Dhaka Univ. J. Biol. Sci. **30**(3 CSI): 487-497, 2022 (June)
DOI: https://doi.org/10.3329/dujbs.v30i3.59040

WATER QUALITY AND POTAMOPLANKTON PERIODICITY OF SITALAKHSYA RIVER, NARAYANGANJ, BANGLADESH

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Keywords: Sitalakhsya River, Physicochemical factors, Potamoplankton, Soluble reactive phosphorus, Soluble reactive silicate, Chlorophyll-a

Abstract

The section of Sitalakhsya River near heavily industrial zone of the District of Narayanganj has been studied for its water quality and potamoplankton dynamics. One year bimonthly sampling from DakhshinRupshi Station of the river was carried out. The air and water temperature of the river ranged from 25.6 - 34.0°C and 26.5 - 32.8°C, respectively. The temperature of water was lower than air by ca. 2.0°C. Water depth at the study station did not vary much but fluctuated only between 6.09 and 7.92 m. The Secchi disc transparency (Zs) varied from 0.2 - 0.6 m showing the lowest in March. Total dissolved Solids (TDS) load in water was 85 - 663 mg/l but the electrical conductivity varied from 110 - 910 µS/cm being the month of March as highest record. pH was alkaline and the fluctuations were negligible (7.2 - 7.4). Alkalinity peaked in March (6.65 meq/l) which dropped to 1.00 meq/l in August and October. Both dissolved oxygen (DO) and free carbon dioxide levels were low which varied from 0.37 - 2.43 and 0.04 - 1.93 mg/l, respectively. Among dissolved nutrients, soluble reactive phosphorus (SRP) showed a low value from May to December (89.48 - 127.70 µg/l). It, however, peaked during March (1265.94 µg/l). Soluble reactive silicate (SRS) concentration ranged from 7.01 - 82.11 mg/l, while the concentration of NO_3-N ranged from 0.19 - 1.29 mg/l. The potamoplankton biomass as chl-a ranged from 3.38 - 24.52 µg/l, while its degraded product phaeopigment varied from 1.97 - 11.13 µg/l. The total density of potamoplankton showed their highest growth during December to March (2223 - 4293 $\times 10^3$) and the lowest from May to October (181 - 785 $\times 10^3$). The ranges of water quality and planktonic parameters recorded from the Sitalakhsya River are quite comparable with three other peripheral rivers of Dhaka Metropolitan City (DMC) namely, Balu, Turag, and Buriganga. But, low DO and poor transparency along with higher load of TDS made this river water quality relatively lower grading compared to others.

Introduction

Potamoplankton, the plankton of running water habitat, though not significantly different in composition and periodicity from the plankton of stagnant water but are characterized by their response to prolonged hydraulic residence time(1). Under such conditions a wide range of variation inthe qualitative aspects of plankton may be seen.

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Parallel to it, the community of plankton should also show fluctuations in their population density over time. This periodic response of their population is also connected with the concentration of dissolved nutrients and other physical factors of water. Sitalakhsya River is one of the most important urban riversencircling the greater Dhaka Metropolis and flowing adjacent to the industrial district Narayanganj. The river port of Narayanganj is also situated on the bank of Sitalakhsya River. Water pollution and various activities of urban population affect this river strongly and the status of its water quality has long been questioned. Although some preliminary study on the water quality of a number of peripheral rivers of Dhaka Metropolis have been carried out but there is almost no or little information available on the density of potamoplankton and its dynamics[(2-5)].

Using finite segment method, one water quality model for the Sitalakhsya River was developed in 1996[(6)]. A comprehensive sampling (~3 months interval) from 1995-96 covering a stretch of the River between the starting point just after Old Brahmaputra to its meeting point with Dhaleshwari River was carried out. The studied length of the river covered discharges from most of the industries and the waste water disposal from Dhaka Metropolis. In that study, along with other hydrological factors 10 water quality related parameters were recorded[(6)].In 2009, the effect of pharmaceutical effluents on the phytoplankton abundance in a selected station of Sitalakhsya River was studied[(7)]. Physico-chemical condition of the studied station varied distinctly. Strong fluctuation of dissolved oxygen was seen there[(7)]. Bhuiyan*et al.* (2020)[(8)] studied some selected sections of Balu River and showed the relationship between phytoplankton biomass as chlorophyll-a (chl-a) and standing crop and the physicochemical factors[(8)]. The navigation channel of Sitalakhsya River passes through the busy industrial city of Narayanganj and receives tremendous volume of industrial and domestic wastes dumped in its water. Water quality of this river is strongly threatened. Phytoplankton biomass as chl-a could serve as a good indicator of water quality along with otherphysico-chemical factors. So, it is important to measure these water quality parameters to see the effect of pollutants. No previous attempt of this kind has been made to study the water quality of Sitalakhsya River. The present study has therefore been aimed to study some selected water quality factors of the river water along with the biomass and density of phytoplankton.

Materials and Methods

The Sitalakhsya River is a distributary channel of the river Brahmaputra. At its origin, it flows southwest direction and then turns east of the city of Narayanganj until it merges with another river named Dhaleshwari near a place named Kalagachhiya. Sitalakhsya is about 110 km long. Its channel is widest at Narayanganj which is around 300 m across. The velocity of water measured at Demra is about 74 m^3/sec. Characteristically, the River remains navigable all through the year and as a result the anthropogenic activity in its course is very strong. The River flows through the district of Gazipur and then passes touching the border of Narsingdi and then reaches Narayanganj. Its maximum depth is 21 m(9).

Collection of samples for the present study was done from a permanent station named Dakhshin Rupshi situated on the bank of the river. The GPS data of the study site shows 23.737225 N and 90.511296 E. Roughly, a bimonthly sampling was carried out in between May, 2017 and March, 2018. The exact months of sampling could be picked up from the Figs1-4, A-B. A boat was used to collect the water and plankton sample from the station. Air temperature (Air t°C) was measured using an alcoholic thermometer graduated up to 40ºC (Gallenkamp, UK). The bulb of the thermometer was exposed and swirled in the surrounding air for one minute and then the alcoholic scale was read and the temperature data was recorded. Water temperature (Wat. t°C) was measured with the help of another identical thermometer fitted in-house in a modified Schindler-Patalas 5 liter capacity water sampler(10). This temperature data was representative for 0.5 m integrated water column of the sampling station. Water depth (Zwat) was measured using a rope with a weight tied at the end. A 20 cm diameter Secchi disc painted black and white cross wisely was used to measure the transparency of water (Zs) as described in Welsch (1948)(11). The collection of half a meter integrated sample water from the pelagic of the river was carried out by dipping a Schindler-Patalas water sampler. Duplicate glass stoppered BOD bottles (125 ml cap., Pyrex, UK) was filled with the sample water and then 1 ml of each of manganoussulphate and alkaline iodide solution was added to the bottles for fixing the DO. The bottles were kept submerged in a bucket of water and transported to the laboratory for titration via Winkler's method(11). By using a portion of the collected water sample, the total dissolved solids (TDS), conductivity (cond.), and pH were measured *in situ* using a Field Multimeter (Hanna Multi Instruments, Code-HI9813-6, S/N-DO108196, Romania). A 5 liter capacity light proof black PVC canister was filled with the water sample drained out from the Schindler-Patalas Sampler, tightly screw-capped, tapped and then made ready for the transportation to the laboratory. This sample was used for determining the free CO_2, alkalinity (alkal.), soluble reactive phosphorus (SRP), soluble reactive silicate (SRS), NO_3-N, chlorophyll-a (chl-a), phaeopigment (phaeo.) and total phytoplankton density (PD) using relevant analytical methods(12-16). All the samples were transported to the National Professor A. K. M. Nurul Islam Laboratory, Department of Botany, University of Dhaka using an ice box. The travel time for transporting the sample to the laboratory took approx. 2 hours. The analysis began immediately after reaching the laboratory and was completed within 48 h. The quantification of potamoplankton was done with the help of a micro plankton counting chamber (Hawksly & Sons Ltd., UK) using a Nikon (Japan) compound microscope at a magnification of 400×.

Results and Discussion

In the present investigation, the measured values of air temperature, water temperature, Zwat, Zs, TDS, cond., pH, DO, free CO_2, alkal., SRP, SRS, NO_3-N, chl-a, phaeo. and PD have been plotted in Figs. 1-4, A-B. The seasonal trend of a pair of related variables have been figured out on a log scale and plotted in each figure. The bimonthly variation of air and water temperature ranged from 25.6 - 34.0°C and 26.5 - 32.8°C, respectively. In both air and water temperature the lowest value was observed in December and the highest in October (Fig. 1A).

The trend line shows that both the air and water temperature proceeds annually hand to hand and the water temperature is always being the lower compared to the air temperature (Fig. 1A). Fig. 1B shows the variation of water depth and conductivity. The water depth of the studied station remained fairly stable and ranged from 6.09 -7.92 m. From August to December and in March the water depth was same (7.92 m). The lowest water depth (6.09 m) was recorded in February (Fig. 1B). The electrical conductivity of the river water ranged from 110 - 910 µS/cm, being the month of March as highest record and October, the lowest (Fig. 1B). Highest water depths on two events (August and October) coincided with the lowest conductivity of water. As it is evident from the trend line, the conductivity values followed a definite flux over the season while the water depth remained almost static (Fig.1B).

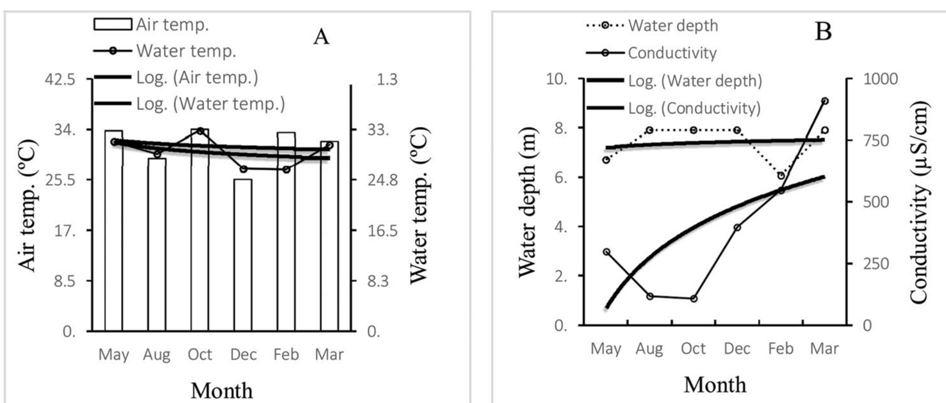

Fig. 1A-B. A, Fluctuations of air and water temperature during study period. B, The rise and fall of water depth and electrical conductivity of water over the measuring period.

Fig. 2A shows the variation and relationship between Zs and TDS of the river water. Zs varied from 0.2 - 0.6 m, while the TDS from 85 - 663 mg/l. Karim[6] reported an annual range of Zs from 0.18 - 1.25 m. The lowest being recorded in September (0.18 m) followed by 0.495, 0.975 and 1.25 m, respectively in November, January, and March (Karim 1996)[6]. However, in the present investigation, more or less a reverse trend has been observed (Fig. 2A). Lowest Zs and highest TDS both occurred in the same month of March. The trend line drawn between these two parameters showed an opposite relationship which crossed each other in December (Fig. 2A). The pH showed a fairly uniform distribution over the annual scale. It ranged from 7.2 - 7.4. While the data on alkalinity showed variable concentrations which ranged from 1.0 - 6.65 meq/l (Fig. 2B). Though the variation in pH value is negligible over different months, the lowest alkalinity occurred at a time when the pH was also low. The trend line showed that these two variables ran parallel with an elevated turn from May to March (Fig. 2B).

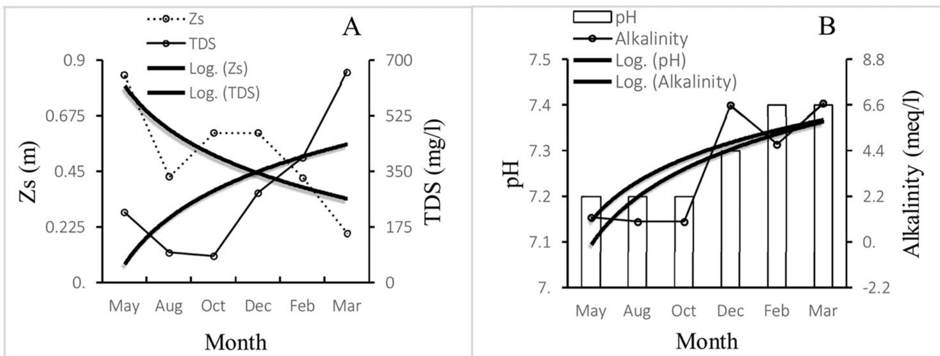

Fig. 2A-B. A, A comparison between Secchi Depth (Zs) and TDS. B, Variation in pH and alkalinity over the period of study.

The concentration of two major dissolved gases DO and free CO_2 was measured and the data are plotted in Fig. 3A. DO ranged from 0.37-2.43 mg/l and the CO_2 from 0.04-1.93 mg/l (Fig. 3A). Though the highest value for both the gases are same but the lowest for CO_2 is nearly 10 times lower than DO. In October, the DO value was high showing the lowest value of CO_2. Though DO follows an almost clear increasing trend line from May to March, this was weaker in case of CO_2 (Fig. 3A). The range of DO concentration recorded by Karim[(6)] showed a clear increase from September to March, where the values were 5.52, 4.97, 6.20 and 6.50 mg/l in September, November, January, and March, respectively. The concentration of SRS ranged from 7.01 - 82.11 mg/l, where the concentration of NO_3-N ranged from 0.19 - 1.29 mg/l (Fig. 3B). The lowest SRS concentration was found in February but for NO_3-N it was in October. However, the highest concentration for both the parameters occurred in May. The trend line for both the parameters showed a very close proximity to each other making clear that their annual sequence of variation is almost identical (Fig. 3B). The concentration of nitrate measured by Karim was very high (7.87 - 10.50 mg/l)[(6)]. The maximum is 8.14-fold higher than that of the present investigation. In the study of Karim[(6)], the highest value was recorded in September and the lowest in November.

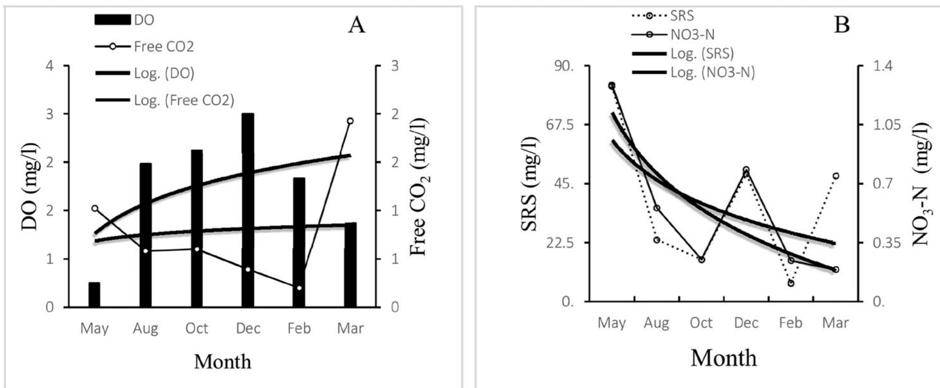

Fig. 3A-B. A, Fluctuations in the concentration of dissolved oxygen (DO) and free CO_2. B, concentration of soluble reactive silicate (SRS) and NO_3-N over the period of measurement.

Fig. 4A shows the annual flux of SRP and chl-a, the former factor ranged 89.48 - 1265.94 µg/l and at the latter from 3.38 - 24.52 µg/l. The lowest value of chl-a concentration was recorded in both August and October when SRP was also closer to low value. The highest SRP was recorded in March which accompanied with second highest chl-a. As it has been evident through the trend line drawn (Fig. 4A), these two parameters showed a close but opposite relationship in the river water. Their relationship has crisscrossed each other just after August (Fig. 4A). After May, chl-a concentration showed a downward trend towards the rest of the period of measurement while an opposite to chl-a, an upward trend was observed in case of SRP from May-March (Fig. 4A). A progressive trend of chl-a from September to March was observed by Karim[6], where the concentration were recorded as 1.86, 2.69, 3.86 and 4.80 µg/l in September, November, January, and March, respectively in between 1995 and 1996. The concentrations of chl-a were supported by a retrogressive trend by SRP (PO_4) where the concentrations were 0.150, 0.125, 0.89 and 0.100 mg/l in September, November, January and March, respectively. In the present investigation, the concentration of phaeopigment ranged from 1.97 - 11.13 µg/l. The highest concentration occurred just at the point of high phytoplankton biomass as chl-a, while the lowest was recorded in October. The total PD ranged from 181 - 4293×10^3ind./l, being the highest density in March and the lowest in October (Fig. 4B).

The patterns of trend line as shown by these two parameters are exactly similar to that shown by SRP and chl-a (Fig. 4A). Phaeopigment showed a downward trend from May to March, while the total PD showed an opposite sequence crisscrossing each other after August (Fig. 4B). Begum and Khanam[7] studied the water temperature of Sitalakhsya River at a point of wastewater disposal from a pharmaceutical factory and obtained a relatively higher range of temperature (18 - 42°C). This might be as because of the temperature of the industrial effluents. A comparative status of the physicochemical and biological parameters from the four peripheral rivers of Dhaka Metropolitan City (DMC) has been provided in Table 1. The maximum air temperature prevailed in the study station of all the peripheral rivers ranged from 34.0 - 36.5°C(8,17,18). This gives a very close figure for the air temperature during the collection time. On the other hand, the maximum value of water temperature ranged from 30.5 - 33.0°C (Table 1). The difference within the ranges for air and water temperature is 2.5°C. So, this clearly indicates a closer

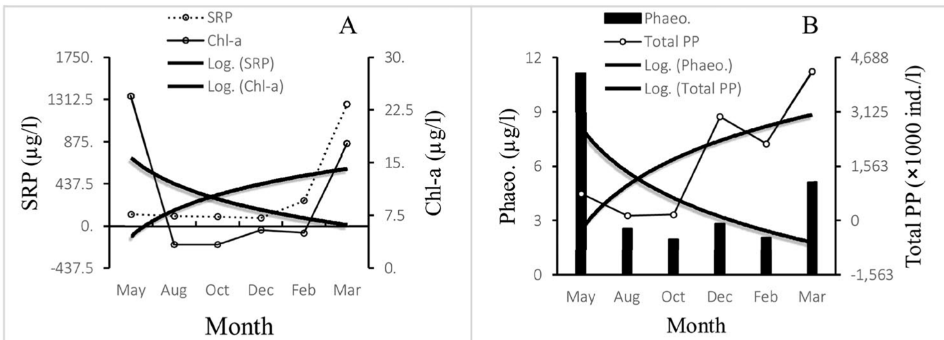

Fig. 4A-B. A, Concentration of soluble reactive phosphorus (SRP) and chlorophyll-a (chl-a). B, Phaeopigment (Phaeo) concentration and total density of potamoplankton (PD) over the period of measurement.

relationship between the air and water temperature of the peripheral rivers of DMC. The trend line which has been drawn for both of this physical parameter also gives similar information (Fig. 1A). The range of the water depth at the sampling station did not vary much as because to carry out the sampling throughout the whole lean and wet period a safer part of the river would have been needed to avoid dryness. As a result, the water depth at the sample collecting stations did not vary widely. The difference between the highest and lowest water depth was 1.81 m (Table 1). Secchi depth indicates the transparency of water particularly the light penetration zone up to which phytoplankton could bring about photosynthesis. This is very important because of primary productivity and the operation of pelagic grazing food chain. In all the peripheral rivers of DMC, the transparency depth never reaches 1 m. The maximum light penetrating zone for Sitalakhsya River was recorded 0.61 m, while the values for Balu, Turag and Buriganga were 0.81, 0.35 and 0.60 m, respectively(8,17,18). TDS related with Zs and PD density because TDS value triggered PD which in fact reduced the light penetration because of self shading effect (Reynolds 1984) (1). In the present investigation, highest PD 4293 $\times 10^3$ ind./l in March coincided with higher TDS (663 mg/l) and lowest Zs (0.20 m). In the present investigation, electrical conductivity of water was low for August and October (110 - 120 µS/cm). Khondker and Zerin(19) also recorded the lowest value (110 - 135 µS/cm) for the river Buriganga. So, it means that the dilution at rainy months lowers the electrical conductivity of the river water. Table 1 show a comparison of conductivity values from all the peripheral rivers of DMC. It is evident that, the maximum conductivity values for Sitalakhsya, Balu, Turag, and Buriganga were 910, 890, 608 and 915 µS/cm, respectively, while the lowest of this account were 110, 17, 175, and 115, respectively. It shows clearly that the peripheral river water has almost similar ionic load annually (Table 1). Except the river Buriganga (6.7 - 6.9), the pH of other rivers ranged from 7.1 - 7.5 (Table 1). Unlike pH, the alkalinity showed a range from 1.0 - 6.65 meq./l in Sitalakhsya River.

Table 1. A comparison of physicochemical parameters among the peripheral rivers of Dhaka Metropolitan.

Parameters*	Sitalakhsya[1] (mean ± sd)	Sitalakhsya[1]	Balu[2]	Turag[3]	Buriganga[4]
Air t°C	31.33 ± 3.35	25.6 - 34.0	25.4 - 36.5	-	15.0 - 35.0
Wat. t°C	29.40 ± 2.50	26.5 - 32.8	23.4 - 32.3	20.8 - 30.5	20.0 - 33.0
Zwat (m)	7.42 ± 0.81	6.10 - 7.92	4.57 - 7.92	-	-
Zs (m)	0.48 ± 0.16	0.20 - 0.61	0.15 - 0.81	0.26 - 0.35	0.17 - 0.60
TDS (mg/l)	291.33 ± 216.58	85 - 663	128 - 634	-	55 - 394
pH	7.28 ± 0.10	7.2 - 7.4	7.1 - 7.5	7.1 - 7.5	6.7 - 6.9
Cond. (µS/cm)	398.33 ± 301.68	110 - 910	17 - 890	175 - 608	115 - 915
Alkal. (meq/l)	3.51 ± 2.77	1.00 - 6.65	0.84 - 6.55	1.17 - 3.67	1.00 - 6.60
DO (mg/l)	1.88 ± 0.93	0.37 - 3.00	0.20 - 4.50	0.84 - 8.97	<0.02 - 9.4
CO_2 (mg/l)	0.73 ± 0.68	0.04 - 1.93	0.06 - 2.90	-	-
SRP (µg/l)	327.03 ± 464.69	89.48 - 1265.94	30 - 1248	42 - 405	34 - 1584
SRS (mg/l)	37.64 ± 27.59	7.01 - 82.11	5.65 - 43.35	7.81 - 32.64	4.0 - 76.0
NO_3-N (mg/l)	0.55 ± 0.42	0.19 - 1.29	0.10 - 0.83	0.07 - 9.53	0 - 0.3
Chl-a (µg/l)	9.92 ± 8.99	5.07 - 24.52	6.77 - 32.60	2.35 - 87.29	2.0 - 160.0
Phaeo (µg/l)	4.28 ± 3.55	1.97 - 11.13	1.85 - 9.13	3.36 - 20.68	-
PP (×10^3 ind./l)	1772 ± 1685	153 - 4293	1178 - 7409	92 - 451	1 - 197

1, present investigation; 2, Bhuiyan *et al*. (2020); 3, Khondker and Abed (2013); 4, Islam and Moniruzzaman (2011). *Please consult Materials and Methods for the full name of the parameters.

Three of the peripheral rivers namely Balu and Buriganga showed a similar range as that of Sitalakhsya[8,17]. Turag showed a little lower range 1.17 - 3.67 meq/l[18]. The effect of industrial effluent discharge into the river might be the reason. The other three rivers namely Sitalakhsya, Balu and Buriganga passes through relatively dense industrial zones compared to Turag. The upper limit of the DO recorded from Sitalakhsya and Balu is nearly 50% lower than Turag and Buriganga. Since one of the reason for it is the chl-a value which evolves oxygen during photosynthesis. So, chl-a concentration of the above mentioned two rivers are also low compared to Turag and Buriganga (Table 1).

Regarding the nutrients like SRP, SRS and NO_3-N which are the key factors for water quality as well as the primary productivity, it has been seen that except Turag, other rivers have high values. The maximum concentration of Sitalakhsya, Balu and Buriganga were 1266, 1248, and 1584 µg/l, respectively. The lowest values for these three rivers were 89, 30 and 34 µg/l, respectively; while the Turag River showed a range of 42 - 405 µg/l. The maximum recorded concentration of SRS for Sitalakhsya, Balu and Buriganga were 82.11, 43.35 and 76.0 mg/l, respectively. The minimum values of SRS for these three rivers were 7.01, 5.65 and 4.0 mg/l, respectively. While the SRS concentration of Turag River ranged from 7.81 - 32.64 mg/l(18). However, for NO_3-N concentration the trend was different, Turag showed a high maximum value of NO_3-N (9.53 mg/l), while for the rivers Sitalakhsya, Balu and Buriganga the maximum recorded values were 1.29, 0.83 and 0.3 mg/l, respectively.

In rivers, the potamoplankton biomass is represented by three main components namely, the chl-a concentration, its degraded product the phaeopigment (phaeo) and the standing crop or population of phytoplankton (PD). Chl-a indicates the instant concentration of functional biomass which keeps on adding primary production into the river water. On the other hand, the phaeopigment actually indicates the intensity of moribund population among the phytoplankton. The diversity in PD can follow different levels such as their size and shape, taxonomic groups, multiplication capacity, etc.

In the present investigation, the chl-a andphaeopigmentconcentration as well as the population of phytoplankton were quantified from the routinely collected samples of the River. The range of chl-a (3.38-24.52 µg/l) what we have recorded for this river is relatively lower compared to Balu, Turag and Buriganga (Table 1). The maximum value (24.52 µg/l) recorded from Sitalakhsyarepresents 75, 28 and 15% of those recorded from Balu, Turag and Buriganga rivers, respectively. The SRP value might be playing a role since the highest SRP concentration encountered a second highest value of chl-a (Fig. 4A). The phaeopigment concentration of the Sitalakhsya River (1.97 - 11.13 µg/l) and Balu River (1.85 - 9.13 µg/l) remained almost closer to each other (Bhuiyan *et al*. 2020)(8). Turag yielded a relatively higher range of phaeopigment concentration (Table 1). The total PD of Sitalakhsya River was also closely related to that recorded value for Balu River (Table 1). The highest value of PD (4293×10^3 ind./l) was recorded in March which coincided with the highest SRP concentration (1265.94 µg/l). From this observation, it can be said that the biomass of potamoplankton as chl-a and the total standing crop (PD) is regulated by the concentration of SRP. The trend lines drawn in Fig. 4A also indicates similar inferences regarding the governing element of the potamoplankton biomass as SRP.

A year bimonthly study on the water quality and potamoplankton periodicity at a fixed station of Sitalakhsya River showed a flux based on the lean and wet period. The data obtained for air temperature, water temperature, Zwat, Zs, TDS, conductivity, pH, alkalinity, DO, CO_2, SRP, SRS, NO_3-N, chl-a, phaeo, and PD related closely with other peripheral rivers of DMC, particularly with Balu, Turag and Buriganga. The water depth fluctuated approximately within two meter and the difference of air and water temperature was around 2ºC. The water showed an alkaline pH level almost all throughout the study period. In December, the water was transparent with moderate concentrations of TDS, electrical conductivity, SRP, SRS, NO_3-N and chl-a. Regarding phytoplankton periodicity, this started with a moderate concentration during May. After that the concentration did fall until December and in February it showed a slight drop and then rose again to its highest concentration. The high density of potamoplankton was associated with a peak concentration of dissolved phosphorus (SRP), water depth, TDS, electrical conductivity and alkalinity. The water quality and potamoplankton density of the studied river was compared with three other peripheral rivers of DMC. TDS load of the river Sitalakhsya is higher than Buriganga but similar with that of Balu. Electrical conductivity and alkalinity were similar in range with Balu and Buriganga but DO is much lower compared with Turag and Buriganga. The ranges of SRP are almost similar with those shown by Balu and Buriganga. Nitrate concentration is similar with that of Balu River. The chl-a value is lower than all other rivers but the phytoplankton density is higher than Turag and Buriganga. High TDS load with low chl-a actually focuses on the lower biological activity of this river, since it has been passing its main course through a densely structured industrial zone of the Dhaka Metropolitan City.

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(Manuscript received: 7 April, 2021; accepted: 27 July, 2021)