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Limnological aspects of a riverine water body: a case study of Dhepa River in Bangladesh

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Abstract

The limnological study is prerequisite for the sustainability of any aquatic environment. The aim of the study was to know the physico-chemical parameters and qualitative, quantitative abundance of plankton. Dhepa River was selected for the purpose of the study. Fortnightly data were collected from three sampling sites from May to December 2014. Nine physico-chemical parameters were measured following standard methods. Plankton was collected through filtration technique. A total of 52 plankton were identified which belongs to five phytoplankton and three zooplankton groups. Chlorophyceae and Rotifera were the dominant groups in all phytoplankton and zooplankton groups, respectively. The physico-chemical parameters were within the suitable and productive ranges. So, government of Bangladesh should take different management approaches to keep the riverine ecosystem pollution free and sustainable for capture fisheries.

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Introduction

Insufficient limnological knowledge creates confusions and controversies for proper management and conservation of a waterbody. In order to have a proper management and best possible use of sufficient data, limnological aspects are needed. It involves the assessment of physico-chemical parameters of water bodies. Moreover, phytoplankton represent biological wealth of a water body and are the base of food chains and food webs which directly provide food for zooplankton, fishes and some aquatic animals (Millman *et al.*, 2005; Sukumaran *et al.*, 2008).

They also produce organic carbon in large rivers and act as primary oxygen source in low-gradient rivers (Davies *et al.*, 2009). On the other hand, zooplankton as a biotic component of the aquatic ecosystems play a fundamental role in cycling of organic materials, helping in regulating algal and microbial productivity through grazing, as suspension feeders and predators in the transfer of primary productivity to fish and other consumers (Dejen *et al.,* 2004). They often exhibit dramatic changes in response to the changes in the physico-chemical and biotic properties of the center point aquatic environment. Hence both phytoplankton and zooplankton are good bio indicators for the assessment of trophic state of water (Vilela *et al.*, 2003; Paturej and Gozdziejewska, 2005; Imoobe and Adeyinka, 2010).

For the sustainable production of rivers it is important to know the limnology of a water body. So the aim of the study was to investigate physico-chemical parameters, qualitative and quantitative abundance of plankton.

Materials and methods

The study was conducted in a riverine ecosystem. For the purpose of the research a tributary of Atrai River named the Dhepa River of the northwest part of Bangladesh, was selected.

It originated from Artai River near Mohanpur and debouched into Punarvaba River in Dinajpur district. Three sampling sites were selected with in latitudes 25°38'N and 25°53'N and longitudes 88°37'E and 88°43'E for the purpose of the study (Fig. 1).

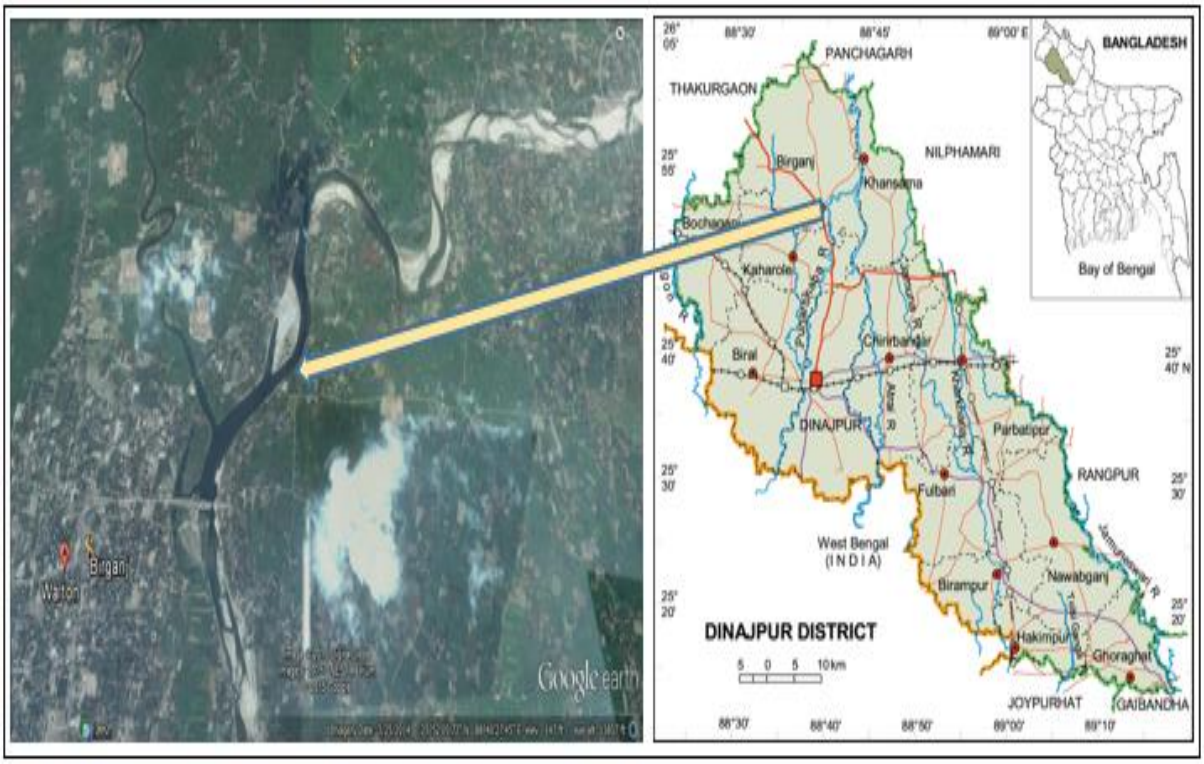

Fig. 1. Satellite image and location of the study area (Source: Google Earth).

Samples were collected from sub-surface zone with three horizontal replicates. Duration of the study was eight month, from May 2014 to December 2014.

Among different physico-chemical parameter water level, water temperature, transparency, pH, dissolved oxygen were measured in the field using measuring scale, digital thermometer, secchi disk, pH meter (HANNA instrument, model: HI-8140), dissolved oxygen meter (YK-22DO), respectively.

To determine phosphate-phosphorus, total hardness, total alkalinity and chlorophyll-a water samples were collected from the respective sites and kept in separate bottle with proper leveling. Water samples were bought to the laboratory of Department of Fisheries Management in Hajee Mohammad Danesh Science and Technology University, Dinajpur. Phosphate-phosphorous was measured with a HACH kit (PO-19).

Total hardness and total alkalinity were determined by trimetric method using HANNA instruments, model: HI-8140, using 0.02 N sulfuric acid and methyl-orange indicator (APHA, 1992), respectively.

Chlorophyll-a was calculated following Vollenweider's equation from Boyd, 1979.

Chlorophyll*a* (µg/L)= $(11.9\times(A_{664}- B_{750})\times V\times 1000)/L\times S$

Where, A_{664}= the absorbance at 664 nm, B_{750}= the absorbance at 750 nm, V= the acetone extract in ml, L= the length of cell in cm^2, S= the volume in ml of sample filtered.

Plankton samples were collected by filtration technique using 25 µm mesh sized plankton net. Highest possible taxonomic identification of plankton was carried out with the help of text book of Barber and Haworth (1981), Bellinger (1992), Pontin (1978), Lind and Brook (1980) and website (Algae Base) with magnification of 10 ×0.25 under the binocular microscope.

Then abundance was calculated using the following formula (Stirling,1985).Number of plankton, $N=\frac{A\times C}{F\times V\times L}\times 1000$

Where, N= No. of plankton cells per liter, A= Total no. of plankton counted, C= Volume of final concentrate of samples in ml, V= Volume of a field in cubic millimeter, F= Number of the fields counted, L= Volume of original water in liter.

An analysis of variance (One Way ANOVA) and Tukey's test was applied for determining significant variation at 5% level of significance among the sampling sites by IBM SPSS Statistics, version 20.0.

Results

Physico-chemical parameters

Water temperature was found to vary 16.20 to 34.80 ^oC, where lower water temperature was found in site1 and highest temperature in site 3 (Table 1).

Fluctuation of water level was ranging from 0.32 to 2.23 m with mean value of 1.12±0.49, 1.17±0.53, 1.13±0.52 m in site 1, 2 and 3 respectively.

Water transparency remains more or less similar among three sites. Mean value of dissolved oxygen was 6.72±1.22, 6.68±1.24 and 6.60±1.30 in site 1, 2 and 3 respectively. The value of pH of Dhepa River remain in the within the range of 6.5 to 8.20.

The total alkalinity value ranged of the Dhepa River ranged 16.00 to 48.00 mg/L. Phosphate-phosphorus concentration were found more than 0.65 mg/L in all site of studied river. Hardness ranged from 60.00 to 120 mg/L. Mean chlorophyll-a concentration were 34.82 µg/L, 31.66 µg/L and 28.76 µg/L in three sampling sites, respectively.

Wide variation of chlorophyll-a concentration was found within the respective sites. On the other hand, significant variation (P>0.05) of physico-chemical parameters among three sampling sites were not observed.

Plankton groups

A total of 52 planktons were identified throughout the study period in the Dhepa River, are shown in Table 2. Out of 39 phytoplankton genus 16 belongs to Chlorophyceae, 7 to Charophyceae, 8 to Bacillariophyceae, 6 to Cyannophyceae and only 2 genusto Euglenophyceae. Of the rest plankton 8 belonged to Rotifera, 3 to Cladocera and 2 to Copepoda. In addition nauplius was identified throughout the study period.

Table 1. Mean values (±SD), ranges and comparison of physico-chemical parameters in three sampling sites of the study river.

Parameters	Sampling seasons			ANOVA Significance	Suitable range	Reference
	Site 1	Site 2	Site 3			
Water Temperature (^{0}C)	26.96±5.72 (16.20-33.60)	27.07±5.76 (16.30-34.00)	27.29±5.93 (16.22-34.80)	NS	25-32	Boyd, 1998
Water level (m)	1.12±4.9 (0.39-2.14)	1.17±0.53 (0.37-2.23)	1.13±0.52 (0.32-2.23)	NS	-	-
Transparency (cm)	32.07±5.36 (22.10-38.25)	32.02±5.18 (22.75-38.12)	31.84±5.07 (22.65-38.10)	NS	30-35	Boyd, 1998
Dissolved Oxygen (mg/L)	6.72±1.22 (5.20-8.95)	6.68±1.24 (5.14-8.88)	6.60±1.30 (4.80-8.87)	NS	>5	Boyd, 1998
pH	7.69±0.72 (6.45-8.95)	7.48±0.85 (6.45-8.96)	7.49±0.87 (6.34-8.96)	NS	6-9	Boyd, 1998
Alkalinity (mg/L)	84.68±21.00 (18.00-48.00)	85.06±21.14 (16.00-46.00)	85.06±21.56 (16.00-48.00)	NS	>20	Boyd, 1998
PO_4-P (mg/L)	0.68±0.12 (0.48-0.88)	0.69±0.11 (0.48-0.88)	0.67±0.11 (0.48-0.88)	NS	0.5-0.7	Bhatnagar, 2004
Hardness (mg/L)	84.67±21.00 (60.00-120.00)	85.06±21.14 (60-120)	85.06±21.56 (60.00-120.00)	NS	>20	Boyd, 1998
Chlorophyll-a (µg/L)	34.82±24.23 (8.33-77.33)	31.66±24.29 (5.95-75.82)	28.76±22.08 (5.95-77.35)	NS	-	-

NS= Mean values are not significantly different (P>0.05).

Among the phytoplankton groups Chlorophyceae was the dominant group in terms of number of genus and abundance. Range of Chlorophyceae cell counts was 0.38 to 8.74×10^3 cells/L. The least dominant group was Charophyceae followed by Euglenophyceae. Among the zooplankton group Rotifera was ranked first dominate group.

Table 2. List of plankton recorder from three sampling sites of Dhepa River during the study period.

Phytoplankton				Zooplankton	
Euglenophyceae	*Euglena*	Chlorophyceae	*Actinastrum*	Rotifera	*Asplanchna*
	Phacus		*Botyococcus*		*Brachionus*
Cyanophyceae	*Anabaena*		*Ceratium*		*Flinia*
	Cosmariums		*Chlorella*		*Keratella*
	Merismopedia		*Gymnodinium*		*Lecane*
	Microcystis		*Microspora*		*Monostyla*
	Nostoc		*Pediastrum*		*Notholca*
	Gloeocapsa		*Plankstosporia*		*Trichocerca*
Bacillariophyceae	*Asterionella*		*Scenedesmus*	Cladocera	*Bosmina*
	Epithemia		*Selenestrum*		*Daphnia*
	Fragillaria		*Spaerocystis*		*Diaphanosoma*

	Melocira	*Sticococcus*	Copepoda	*Cyclops*
	Navicula	*Tetraedon*		*Diaptomus*
	Surirella	*Treubaria*	Crustacean larvae	Nauplius
	Synedra	*Ulotrix*		
	Tabellaria	*Volvox*		
Charophyceae	*Arthrodesmus*			
	Closterium			
	Euastrum			
	Micrasteria			
	Sphaerozosma			
	Spirogyra			
	Zygnema			

The mean abundance of Rotifera was ranged from 1.19±0.75×10³ cells/L to 1.28 0.94×10³ cells/L among the sites. The mean abundance of planktons of all groups did not vary significantly ($p>0.05$). While only significant variation ($p<0.05$) was observed in Cyanophycea, where site1 varied with site 3 and mean abundance was 3.01±2.58×10³ cells/L. The abundance of total plankton were ranged from 5.89×10³ cells/L to 32.33×10³ cells/L. The total abundance of phytoplankton was comparatively higher to zooplankton (Table 3, Fig. 2).

Table 3. Mean values (±SD), ranges and comparison of physico-chemical parameters in three sampling sites of the study river.

Parameters	Sampling seasons			ANOVA Significance
	Site 1	Site 2	Site 3	
Euglenophyceae	0.57±0.07 (0.00-2.28)	0.60±0.51 (0.00-2.04)	0.64±0.55 (0.00-2.34)	NS
Cyanophyceae	3.01^{a}±1.20 (1.52-9.54)	2.71^{ab}±1.13 (0.93-5.85)	2.93^{b}±1.19 (0.64-7.56)	*
Bacillariophyceae	5.27±2.58 (1.68-11.66)	5.08±2.68 (1.28-12.47)	5.08±2.53 (1.74-12.16)	NS
Charophyceae	1.19±0.85 (0.00-3.76)	1.01±0.72 (0.00-2.80)	1.18±0.88 (0.00-3.40)	NS
Chlorophyceae	3.35±1.95 (0.38-8.74)	3.03±1.64 (0.58-6.84)	3.04±1.65 (0.64-8.40)	NS
Copepoda	0.59±0.57 (0.00-3.42)	0.58±0.50 (0.00-2.58)	0.53±0.41 (0.00-1.50)	NS
Cladocera	0.31±0.25 (0.00-1.41)	0.33±0.22 (0.00-1.92)	0.29±0.21 (0.00-1.12)	NS
Rotifera	1.19±0.75 (0.00-3.60)	1.28±0.94 (0.00-3.42)	1.28±0.94 (0.00-3.92)	NS
Nauplius larvae	0.81±0.60 (0.00-2.40)	0.85±0.54 (0.00-2.20)	0.76±0.50 (0.00-2.38)	NS
Total phytoplankton	13.38±5.05 (6.46-30.74)	12.56±5.18 (4.96-23.22)	12.37±5.13 (4.40-24.32)	NS
Total zooplankton	2.90±1.17 (0.93-7.60)	3.06±1.79 (0.31-6.84)	2.85±1.62 (0.58-7.28)	NS
Total plankton	16.27±5.21 (7.98-32.33)	15.61±6.08 (5.89-27.73)	15.22±5.95 (27.73-27.36)	NS

NS= Mean values are not significantly different ($P>0.05$)

*Mean values with different superscript letters in the same row indicate significant difference at 5% level based on one way ANOVA followed by Tukey's test.

Discussion

The present study describes the qualitative and quantitative abundance of plankton and with some other physico-chemical parameters. The suitability of parameters are pre requisite for a healthy aquatic environment and for the production of sufficient fish food organisms as well as primary productivity (Rahman, 1992).

Water temperature, the most important physico-chemical parameters, influences aquatic ecology (Huet, 1986). The observed temperature variations were 16.20°C to 34.80°C, which is within the optimal ranges (18.3-37.8°C) for production of plankton (Begum *et al.*, 2007; Hossain *et al.*, 2007). Ferdoushi and Rakiba, 2014 also found highest water level in the same river as 5.67 ft (1.75 m), which was may be due to closing of the sluice gate.

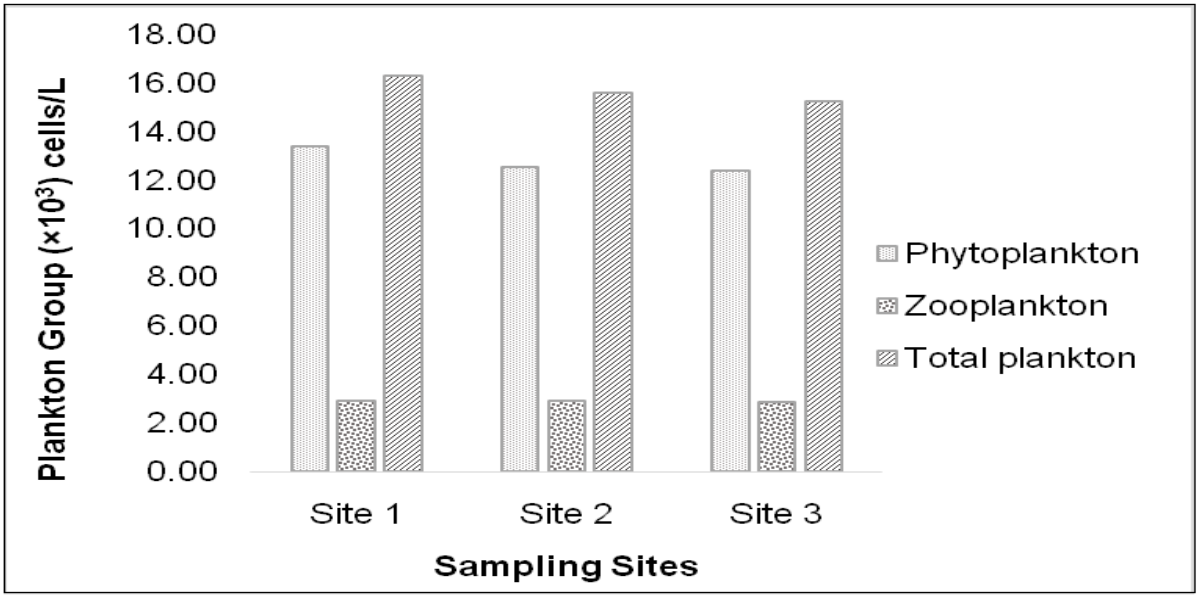

Fig. 2. Comparative abundance of plankton groups among three sampling sites.

In the present study the range of transparency was 22.10 cm to 38.95 cm. Rahman, 1992 reported that the transparency of a productive water body should be 40 cm or less which is similar to this research. The observed dissolved oxygen of the present study was varied from 4.85 to 8.84 mg/L, which agree with the finding of Karna fully River by Khandakar, 1986. Begum and Khanam, 2009 observed 6.6-8.0 pH in Shitalakhya River water of Bangladesh which is also similar to the present study. Moyle, 1946 recorded total alkalinity ranged from 0.00-20.00 mg/L was low and 40.00-90.00 mg/L were medium to high production. Alkalinity of the study area indicates medium to high productivity. Dissolve phosphorus is probably important factor affecting water quality, because it is needed for phytoplankton growth (Boyd, 1982; Hossain *et al.,* 2007). Fluctuation of PO_4-P ranges from 0.48 to 0.88 mg/L which is similar to Shah *et al.*, 2008, who reported PO_4-P ranged from 0.3 to 0.9 mg/L. Sabbir *et al.*, 2001 found hardness within the range of 36.9 to 217.4 ppm with an average value of 106.7(±17.97). The value of chlorophyll-a in the studied river was close to findings of Khondoker and Abed, 2013.They found chlorophyll-a ranged from 1.84 to 162.8 µg/L.

Mahmud *et al.*, 2007 found Chlorophyceae as the most dominant group among phytoplankton abundance from Mouri river of Khulna. Similar result was observed by Panigrahi and Patra in 2013 at Mahanadi River in India. Ferdoushi and Rakiba, 2014 also found Bacillariophyceae as second dominant group. Shah *et al.*, 2008 observed that Cyanophyceae was the second dominant group in southwest coastal water. Euglenophyceae was the least dominant group in Melen River recorded by Baykal *et al.*, 2009.

Four groups of zooplankton population namely Copepods, Rotifers, Cladocera and Ostracods from the river Meghna were reported by Ahmed *et al*., 2003, which is more or less similar to the finding of present study. Rotifera was ranked first in position of the total zooplankton abundance in hilsha migratory river in Bangladesh (Ahson, 2012). The study of the limnological parameters revealed no serious pollution in the studied river.

Conclusion

The physico-chemical parameters and plankton abundance indicates stable condition of the river, which suggests that the river is still in productive and suitable stage for capture fisheries. However, different management strategies could be taken by the concerned authority for sustainable and pollution free aquatic environment for future uses.

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