mg/L) | 0.23 ± 0.03 (0.19 - 0.30) | 0.27 ±0.08 (0.20 - 0.29) | 0.23 ±0.03 (0.17 - 0.27) | 0.25 ±0.03 (0.18 - 0.30) | 0.57 ± 0.05 (0.41 - 0.68) |
| Nitrite ($NO_2$) (mg/L) | 0.63 ± 0.06 (0.46-0.87) | 0.68 ±0.08 (0.37-0.91) | 0.67±0.09(0.42-0.89) | 0.73±0.03 (0.55-0.85) | 0.95±0.06 (0.69-0.98) |
| Total hardness as $CaCO_3$(mg/l) | 66.00±6.26 (60-.72) | 150.00±.16 (142-165) | 167.00±.23 (152-175) | 270.00±.38 (252-282) | 61.00±7.26 (58-.69) |

(T1=Pira River, $T_2$ = Andarmanik River, $T_3$= Sonatala River, $T_4$= Khaprabhanga River, $T_5$= Rupsaha River)

***Temperature***

Temperature of pond water was found to be more or less similar in different treatments. The overall mean values of water temperature were 28.17 ±0.98, 27.41 ±1.21 , 28.12 ± 1.11 and 27.13 ± 1.26, 26.62 ± 1.01 $^0$C in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively, which were within the recommended suitable range (21.9$^o$C to 33.5$^o$C) for fish culture (Fair and Foftner, 1981). There were no significantly different of temperature among the treatments using ANOVA ($P<0.05$). The fluctuation in water temperature was very minimum difference among the treatments due to the location of Rivers Overall mean of water temperature in ponds are shown in Table 1

Moncrief and Jones (1977) stated that for 10$^o$C rise of water temperature metabolic rate becomes double. In warm water fish, maximum metabolic rate is observed at temperature ranges of 30 to 35$^o$C. Sudden changes of water temperature, even within the tolerant limit, may fall a fish in stress. So, very high temperature in summer and very low in winter is a major problem in fish culture. In Bangladesh fish grows all the year round and there is no problem of very low temperature but sometimes extremely high temperature kills fishes especially in a shallow and turbid water body (Rahman *et al.*, 1982).Optimum temperature for pangus ranges from 27 to 31$^o$C. (Fujimura and Okamoto, 1972; Sandifer *et al*., 1983). The temperature ranged from 20 to 34$^o$C in the present study is more or less similar to Alam *et al.* (1997), Huq *et al.* (2004), Asaduzzaman (2005), Rahman (2005) and Kunda *et al.* (2008a) who recorded temperature ranges from 29.47 to 30.55, 27.8 to 29.5, 29.84 to 30.93, 26.0 to 35.0 and 22 to 34$^o$C, respectively. Temperature below 14$^0$C or above 35$^0$C are generally lethal, 29-31$^0$C being optimal (Akiyama *et al*., 1982). So, it was supposed that water temperature would never rise to 35$^0$C but it might drop down to lower critical level (14$^0$C). Jia-Mo *et al*. (1988a) reported that the water temperature ranged from 28.5 to 33 $^0$C was suitable for fish culture. Mollah and Haque (1987) reported water temperature ranged from 26.00 to 32.44 $^0$C in the pond of BAU campus, Mymensingh. Kanak *et al.* (1992) also gave the same opinion. MacLean *et al.* (1994) conducted that water temperature ranging from 28.9 to 29.1$^0$ C were favorable for fish culture.

***Transparency***

Water transparency varied in different Rivers under different treatments. The mean values of water transparency of treatments $T_1$ $T_2$ $T_3$ $T_4$ and $T_5$ were 31.00±1.86, 32.00±1.66 34.00±1.94, 36.00±1.26 and 28.00±1.46 cm respectively (Table 1). Water transparency is an apparent measure of pond productivity. It has an inverse relationship with the abundance of plankton. Boyd (1990) noted that the transparency of water was affected by many factors such as silt, microscopic organisms, suspended organic matter, season of the year, latitude and intensity of light, application of manure, grazing pressure of fishes or prawns and rainfall. He recommended a transparency between 15 to 40 cm as appropriate for fish or prawn culture. Wahab *et al*. (1995) suggested that the transparency of productive water should be 40 cm or less. The mean values of water transparency in the present study were within the suggested values. Kohinoor *et al.* (2000) recorded transparency ranged from 15 to 58 cm from the ponds in BAU campus. The transparency in the present study ranges from 27 to 38 cm which is almost similar with the findings of Rahman (2005) and Kunda *et al.* (2008) who recorded values ranged from 15 to 45 cm, and 28.22 to 33.85 cm, respectively. The transparency values of different treatment in the present study indicated that River water seemed to be within the productive range for fish. The relation between transparency and salinity shown in Fig.1.

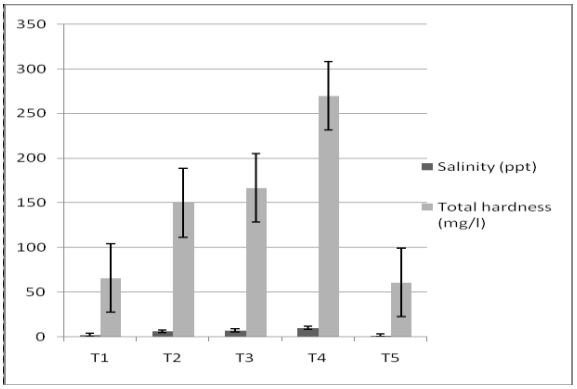


**Fig. 1**. Relation between salinity and hardness

***Dissolved oxygen***

The overall mean values of water temperature were 6.56 ± 0.12, 6.47 ±0.23, 6.34 ± 0.12, 6.19 ± 0.22, and 6.67 ± 0.29 ppm in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively There was no significant difference ($P> 0.05$) among the treatments, when ANOVA was performed. Overall mean of dissolved oxygen in different treatment are shown in Table 1.

The concentration of dissolved oxygen in the present study was similar to the findings of Alam *et al*. (1997), Kohinoor (2000), Ahmed (2004), Ali *et al*. (2004), Fatema (2004) and Asaduzzaman (2005) who recorded dissolved oxygen ranged from 4.0 to 7.0, 2 to 7.04, 3.4 to 8.1, 4.3 to 6.9, 6.10 to 6.35, 5.75 to 5.81 and 1.2 to 7.2 mg $l^{-1}$, respectively. The concentrations of dissolve oxygen in the experimental ponds were more or less similar to the study of the Hasan (1998), Paul (1998) and Mollah and Haque (1978). The mean values of DO of the present study

were more or less similar to the study of the Kohinoor *et al.* (1998). Hoq *et al.* (1996) recorded DO ranging from 4.0 to 5.9 $mgl^{-1}$ in five prawn farmers ponds, which were suitable for fish culture. Wahab *et al.* (1995) recorded DO ranging from 2.0 to 7.2 mg/l during their experiment from the ponds of BAU campus. Dewan *et al.* (1991) recorded DO ranging from 2.2 to 8.8 mg/l, in ponds of BAU campus, Mymensingh.

***pH***

pH values were found to fluctuate from 6.72 to 7.64, 6.48 to 7.13, 6.95 to 7.35 and 6.86 to 7.6 in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ (Table 1). The pH value recorded from the River agreed with the findings of Ahmed (2004), Ali *et al.* (2004), Fatema (2004), Asaduzzaman (2005) and Asaduzzaman *et al.* (2006a) who found the ranges of pH from 6.3 to 8.9, 7.55 to 7.84, 7.05 to 7.72 and 7.51 to 7.91, respectively. According to Swingle (1957) pH value ranging from 6.5 to 9.5 was suitable for pond fish culture. The values of the Swingle study more or less agreed with the values of present study. Paul (1998) also recorded pH value ranging from 6.51-9.45. In the present study, pH values varied from 7.26 to 7.79, which was more or less similar to the findings of Akiyama *et al.* (1982), Dewan *et al.* (1991), Azim *et al.* (1995), Wahab *et al.* (1995) and Kohinoor *et al.* (1998). These values were also within the suitable range for fish culture. There was no significant difference (P> 0.05) among the treatments when ANOVA was performed.

***Salinity (ppt)***

Mean values of total salinity were 2.17 ±0.12, 6.17 ±0.82, 7.17 ±0.92, 10.17 ±0.1.12 and 1.78 ±0.12 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively (Table 1). There were significant difference (P>0.05) among treatment. Lowest salinity was found in Rupas River and highest salinity was found in Khaprabhanga River due to the distance from sea.

***Total Alkalinity***

Mean values of total alkalinity were 187.5±2.25, 165.5±3.1, 185.5±2.15, 175±2.5 and 180.5±3 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively (Table 1).There was no significant difference (P>0.05) among treatment. Total alkalinity in the present study ranged from 150 mg/l to 200 mg/l, which is more or less similar to the findings of Alam et al. (1997), Ahmed (2004), Asaduzzaman (2005) and Kunda *et al.* (2008b). Therefore, it can be concluded that the total alkalinity was within suitable range for fish.

***Total Hardness***

Total hardness of water was found to range from 58 mg/l to 282 mg/l. Mean values of total hardness were 66.00±6.26, 150.00±.16, 167.00±.23, 270.00±.38 and 61.00±7.26 mg/l in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively. There were significant difference (P> 0.05) among the treatments when ANOVA was performed due to different salinity. The relation between transparency and salinity shown in Fig.2.

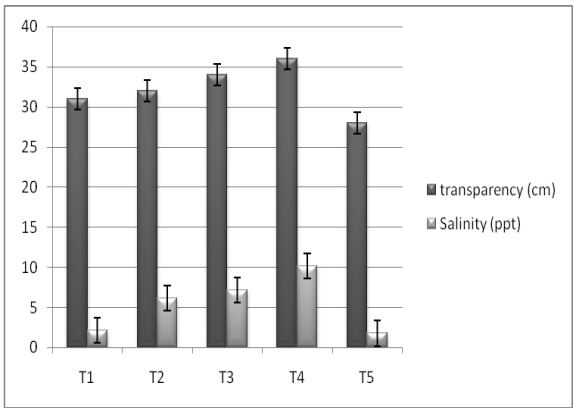


**Fig. 2.** Relation between salinity and transperancy

***Ammonia-nitrogen (mg $l^{-1}$)***

The mean values of $NH_3$-N ($mgl^{-1}$) were found to vary from 0.23 ± 0.03, 0.27 ±0.08, 0.23 ±0.03, 0.25 ±0.03 and 0.57 ± 0.05 $mgl^{-1}$ in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively (Table 1). There was no significant difference (P< 0.05) among four treatments when ANOVA was performed expect Rupsha River. Ammonia concentration of Rupsha River ($T_5$) higher than other four Rivers due to municipal waste product of Khulna city. In the present study, the highest and the lowest concentration of total ammonia were 0.22 and 0.08 $mgl^{-1}$ respectively. There were no significantly different among the treatments when compared using ANOVA (P>0.05). Wahab *et al.* (1995), Azim *et al.* (1995), Wahid *et al.* (1997), Hasan (1998), Ali (1998), Paul (1998) recorded $NH_3$-N of 0.09 to 0.99 mg/l in ponds of BAU campus, Mymensingh, which were more or less similar to the present study. Wahab *et al.* (1996) recorded $NH_4$-N of 0.07 to 0.23 mg which lies within the range of the values obtained in present study. But the ranges of ammonia nitrogen, 0.0 to 0.43 mg/1 and 0.0 to 0.27 mg/1 respectively reported by Wahab *et al.* (1995) and Raihan (2001) were slightly lower than the ranges obtained in the present study. Therefore, the concentrations of ammonia-nitrogen in all Rivers of the present study were more or less within acceptable limits.

***Nitrite (mg l$^{-1}$)***

The mean values of nitrite ($NO_2$) concentration were 0.63 ± 0.06 , 0.68 ±0.08, 0.67±0.09, 0.73±0.03 and 0.95±0.06 mgl$^{-1}$ in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ respectively (Table 1). There was no significant difference (P> 0.05) among four treatments when ANOVA was performed except Rupsha River. Nitrate concentration of Rupsha River ($T_5$) higher than other four Rivers due to municipal waste product of Khulna city. Levels of nitrites greater than natural residual amounts can be acutely toxic to fish. Available information on safety limits of $NO_2$-N is very limited, the suggested maximum level for prolonged exposure in hard freshwater is 0.01 mg l$^{-1}$. Nitrite concentration during the study period recorded was 0 to 0.492 mgl$^{-1}$, which are more or less similar to the findings of Asaduzzaman (2005) who recorded nitrite-nitrogen concentration ranging from 0.006 to 0.031 mg l$^{-1}$, but lower than Asaduzzaman *et al*. (2006a) recorded values ranges from 0.015 to 0.058 mg l$^{-1}$.

***hytoplankton Concentration***

Total phytoplankton concentration found in $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were 59.53±10.70, 55.93±10.10, 54.33±7.44, 49.53±14.70 and 13.9±1.42 (×10$^3$ cells l$^{-1}$) respectively (Table 2). Highest concentration of phytoplankton was found in Rupsha River where the average salinity was 1.78 ppt and lowest phytoplankton concentration was found in Khaprabhanga River salinity where the average salinity was 10.17 ppt.

**Table 2.** Mean abundance ±SE of plankton (×10$^3$ cells l$^{-1}$) as recorded from the ponds under different treatments.

| **Plankton group** | **$T_1$** | **$T_2$** | **$T_3$** | **$T_4$** | **$T_5$** |
|---|---|---|---|---|---|
| Bacillariophyceae | 24.03±10.03 (2.50-161.00) | 17.13±3.95 (3.00-60.50) | 16.37±3.38 (8.00-34.0) | 24.37±3.36 (5.00-32.00) | 15.37±2.38 (6.00-41.00) |
| Chlorophyceae | 17.80±1.59 (4.00-25.50) | 25.06±4.29 (11.00-78.50) | 26.06±4.56 (12.0-79.5) | 18.80±1.89 (5.00-22.50) | 28.06±2.70 (7.00-40.50) |
| Cyanophyceae | 6.80±1.02 (1.00-13.50) | 7.37±2.64 (0.50-42.00) | 8.35±2.54 (5.0-34.00) | 7.93±0.71 (2.00-32.00) | 6.93±0.76 (3.00-11.50) |
| Euglenophyceae | 10.90±1.15 (5.00-19.00) | 6.37±1.33 (2.00-18.50) | 8.37±3.33 (4.00-22) | 11.7±2.52 (4.00-22.43) | 13.9±1.42 (6.50-25.52) |
| Total phytoplankton | 59.53±10.70 (27.5-200.50) | 55.93±10.10 (22.0-184.50) | 49.53±14.70 (25 -160.50) | 54.33±7.44 (24.00-174) | 64.33±4.44 (30.00-190) |

($T_1$=Pira River, $T_2$ = Andarmanik River, $T_3$= Sonatala River, $T_4$= Khaprabhanga River, $T_5$= Rupsaha River)

## Conclusion

Different salinity was found in different River based on the distance from sea. Ammonia and nitrite concentration of Rupsha River higher than other four Rivers due to municipal waste product of Khulna city. A proportionally strong relationship was found among salinity, transparency and hardness. Highest concentration of phytoplankton was found in lowest salinity and lowest phytoplankton concentration was found in highest salinity.

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