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Article

Assessment of physicochemical conditions and plankton populations of the river Padma, Bangladesh

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Abstract: The study was conducted to investigate the physicochemical and biological aspects of the river Padma in three sampling stations *viz* Mawa, Godagari and Paksi from January 2014 to December 2014. Ten physical and nine chemical parameters of water and plankton community both phytoplankton and zooplankton of this aforesaid area were studied. Physicochemical parameters of water such as temperature, pH, hardness, alkalinity, dissolve oxygen (DO), free carbon dioxide (CO_2), total dissolve solids (TDS), turbidity, biological oxygen demand (BOD) and chemical oxygen demand (COD) were studied. Maximum water depth 23.9±6.5 ft was recorded from Paksi and lowest water depth (19.7±6.3 ft) was recorded in Godagari. The highest air temperature was found 32.5±8.9^{0}C in Paksi and lowest temperature was found 28.3±3.9^{0}C in Godagari. Water temperature was found lowest (25.7±4.1^{0}C) in Godagari and highest (29.3±7.9^{0}C) in Paksi. Transparency was found lowest in Godagari 36.4±16.4 cm and highest 45.9±20.5 cm in Paksi. Conductivity was found highest in 390.2±411 (µs/cm) in Godagari. Turbidity was found lowest 16.5±36.3 in Paksi. TDS was found highest 190.4±196.9 mg/l in Godagari. Dissolve oxygen content in Mawa was found lowest 6.71±1.1 mg/l. pH was ranging from 8.0±2.4 in Mawa to 8.2±0.2 in Godagari among the three sampling spots of Padma river. Total alkalinity was found lowest 98.2±36.7 mg/l in Paksi. Total hardness was found lowest 83.4±45.9 mg/l in Godagari. BOD (B) was found highest 6.2±1.6 mg/l in Mawa. COD was found lowest 13.1±8.6 mg/l in Paksi. Total plankton density was found 2100±695.4 (Nos. /l) in Mawa, 2350±670.2 (Nos./l) in Godagari and 2280±710.5 (Nos./l) in paksi respectively. Total sixty genera under six classes of phytoplankton were observed and twenty two genera of zooplankton under four families were identified. Chlorophyceae, Bacillariophyceae, Cyanophyceae, Xanthophyceae, Euglenophyceae and Dinophyceae were the major groups of phytoplankton and Rotifera, Copepod and Cladocera were the major groups of zooplankton during the study period. The mean contribution of phytoplankton was more than 91.33% in all three rivers and zooplankton contributed the rest.

Keywords: physicochemical parameters; plankton; pollution; Padma river

1. Introduction

Rivers have always been the most important freshwater resources, along the banks of which our ancient civilizations have flourished, and most developmental activities are still dependent upon them. River basin has been a major source of water supply for many purposes and provides fertile lands, which support the development of highly populated residential areas due to its favorable conditions (Mouri *et al.,* 2011). Rivers constitute the main inland water body for domestic, industrial, and agricultural activities and often carry large municipal sewage, industrial waste water discharges, and seasonal runoff from an agricultural field (Singh *et al.,* 2004; Pradhan *et al.,* 2009). The growing problem of degradation of our river ecosystem has necessitated the monitoring of water quality of various rivers all over the country to evaluate their production capacity, utility

potential and to plan restorative measures (Datar and Vashistha, 1992; Das and Sinha, 1993). Good water quality resources depends on a large number of physicochemical parameters and the magnitude and source of any pollution load; and to assess that, monitoring of these parameters is essential (Reddi *et al.,* 1993). The population explosion and increasing demands have exerted extra pressure on natural water resources like rivers and lakes. The changed physicochemical characteristics of water have serious repercussions on aquaculture, fisheries and agricultural production (Singh *et al.,* 2002). Assessment of water resource quality of any region is an important aspect of developmental activities, because rivers, lakes and manmade reservoirs are used for water supply to domestic, industrial, agricultural and fish culture (Jackher and Rawat, 2003). Chemical composition of water is a function of hydro geochemical processes acting in a given environment, thus, monitoring of water quality parameters provide important information for water management (Matthieu *et al.,* 2005; USEPA, 1983). About one third of the drinking water requirement of the world is obtained from surface sources like rivers, dams, lakes and canals (Jonnalagada and Mhere, 2001). But, these sources serve as best sinks for the discharge of domestic as well as industrial waste water (Das and Achary, 2003; Tukura *et al.,* 2009). Although several reports on the assessment of water quality based on physicochemical and trace metals distributions in the Ganges and Brahmaputra River have been published by several workers (Datta and Subramanian, 1998; Islam *et al.,* 2012; Singh *et al.,* 2012) very little information is available about the overall status of water quality and seasonal variations in the biological aspects of the Padma River passing from Bangladesh.

Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties. Water quality provides current information about the concentration of various solutes at a given place and time. For optimum development and management for the beneficial uses, current information is needed which is provided by water quality programmes (Lloyd, 1992). Unequal distribution of water on the surface of the earth and fast declining availability of useable freshwater are the major concerns in terms of water quantity and quality (Boyd and Tucker, 1998). The relationship between the physicochemical parameters and plankton production of water bodies are of great importance in management strategies of aquatic ecosystems. Reservoirs, ponds, rivers and ground waters are used for domestic and agricultural purposes. The quality of water may be described according to their physic-chemical and plankton characteristics. The phytoplankton in a reservoir is an important biological indicator of the water quality. While phytoplankton are important primary producers and are at the base of the food chain in open water, some species on the other hand can be harmful to human and other animals by releasing toxic substances (hepatotoxins and neurotoxins etc) into the water (Whitton and Potts, 2000). Phytoplankton is recognized worldwide as bioindicator organisms in the aquatic environment (Yakubu *et al.,* 2000).

2. Materials and Methods

2.1. Study area

The study was conducted to investigate the physicochemical and biological aspects in three sampling stations of the river Padma *viz* Mawa, Godagari and Paksi (Table 1) from January 2014 to December 2014.

Table 1. Name of the sampling spots with GPS point.

Name of the river	Name of spots	GPS point (Latitute, Longitute)
Padma	Mawa (Monshigonj)	N-23^{o}27.36′ E-90^{0}15.27′
	Godagari (Rajshahi)	N-24^{0}29.321′ E-88^{0}18.176′
	Paksi (Kustia)	N-24^{0}05.443′ E-90^{0}01.404′

2.2. Determination of physicochemical parameters of water

2.2.1. Temperature

For the determination of temperature of surface water, dip the thermometer directly into the water keep it there for about one minute and note the temperature reading in the thermometer immediately.

2.2.2. Dissolved oxygen (DO)

Take 50 ml filtered water sample in a 250 ml conical flask, add 5 ml: 3 H_2SO_4 and shake the flask gently. Add 10 ml of $KMnO_4$ to this acidified water and heat in a water bath. After half an hour, remove the flask from the water bath and add 10 ml NH_4 oxalate to it and this were result in disappearance of the existing pink color of the solution. Now add to this colorless solution. Burette reading was noted.

2.2.3. Free carbon dioxide (CO_2)

Take 100 ml of the freshly collected water sample in a white porcelain basin. Add 3-4 drops of phenolphthalein indicator into the water. The sample was turns pink, if the P^H of water is above 8.3 and free CO_2 was not present. The solution remains colorless after addition of indicator, titrate it with N/44 NaOH with gently stirring with a glass rod till the color turns pink.

2.2.4. p^H

Generally Lovibond comparator was used for colorimetric estimation of pH values of water. Attach the colored disc of this indicator with comparator. Take 10 ml of clear water sample in two glass couvettes. Add 0.5 ml of the selected indicator to water in one couvettes and keep it in the specific groove of the comparator. Put the other couvettes having water sample only, in another groove, just in front of the colored disc. The disc was different shades of colures in it which are comparable to colures developed with the indicator at various P^H values. Match the color developed by the indicator in the water sample with the shades of colures of the disc by rotating it slowly. When the color of the test sample and that of the disc matches, corresponding reading was the P^H of water.

2.2.5. Conductivity

Immerse the cell of the conductivity meter in the standard KCI solution and read the conductivity value in the meter.

2.2.6. TDS

For estimation of TDS, heat a clean porcelain basin in an oven at 105^0c. Cool in desiccators and weight it accurately (W1). Shake the water sample thoroughly and take 100 ml of the sample in the basin. Evaporate the water sample to dryness in oven at temperature around 100^0c. After drying, keep the basin at 105^0c for half an hour. Cool it in desiccators and weigh the basin along with the residue (W2). Filter the water sample with the help of a Whatman no. 42 filter paper and use 100 ml of the filtrate for drying and weighing (W3).

TDS (mg/l) = (W3-W1) mg× 10

2.2.7. Alkalinity

Take 100 ml water sample in a 250 ml conical flask and add 3 drops of phenolphthalein indicator. The water was turns pink, titrate with 0.02N H_2SO_4 until the pink color just disappears. Volume of acid used was recorded. Then add three drops of Methyl orange indicator in the same water sample. If the water turns yellow, titrate with same acid until a faint orange end point was obtained. Volume of the acid used during the titration was recorded.

2.2.8. Hardness

Take 5 ml of water sample in a 100 ml conical flask and dilute it to about 25 ml. Add 1 ml of NH_4Cl-CH_4OH buffer and 3 to 4 drops of ferrochrome black-T indicator to get a wine red color. Titration was done against 0.01 N EDTA until the color changes to blue.

2.2.9. Biochemical oxygen demand (BOD)

Demand for oxygen in a water body may be exerted by (a) carbonaceous organic materials and (b) oxidisable nitrogenous compounds which may react with dissolved molecular oxygen and thus create oxygen tension in the water (Banerjee and Chattopadhyay, 1980). The biochemical oxygen demand (BOD) is a measure of the amount of oxygen required by the microorganisms to decompose the organic matter in a water sample under a specific set of conditions (Boyd, 1978). The property has a direct bearing on the oxygen balance of water, particularly when the environment is rich in organic materials. Complete decomposition of organic matter may require a long time and hence a five day incubation period has been suggested for most practical purposes (APHA, 1971). For determination of BOD value an aliquot of the water sample is incubated in dark at 20^0C for 5 days and the DO level achieved in this sample is deducted from the initial DO value of water. This gives an estimate of the amount of oxygen required to decompose the organic matter in the water body during 5 day period under the specified condition. In case of water samples rich in organic matter, the consumption of oxygen may be so high that the DO level of water may be completely exhausted. In such cases, suitable dilutions of the water samples are done in order to obtain the BOD value.

Take about 1 L of water sample in a suitable container and shake it thoroughly to increase its DO level. Fill two BOD bottles (narrow neck glass Stoppard bottle or usually 250 ml volume) with the water sample. One of these

bottles should be black colored or wrapped with black paper/polythene sheet to avoid entry of light. Incubate this opaque bottle in a BOD incubator at 20^0c. Determine the DO of the other bottle. Bring out the incubated bottle from the incubator after 5 days and determine the DO of this water sample.

2.2.10. Chemical oxygen demand (COD)

The chemical oxygen demand is a measure of the total amount of oxygen which is required to oxidize all the organic matter in a sample to Co_2 and H_2O (Boyd, 1978).This property, therefore indicates the organic matter concentrations of pond water and also exhibits close correlation with BOD values as well (Sawyer and McCarty, 1967). In the measurement of COD, all the organic matter present in a water body is oxidized with the help of a standard oxidizing agent. The amount of oxidizing agent consumed during this process indicates the quantity of oxygen required for this purpose and from this COD is determined. In this method, potassium dichromate ($K_2Cr_2O_7$) is used for carrying out the oxidation. The excess $K_2Cr_2O_7$ is back titrated by standard ferrous ammonium sulphate Fe $(NH_4)_2(SO_4)_2$) solution to know the actual amount of standard $K_2Cr_2O_7$ required for oxidation of organic matter in the water sample. The equivalent requirement of oxygen for oxidizing the same amount of organic matter as has been oxidized by $K_2Cr_2O_7$ is then worked out.

Take 20 ml of water sample in a conical flask. Add a few glass beds. Mix exactly 10 ml of 0.025 N $K_2Cr_2O_7$ to the water sample and then add slowly 30 ml of conc. H_2SO_4. Attach the flask to a refluxing condenser and reflux for 2 hrs over a heater. After refluxing wash the inside residues of the condenser into the flask, dilute with about 75-80 ml distilled water. Add 10 ml of orthophosphoric acid to prevent interference of ferrous ions during titration. Add about 1 ml of diphenyl amine indicator to develop a blue color in the solution and titrate with standard Fe $(NH_4)_2(SO_4)_2$ until the blue color flushes to green. Run a blank in exactly the same procedure with all the reagents excepting the sample.

2.2.11. Turbidity

A standard Secchi disc is a circular metallic plate having 10 cm radius. The upper surface of the disc was divided into four quarters, painted alternately in black and white colours. The disc was gradually lowered into the water with the help of a rope fixed to the centre of it and the depth at which the upper surface of the disc just disappears is noted. Now the disc was lifted up ward very slowly and the depth at which it reappears was noted.

2.2.12. Determination 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. 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

3. Results

3.1. Physicochemical parameters of water

Nineteen (ten were physical and nine were chemical) physicochemical parameter of water *viz* water depth, water temperature, air temperature, water colour, odour of water, bottom type, transparency, conductivity, turbidity, TDS, dissolve oxygen (DO), free carbon dioxide (Co_2), pH, NH_3, total alkalinity, total hardness, BOD (B), BOD (N) and COD, plankton community both phytoplankton and zooplankton content of the selected sampling spots

of the river Padma were studied (Tables 2 and 3). The lowest water depth (19.7±6.3 ft) was recorded in Godagari and the highest in (23.9±6.5 ft) in Paksi. The highest air temperature was found 32.5±8.9^{0}C in Paksi and lowest temperature was found 28.3±3.9^{0}C in Godagari (Figure 1). Water temperature was found lowest (25.7±4.1^{0}C) in Godagari and highest (29.3±7.9^{0}C) in Paksi. Transparency was found lowest in Godagari 36.4±16.4 cm and highest 45.9±20.5 cm in Paksi. Conductivity was found highest in 390.2±411 (µs/cm) in Godagari. Turbidity was found lowest 16.5±36.3 in Paksi. TDS was found highest 190.4±196.9 mg/l in Godagari. Dissolve oxygen content in Mawa was found lowest 6.71±1.1 mg/l. pH was ranging from 8.0±2.4 in Mawa to 8.2±0.2 in Godagari among the three sampling spots of Padma river. Total alkalinity was found lowest in 98.2±36.7 mg/l in Paksi. Total hardness was found lowest 83.4±45.9 mg/l in Godagari. BOD (B) was found highest 6.2±1.6 mg/l in Mawa. COD was found lowest 13.1±8.6 mg/l in Paksi.

Table 2. Physicochemical parameters of water from three sampling spots of the river Padma.

Parameters	Padma river		
	Mawa (Mean±SD)	Godagari (Mean±SD)	Paksi (Mean±SD)
Water depth (ft)	21.5±7.8	19.7±6.3	23.9±6.5
Air temp (^{0}C)	30.2±12.5	28.3±3.9	32.5±8.9
Water temp (^{0}C)	28.4±6.7	25.7±4.1	29.3±7.9
Water colour	Light green	Light green	Brownish
Odour of water	Fresh	Fresh	Fresh
Bottom Type	Sandy	Sandy	Sandy
Transparency (cm)	40.5±18.4	36.4±16.4	45.9±20.5
Conductivity (µs/cm)	318.6±220.3	390.2±411	315.7±247.9
Turbidity	25.8±12.7	59.6±61.4	16.5±36.3
TDS (mg/l)	187.4±110.5	190.4±196.9	152.7±118.5
Dissolved O_2 (mg/l)	6.71±1.1	6.8±0.9	6.9±1.9
Free CO_2 (mg/l)	3.7±1.3	3.6±0.5	3.8±1.4
pH	8.0±2.4	8.2±0.2	8.1±2.5
NH_3 (mg/l)	0±0	0±0	0±0
Total alkalinity (mg/l)	110.5±55.2	111.4±43.1	98.2±36.7
Total hardness (mg/l)	120.3±56.7	83.4±45.9	122.1±43.2
BOD (B) (mg/l)	6.2±1.6	5.5±1.5	6.18±1.7
BOD (N) (mg/l)	6.8±2.0	6.9±0.6	6.9±2.1
COD (mg/l)	15.6±6.5	18.9±13.1	13.1±8.6

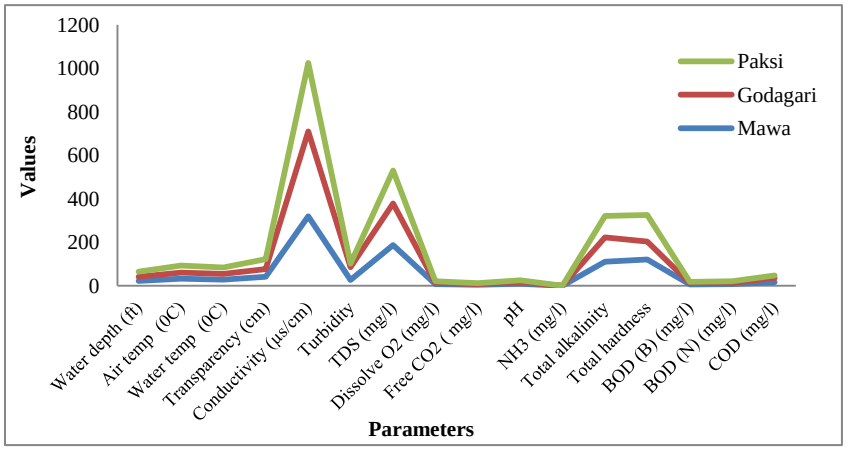

Figure 1. Average variation in the physicochemical parameters of water.

3.1. Plankton population of the river Padma

Abundance of plankton in three sampling spots also showed a wide range of variation. More than 80 genera of plankton were identified under 10 families (Tables 3 and 4). Total plankton density was found 2100±695.4 (Nos./l) in Mawa, 2350±670.2 (Nos./l) in Godagari and 2280±710.5 (Nos./l) in paksi respectively. Chlorophyceae, Bacillariophyceae, Dinophyceae, Myxophyceae were the major groups of phytoplankton (Figure 2). Cladocera, Copepod, and Rotifera were the major groups of Zooplankton (Figure 3). Phytoplankton

largely dominated over zooplankton throughout the study period. The mean contribution of phytoplankton was more than 91.33% in all three rivers and zooplankton contributed the rest.

Table 3. Name of Phytoplankton found in the river Padma

Sl No.	Family	Genus
1.	Bacillariophyceae	*Amphora, Anomoeoneis, Asterionella, Bacillaria, Coscinodiscus, Cyclotella, Diatoma, Fragillaria, Gomphonema, Gyrosigma, Melosira, Navicula, Nitzschia, Pleorosigma, Rhizosolenia, Surirella, Synedra, Tabellaria, Triceratium*
2.	Chlorophyceae	*Actinastrus, Ankistrodesmus, Botryococcus, Chlorella, Closterium, Coelastrum, Micractinium, Microspora, Muogeotia, Oedogonium, Oocystis, Palmella, Pediastrum, Pleorococcus, Scenedesmus, Selenestrum, Spirogyra, Staurastrum, Stichococcus, Synedra, Tetraedron, Ulothrix, Uroglena, Volvox, Zygnema*
3.	Cyanophyceae	*Anabaena, Aphanizomenon, Aphanocapsa, Chroococcus, Gomphosphaeria, Merismopedium, Microcystis, Nostoc, Oscillatoria, Polycistis, Spirulina*
4.	Euglenophyceae	*Euglena, Phacus*
5.	Xanthophyceae	*Botrydium, Tribonema*
6.	Dinophyceae	*Ceratium*

Table 4 Name of Zooplankton found in the river Padma

Sl. No.	Family	Genus
1.	Copepoda	*Cyclops, Diaptomus, Laptodora, Mesocyclops, Naupleus*
2.	Cladocera	*Bosmina, Diaphanosoma, Daphnia, Moina, Sida*
3.	Rotifera	*Anuraeopsis, Asplanchna, Brachionus, Filinia, Hexarthra, Keratella, Polyarthra, Trichocerca*

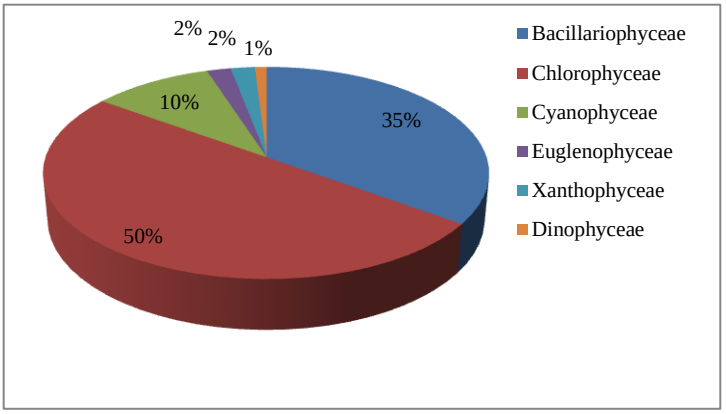

Figure 2. Phytoplankton composition of Padma river.

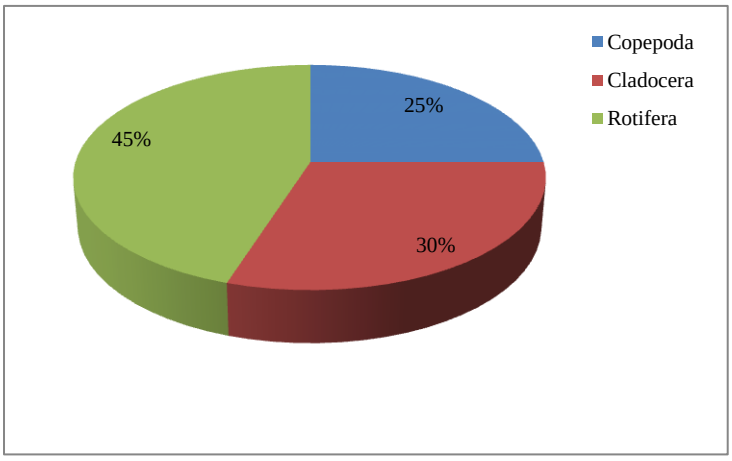

Figure 3. Zooplankton composition of Padma river.

4. Discussion

The studied physical and chemical properties for water samples in the selected three sites are summarized in Table 2. Because of its great impact on aquatic life, water temperature is an important component of a water quality assessment (Collins *et al.,* 2008). Temperature is a critical water quality parameter, since it directly influences the amount of dissolved oxygen that is available to aquatic organisms (Ahmed *et al.,* 2003). Temperature affects the distribution, health, and survival of aquatic organisms. While temperature changes can cause mortality, it can also cause sub-lethal effects by altering the physiology of aquatic organisms (Collins *et al.,* 2008). Temperatures outside of an acceptable limit affect the ability of aquatic organisms to grow, reproduce, escape predators, and compete for their habitat. The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream (ADB, 1994). The transparency of productive water bodies should be 40cm or less (Stepenuck *et al.,* 2002). The pH of a water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity (Dara, 2002). The pH was found 8.0 to 8.2 in the present study. Adequate dissolve oxygen is necessary for good water quality, survival of aquatic organism and decomposition of waste by microorganism (Chowdhury and Raknuzzaman 2005). Maximum dissolve oxygen value was found 6.7 to 6.9 mg/l. The rise in temperature in the river water can be correlated with increase in carbon dioxide levels (Shafi *et al.,* 1978). Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them (Sileika *et al.,* 2006).Total alkalinity of water is due to presence of mineral salt present in it. It is primarily caused by the carbonate and bicarbonate ions. Total dissolve solids (TDS) are a measure of the amount of particulate solids that are in solution. This is an indicator of nonpoint source pollution problems associated with various land use practices. They are the direct measurement of particle concentration that quantifies the diffraction of light caused by particles in the water (Collins *et al.,* 2008). TDS concentration was found 152.7 mg/l to 190.4 mg/l in the present study. TDS concentrations have been recommended by the USEPA (up to 500 mg/l) as useful indicators of water quality and are important measurements for a number of reasons (Sawyer *et al.,* 1994). Increased TDS are frequently indicators of erosion. BOD directly affects the amount of dissolved oxygen in rivers and streams. BOD of 10 mg/l in irrigation water quality standards for Bangladesh (ADB, 1994). The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. In the present study BOD, B was found 5.5 mg/l to 6.2 mg/l. In the conjunction with the BOD test, the COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances (Sawyer *et al.,* 1994). In the present study, COD values varied between 13.1 mg/l to 18.9 mg/l. The mean contribution of phytoplankton was about 91.3% in all sampling spots and zooplankton contributed the rest. Higher percentage composition of phytoplankton 76.0% to 93.6% from the Meghna river (Rahman *et al.,* 2012).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 (Rahman, 1992). Chlorophyceae was found most dominating group in phytoplankton among phytoplankton abundance from Mouri river of Khulna (Kar *et al.,* 2008). Bacillariophyceae was formed 2nd place in the total phytoplankton abundance, similar result also reported from Mouri river of Khulna (Kar *et al.,* 2008). About 23 genera of zooplankton, of which 12 belonged to Rrotifers, 4 to Copepods, 6 to Cladocerans and 1 to Ostracods from the river Buriganga (Belcher and Swale, 1978). In the present study, zooplankton constituted 8.6% of the total plankton abundance. Zooplankton contributed more than 3% to the total planktonic organisms (Ahipathi and Puttaiah, 2006). Copepods were found the dominanting group in zooplankton. Copepods (51.2%) were the most dominating group among total zooplankton abundance (Ahipathi and Puttaiah, 2006).

5. Conclusions

Padma is one of the main rivers of Bangladesh. This river plays a vital role as the important freshwater resources of Bangladesh. Its water is used for different purposes such as irrigation, navigation, fisheries, dumping of domestic and industrial waste and recreational purposes. But day by day the flow of the river is decreasing and with increasing population the quality of water also decreasing. The present baseline information of the physicochemical properties of river water and plankton population would be a useful tool for further ecological assessment and monitoring of the river quality. At the present stage, it is essential to use the vast knowledge on the ecology of plankton communities in the Padma river for the ecosystem management aimed at improving the water quality.

Conflict of interest

None to declare.

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