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Article

Physicochemical properties and plankton abundance in sanctuary and non sanctuary areas in the river Meghna, Bangladesh

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Abstract: The study was conducted in the selected sampling spots of sanctuary and non-sanctuary areas *viz,* Chor bhoirobi, Kaligonj, Ramgoti, Sureswar, Gajaria and upper area of Tarabunia to assess the impact of sanctuary on the abundance and biodiversity of fishes in the river Meghna from September 2015 to December 2015. Seven physicochemical parameters *viz* water temperature, air temperature, dissolve oxygen (DO), free carbon dioxide (Free CO_2), pH, total alkalinity and total hardness, plankton community both phytoplankton and Zooplankton and CPUE with species composition of the river Meghna were studied. In the sanctuary area, Air temperature was found lowest 22.0°C ±1.1 in Ramgoti and highest 33.5°C±0.5 in Chor bhoirobi area of the river Meghna. Water temperature was found ranged from 20.8°C ±0.5 to 32.5°C ±0.2 in Kaligonj. Concentration of dissolve oxygen was found lowest 4.9± 0.1 mg/l in Ramgoti and highest in Chor bhoirobi 6.0±0.2 mg/l. Free carbon di oxide was found highest in Ramgoti 19±0.8 mg/l and lowest in Chor bhoirobi 13.4±0.4 mg/l. P^H was found ranged from 7.2±0.6 in Kaligonj to 7.9±0.2 in Chor bhoirobi. Total alkalinity was found highest in Ramgoti 85±11.2 mg/l and lowest in Chor bhoirobi 72.7±4.7 mg/l. Total hardness was found highest in Ramgoti 150.0±45.1 mg/l and lowest in Kaligonj 52.0±12.7 mg/l. In the non sanctuary area, Air temperature was found ranged from 21.10°C ±1.0 to 33.2°C±0.8 in Gajaria and area of the river Meghna. Water temperature was found lowest 17.8°C ±1.3 in Gajaria and highest 31.2°C ±0.6 in Upper Tarabunia. Concentration of dissolve oxygen was found lowest 5.0± 0.3 mg/l in Gajaria and highest in Upper Tarabunia 5.9±0.1 mg/l. Free carbon di oxide was found highest in Gajaria 19.7±1.5 mg/l and lowest in Sureswar 16.2±0.7 mg/l. P^H was found ranged from 7.3±0.6 in Sureswar to 7.9±0.2 in Gajaria. Total alkalinity was found ranged from 89.3±25 mg/l to 72.5±11.5 mg/l in Sureswar. Total hardness was found highest in Gajaria 89.2±14.9 mg/l and lowest in Sureswar 62.0±26.3 mg/l. Total 40 genera of phytoplankton belongs to Bacillariophyceae Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, Myxophyceae and Xanthophyceae were recorded. Total 9 genera of zooplanktons were found with four families namely Rotifera, Cladocera, Copepoda and Ostracoda. Total 56 boats were estimated to be fishing for hilsa between sanctuary and non sanctuary areas of Bangladesh during September to December. Total length of the boats varied between 6.7 and 16.5 m with an average of 13 m.

Keywords: assessment; impact; sanctuary; abundance; the Meghna river; Bangladesh

1. Introduction

The hilsa shad, *Tenualosa ilisha* (Hamilton, 1822) is an important migratory species in the indo-pak subcontinent and the Persian Gulf region, especially in Bangladesh and India. Hilsa is one of the important and biggest fisheries resources for Bangladesh. About 11% of the countries fish production comes from hilsa. More than 2% people of our country directly or indirectly are related with the hilsa fishery and it is the main source of their livelihood. Economic contribution of this single species is very high in an agricultural based country like Bangladesh. In previous years hilsa played a significant role for the development of economic background of

Bangladesh. More or less 2 million fishermen are related with the hilsa fishery. It has a great lifecycle that follows the general pattern of breeding upstream in freshwater. The fish hilsa is anadromous with a life cycle that follows the general pattern of breeding upstream in fresh water and the larvae hatching from the free-floating eggs. The immature young stages grow in river channels and then descend to the sea for a period of feeding and growth before returning to the rivers as mature breeding adults to complete the cycle. The fish is a highly fecund fish. A large-sized female may produce up to 2 million eggs. Although its spawn more or less throughout the year, they have a minor spawning season during February-March and a major season in September-October. Immature hilsa fish (6-10 cm) known as *jatka* are extensively caught during their seaward migration in some of the major rivers of the country (National Encyclopedia of Bangladesh). During the commencement of the south-west monsoon and consequent flooding of all the rivers. It starts its spawning migration upstream. A mature Hilsa shad with a length ranging from 30-55 cm lays 0.1-2.0 million eggs, the eggs are deposited in fresh water and hatching takes place in about 23 to 26 hours at an average temperature of 23ºC. During maturation it decreases its food intake and ceases feeding for the duration of spawning migration. After growing for 1-2 years in sea, hilsa fish matures and reaches a size of 32-55 cm prior to their spawning migration towards inland rivers and the cycle continues. Hilsa is primarily a plankton feeder and its food includes blue-green algae, diatoms, desmids, copepods, cladocera, rotifers etc. The feeding habit may vary according to the season and age of the fish. The highest length of hilsa is 60 cm but commonly found 35-40 cm. A large size hilsa fish weight is 2.5 kg. The growth rate of female hilsa is faster than the male. They are known as fast swimmer and can cover 60 Km at a time. Mainly the breeding season of hilsa fish is September to October. It is known as major breeding season and the minor breeding season is February to March. Although, hilsa spawn is more of less throughout the year.

The hilsa fishery in Bangladesh has been suffered by a combination of factors *viz.* serious recruitment over-fishing (indiscriminate harvest of gravid fishes) and growth over-fishing (indiscriminate catching of *jatka*). In these circumstances, considering the importance of hilsa in nutrition, employment and economy, the Hilsa Fishery Management Action Plan (HFMAP) was prepared for the development, management and conservation of hilsa incorporating the objectives of protection of nursery and breeding grounds and banning capture of hilsa indiscriminately. It has been identified that the highest number of ripe and running hilsa are being caught indiscriminately during five days before and nine days after the full moon including the full moon day altogether of September-October every year during their peak spawning time and thus their recruitment was being hampered. Hence, fishing ban is required for certain time specification for their successful breeding. In the above context, Government has enacted a new rule under the Protection and Conservation of Fish Act, 1950 banning the hilsa catch during this period for successful spawning. For the impact assessment of sanctuary and non sanctuary areas, physicochemical parameters, phytoplankton and zooplankton concentration of water were collected for the comparative study.

2. Materials and Methods

2.1. Study site

Present study was conducted in the selected sampling spots of the sanctuary and non sanctuary area of the river Meghna *viz*, Chor bhoirobi, Kaligonj, Ramgoti, Sureswar, Gajaria and upper area of Tarabunia. Modernized vessel and speed boat were utilized for sampling and data collection from inside and outside of the sanctuary. Major spawning grounds of hilsa and related areas near the sanctuary areas were visited for comprehensive study.

2.2. Sample collection

The water samples were collected monthly during day time from the selected sampling spots (Table1). Water samples were collected from Surface water samples were collected from 15-30 cm below the river water surface and at distances of 40-80 cm from the bank of the river in labeled sample bottles that were washed with conc. HNO_3 and rinsed repeatedly with distilled water. Before sample collection, sample bottles were rinsed three times also with the river water. Plankton samples were collected from each sampling sites normally at early morning by standard drop count method (APHA, 1995) during the study period. For plankton study 10 liters of water sample from each sampling stations was collected in plastic containers. Then the concentrated plankton samples were preserved in plastic vials with 5% formalin for subsequent studies in the laboratory of Riverine station. Replicate plankton samples were collected by means of a bucket (50litre) and filtered through bolting silk plankton net of 50µ. The filtrate were transferred to 100ml plastic bottle and preserved immediately in 1:100 Lugol's solution. Counting and identification were done as per Ward and Whipple (1959) and Presecot (1962).

2.3. Study of water quality parameters

Different physical and chemical parameters of the studied sampling stations were investigated during this study (Figure 1).

2.3.1. Physical parameters

Emphases were given on two important physical factors- air temperature and water temperature during the present study.

2.3.1.1. Air and water temperature

A centigrade thermometer within the range of 0°C to 120°C was used to record the air and water temperature. The water temperatures of each sampling stations were recorded at three depths (surface layer, mid layer and ground layer) by dipping the thermometer into the water. Three replications of each reading were taken and finally average value was recorded as water temperature.

2.3.2. Chemical parameters

During the present study, five key chemical factors namely dissolved oxygen (DO), free carbon dioxide (CO_2), hydrogen ion concentration (pH), total alkalinity and total hardness were studied in each sampling stations. Chemical parameters of sanctuary and non sanctuary areas were done by HACH water test kit (Model FF2, USA) and APHA (1995) method was followed for this work.

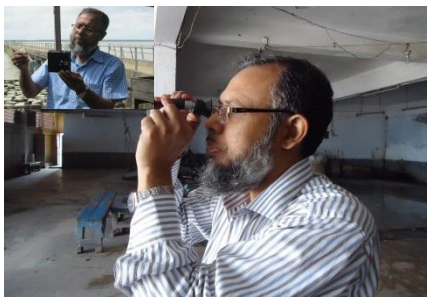

Figure 1. Monitoring of water quality parameters during the study period.

2.4. Microscopic investigation

For the qualitative and quantitative study of plankton 1 ml of the concentrated plankton sample was taken by a dropper and then put on the S-R (Sedgwick-Rafter) counting cell. The S-R cell is a special type of slide having a counting chamber of 55 mm in length, 20 mm in wide and 1 mm depth. The volume of chamber is 1 ml. 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 for plankton identification and counting.

2.4.1. Qualitative and quantitative study of plankton

Collection of plankton was made by sieving 50 liters of habitat water from approximately 10 - 12 cm below the surface level passed through a 25 μm mesh net and finally concentrated to 25 ml. The population of plankton accumulated in the container were then transferred to other bottle and immediately preserved in 4% formalin, labeled and then transferred to laboratory for further experimentation. Each sample was stirred smoothly just before microscope examination. One ml from agitated sample was transfer to a Sedge-wick Rafter counting cell with a wide mouth graduated pipette. The abundance of plankton was estimated by counting their presence per focus of the microscopic field (Figure 2). Plankton was identified by several workers. Identification of plankton (phytoplankton and zooplankton) up to generic level was made according to Prescott (1964). Number of plankton in the S-R cell was derived from the following formula:

$$\text{Number of species/Liter} = \frac{C \times 1000\ mm^3}{L \times D \times W \times S}$$

Where,
C = Number of organisms counted
L= Length of each stripe (S-R cell length) in mm
D = Depth of each stripe in mm
W = Width of each stripe in mm
S = Number of stripe

Figure 2. Qualitative and quantitative assessment of plankton during the study period.

2.5. Data analysis

MS Excel 2010 version was used to the analysis of data obtained which include descriptive analyses. Likewise correlation was also utilized in the case of testing for any significant correlation between the variables.

3. Results

The physicochemical parameters (Mean±SD) values obtained from the selected sampling sites of the river Meghna were given in Table1 and Table 2.

3.1. Physical parameters

3.1.1. Air and water temperature

In the sanctuary area, Air temperature was found lowest 22.0°C ±1.1 in Ramgoti and highest 33.5°C±0.5 in Chor bhoirobi area of the river Meghna. Water temperature was found ranged from 20.8°C ±0.5 to 32.5°C ±0.2 in Kaligonj (Table 1). In the non sanctuary area, Air temperature was found ranged from 21.10°C ±1.0 to 33.2°C ±0.8 in Gajaria and area of the river Meghna. Water temperature was found lowest 17.8°C ±1.3 in Gajaria and highest 31.2°C ±0.6 in Upper Tarabunia.

3.2. Chemical parameters

3.2.1. Dissolved oxygen (DO)

In the sanctuary area, Concentration of dissolve oxygen was found lowest 4.9±0.1 mg/l in Ramgoti and highest in Chor bhoirobi 6.0±0.2 mg/l. In the non sanctuary area, Concentration of dissolve oxygen was found lowest 5.0± 0.3 mg/l in Gajaria and highest in Upper Tarabunia 5.9±0.1 mg/l.

3.2.2. Free carbon dioxide (CO_2)

In the sanctuary area, free carbon di oxide was found highest in Ramgoti 19±0.8 mg/l and lowest in Chor bhoirobi 13.4±0.4 mg/l. In the non sanctuary area, free carbon di oxide was found highest in Gajaria 19.7±1.5 mg/l and lowest in Sureswar 16.2±0.7 mg/l.

3.2.3. Hydrogen ion concentration (pH)

In the sanctuary area, P^H was found ranged from 7.2±0.6 in Kaligonj to 7.9±0.2 in Chor bhoirobi. In the non sanctuary area, P^H was found ranged from 7.3±0.6 in Sureswar to 7.9±0.2 in Gajaria.

3.2.4. Total alkalinity

In the sanctuary area, total alkalinity was highest in Ramgoti area 85.0±11.2 mg/l and lowest in Chor bhoirobi 72.5±4.5 mg/l. In the non sanctuary area, total alkalinity was highest in Sureswar 89.3±25.0 mg/l in the month of December and lowest in Sureswar 72.5±11.5 mg/l in the month of October.

3.2.5. Total hardness

In the sanctuary area, total hardness was highest in Ramgoti 150.0±45.1 mg/l in the month of December and lowest in Kaligonj 52.0±12.7 mg/l in the month of September. In the non sanctuary area, total hardness was highest in Gajaria 89.2±14.9 mg/l in the month of October and lowest in Sureswar 58.0±27.2 mg/l in the month of September.

Table 1. Water quality parameters of three selected sampling spots of sanctuary area (Gazaria, Sureswar and Upper Tarabunia) in the river Meghna.

Sampling spots	Month/15	Parameters (Mean±SD)						
		Air temp (°c)	Water temp (°c)	Dissolve Oxygen (mg/l)	Free carbon di oxide (mg/l)	P^H	Total alkalinity (mg/l)	Total hardness (mg/l)
Chor bhoirobi	September	33.5±0.5	31.5±1.3	5.6±0.2	15.5±0.6	7.7±0.3	72.5±4.5	96.0±17.2
	October	33.3±0.7	30.7±1.1	6±0.2	13.4±0.5	7.3±1.2	78±5.3	90.0±8.9
	November	29.8±1.1	28.2±1.3	5.5±0.5	14.3±1.2	7.9±0.2	79.7±5.0	70.3±1.5
	December	23.5±0.5	22.5±1.3	5.6±0.2	15.5±0.6	7.7±0.3	72.7±4.7	98.0±33.2
Kaligonj	September	31.8±0.2	29.9±1.1	5.0±0.1	18.5±0.5	7.2±0.6	78.2±18.3	52.0±12.7
	October	33.0±0.7	32.5±0.2	5.6±0.2	17.4±1.1	7.5±0.3	73.6±12.2	61.0±11.2
	November	30.5±0.5	29.0±1.0	5.6±0.1	17.2±0.8	7.6±0.2	80.0±7.9	72.0±18.2
	December	22.2±0.7	20.8±0.5	5.2±0.2	18.6±1.2	7.5±1.1	79.3±5.0	112.0±43.1
Ramgoti	September	32.0±0.4	31.3±0.3	5.1±0.3	18.1±2.1	7.8±0.8	73.1±13.5	95.0±17.2
	October	33.4±0.5	32.2±0.2	5.5±0.2	17.4±1.4	7.6±0.5	85.0±11.2	70.0±27.4
	November	30.8±0.3	29.0±0.9	4.9±0.1	19.0±0.8	7.3±0.2	75.0±7.8	105.0±55.2
	December	22.0±1.1	21.5±0.4	5.0±0.4	18.6±0.5	7.7±0.6	74.4±23.4	150.0±45.1

Table 2. Water quality parameters of three selected sampling spots of non-sanctuary area (Gazaria, Sureswar and Upper Tarabunia) in the river Meghna.

Sampling spots	Month/15	Parameters (Mean±SD)						
		Air temp (°c)	Water temp (°c)	Dissolve Oxygen (mg/l)	Free carbon di oxide (mg/l)	P^H	Total alkalinity (mg/l)	Total hardness (mg/l)
Gazaria	September	32.4±0.3	30.2±0.8	5.0±0.3	19.7±1.5	7.9±0.2	77.0±5.3	73.7±16.3
	October	33.2±0.8	31.2±1.0	5.7±0.4	17.7±3.8	7.7±0.3	83.7±14.0	89.2±14.9
	November	30.7±0.6	29.8±0.3	5.6±0.3	16.8±2.4	7.5±0.5	74.0±5.3	82.0±16.7
	December	21.1±1.0	17.8±1.3	5.1±0.5	16.5±1.3	7.8±0.4	78.2±6.8	80.3±21.4
Sureswar	September	30.8±0.6	29.9±1.1	5.5±0.6	18.5±0.4	7.3±0.6	76.3±16.3	58.0±27.2
	October	32.0±0.6	31.5±0.9	5.8±0.4	17.4±1.2	7.6±0.2	72.5±11.5	62.0±26.3
	November	29.5±0.7	28.9±1.2	5.7±0.1	16.2±0.7	7.7±0.3	82.2±17.9	70.0±19.5
	December	22.1±0.7	21.5±0.8	5.2±0.2	19.6±1.2	7.5±1.0	89.3±25.0	75.0±18.3
Upper Tarabunia	September	32.5±0.6	31.2±0.6	5.1±0.5	18.4±2.0	7.7±0.9	76.1±23.4	60.0±17.4
	October	32.4±0.9	31.1±0.6	5.2±0.3	17.3±1.6	7.8±0.1	84.0±31.4	66.0±18.0
	November	29.8±0.3	28.0±0.9	5.9±0.1	18.1±0.7	7.4±0.4	80.2±21.8	72.0±26.1
	December	22.0±1.1	21.7±0.4	5.6±0.4	18.4±0.9	7.6±0.5	74.4±27.1	80.0±25.2

3.3. Plankton composition of sanctuary and non sanctuary areas

During the study period, from sanctuary and non sanctuary areas total 40 genera of phytoplankton belongs to Bacillariophyceae Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, Myxophyceae and Xanthophyceae were recorded. In the river Meghna, phytoplanktons were dominated largely over zooplanktons. The mean contribution of phytoplankton was about 91.5% of the total planktonic organisms and zooplankton contributed the rest. Higher phytoplankton concentrations in water normally indicate higher productivity. During the present investigation, from sanctuary and non sanctuary areas total 9 genera of zooplanktons were found with four families namely Rotifera, Cladocera, Copepoda and Ostracoda from the selected sampling spots. Zooplankton was found 8% in the total planktonic organisms. Creating factors such as light intensity, food availability, dissolved oxygen and predation affect the population dynamics of zooplankton. In this study, the zooplankton diversity was recorded in the following order; Rotifera>Copepoda>Cladocera>Ostracoda.

4. Discussion

The primary productivity of a water body depends on its physical, chemical and other environmental factors (Rahman, 1992). Appropriate water quality parameters are preconditions for a healthy aquatic environment and for the optimum production of plankton. Present study revealed that the water temperature recorded in both sanctuary and non sanctuary areas were within the suitable range of 26.06°-31.97°C (Boyd, 1982) for the survival of fish during the study period. Nonetheless, the downfall of water temperature can be attributed to the

commencement of winter season in the country. Furthermore, pH is a key factor in the aquatic environment for plankton production and fish culture. The pH value of water in all the areas during the study period was mostly found to be within the suitable range of 6.5 to 9.0 (DoF, 2005) for fish growth. However, the slight fluctuation in pH values might be due to fluctuation of water level and/or differences in soil type. Moreover, dissolved oxygen (DO) is indispensable for the metabolism of all aquatic organisms that possesses aerobic respiratory biochemistry (Wetzel, 1983). Though there were significant differences in the DO among the studied areas, dissolved oxygen in all the water bodies were suitable for supporting optimal fish growth (DoF, 1998). Additionally, the free CO_2 in all the studied water bodies were below 12.0 mg/l which is essential for supporting optimum fish growth (DoF, 1998). These differences in free CO_2 might be owing to several factors including respiration, decomposition and photosynthesis (Wetzel, 1983). Furthermore, alkalinity is a measure of the ability of a solution to neutralize acids to the equivalence point of carbonate or bicarbonate. The alkalinity of water depends on the carbonate and bicarbonate ions solely and to lesser degree with magnesium, sodium and potassium. Some amount of them is used by phytoplankton as carbon source (Ahmad and Singh, 1993). Waters with low values of alkalinity are generally biologically less productive than those with high values. Shafi *et al*. (1978) reported that higher percentage of phytoplankton 76.0 to 93.6% from the same ecosystem. Sundar *et al.* (1995) also reported that the major contribution of phytoplankton (> 97.0%) and lower concentration of zooplankton 0.13 to 2.4% at three stations in the Guala river of Uttar Pradesh, India. Shafi *et al.* (1978) and Sundar *et al*. (1995) reported the almost same observation in their investigations. Ahmed *et al.* (2003) also found that zooplankton contributed more than 3% in the total planktonic organisms.

5. Conclusions

Results leads to a clear cut picture that there is an immediate need of restoration, improvement and proper management of these secret water bodies both the sanctuary and non sanctuary areas for the human and environment. It is important to develop a plan of action to be taken when a water quality measurement approaches being outside the desirable range and stressful concentrations. This is why monitoring regularly and recording data is important it will aid in anticipation of needed action.

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Conflict of interest

None to declare.

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