WATER QUALITY ASSESSMENT OF TONGI KHAL (CANAL) DURING DRY SEASON

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ABSTRACT

Ecosystem health of the peripheral rivers of Dhaka, the capital city of Bangladesh, has degraded significantly over the last few decades. Though some of these peripheral rivers are marked as Ecologically Critical Area (ECA) by the Government, there is no system in place for monitoring of water quality and ecosystem health of the rivers. In this study, water quality of Tongi khal (canal), one of the heavily polluted surface water system in Dhaka, was monitored during the dry (low flow) season. During dry season, aquatic ecosystem remains in critical state due to lack of precipiatation and low upstream flows that reduce the pollution level by dilution. Four seperate sampling campaigns (two in pre-monsoon and two in winter) were carried out to collect water samples from four distinct points of Tongi khal. The water samples were analyzed, both in-situ and in the laboratory, for a range of water quality parameters. Results of the water quality analysis shows that Tongi khal is heavily polluted by discharges from both industrial and domestic sources. Anoxic condition has been identified in the river during the dry season, with very low dissolved oxygen (~ 0.2 mg/L), negative ORP (redox potential) and high sulfide concentrations (as much as 177.5 µg/L) in the river water. Dry period water quality of Tongi khal is characterized by high concentrations of organic matter (highest BOD_5 91.9 mg/L, COD 212 mg/L), ammonia (highest concentration 25.2 mg/L), phosphate (up to 8.31 mg/L), and sulfate (as high as 295 mg/L). Most of those parameters (except pH) do not meet the Bangladesh National Standard. Moreover, this study reveals significant spatial and temporal variation of dry season water quality of Tongi khal. Water quality of Tongi khal becomes worse at the end of the dry season i.e., March-April. During this pre-monsoon period, highest BOD_5, COD and ammonia concentration in Tongi khal water were 91.9 mg/L, 212 mg/L and 25.2 mg/L, respectively; the corresponding values for the samples collected during December-January (i.e., winter) are 62.5 mg/L, 146 mg/L and 13.75 mg/L, respectively. Furthermore, water quality of Tongi khal deteriorates as one moves from upstream of the industrial locations to downstream (towards Balu River), due to the discharge of industrial (as well as domestic) effluents from industrial establishments. The highest values of BOD_5, COD, and ammonia were identified at sampling points downstream of the industrial locations.. Bangladesh government has plans to resuscitate the peripheral rivers of Dhaka. This study provides a baseline scenario of pollution of Tongi khal during the dry season. This will help to plan and execute a successful restoration program for this surface water system.

Keywords: *Peripheral river, Pollution, Tongi khal, Water quality.*

1. INTRODUCTION

The peripheral river systems (Turag, Tongikhal, Balu, Shityalakhya, Buriganga river) of Dhaka, the capital city of Bangladesh, are highly polluted by unregulated industrial and land developments (Bird et al., 2018). The pollution of the rivers has reached such a state that the Bangladesh Government has declared the peripheral river systems as Ecologically Critical Area in 2009 (DoE, 2015). Proper assessment of the ecosystem health for such ecologically sensitive surface water systems require regular monitoring, based on which corrective measures are to be adopted. However, no systematic monitoring of the river system is currently in place.

Tongi khal (canal) is a surface water system that connects Turag river with Balu river. Tongi khal is reported to be polluted by the nearby Tongi industrial cluster. This cluster is located to the east of Dhaka city and industries in this cluster are concentrated in the Tongi BSCIC area, Tongi industrial area, Cherag Ali, Ershad Nagar, Vhadam, Gazipura, Sataish and Nimtoli areas. Polluting industries in this cluster include textile-dyeing, chemical-pharmaceutical, printing-packaging, glass-ceramic factories, foods, and other miscellaneous industries (MoEF, 2010).

Several studies (e.g., Bhuiyan et al., 2011; Rahman et al., 2012; Mobin et al., 2014; Ahmed et al., 2016; Sarkar et al., 2016; Sikder et al., 2016; Zakir et al., 2016; Hafizur et al., 2017, Tahmina et al., 2018, Islam et al., 2018) have been carried out over the years to assess the surface water quality of Tongi khal. However, most of those studies are based on assessment of water quality by collection of water samples at a single time and analysis of the samples for limited number of water quality parameters. The Department of Environment (DoE) measures only few water quality parameters (pH, DO, BOD, COD, TDS, SS, Chloride, Alkalinity, Total Coliform, Fecal Coliform) in Tongi khal on a monthly basis. Moreover, laboratory assessment studies (Das and Ali., 2018; Das et al., 2019) have reported presence of highly contaminated sediment in Tongi khal which has a direct influence in the surface water chemistry.

Recently Bangladesh government has started an initiative to restore many of the major river systems of Bangladesh including Tongi khal (canal). Before starting any restoration activity, it is important to assess the baseline pollution scenario. For assessment of pollution, the dry season is the most critical period when there is virtually no precipitation and upstream flow reaches its minimum. This study aims to provide a baseline scenario of pollution of Tongi khal during the dry season by systematic sampling and analysis of water samples throughout the dry season (December to April) over a critical stretch of the khal (canal).

2. MATERIALS AND METHODS

2.1 Collection of surface water samples:

Since the water quality of Tongi khal becomes strained during the dry season compared to wet season, sampling was done during dry season (pre-monsoon and winter). Surface water sampling was performed twice during pre-monsoon season (March 2017, April 2017) and twice during winter season (December 2017, January 2018). Four distinct points were selected for carrying out the surface water sampling (shown in Fig. 1). The four-sampling location are: S1: Near Iztema field, S2 and S3: Near Industrial establishments, and S4: Just before the confluence of Tongi khal with Balu river.

Table 1: GPS locations of sampling points

Sampling Location	Latitude	Longitude
S1	23°53'9.79"N	90°23'33.39"E
S2	23°53'18.18"N	90°25'20.66"E
S3	23°53'36.19"N	90°25'41.17"E
S4	23°53'57.24"N	90°26'34.61"E

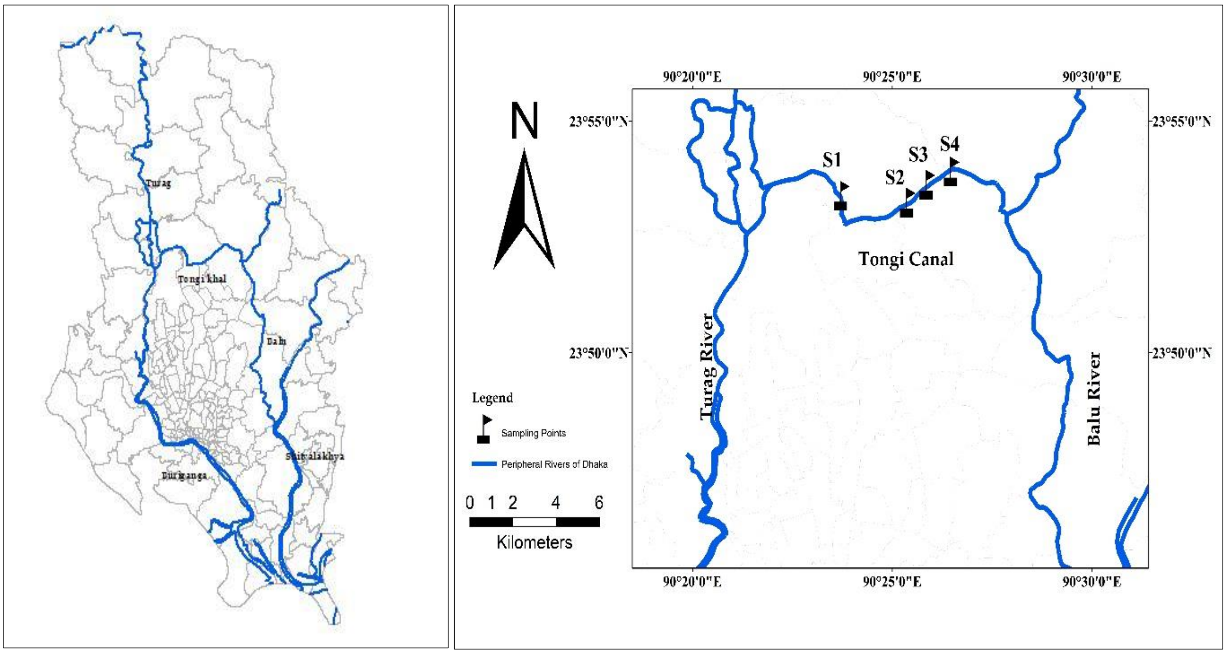

Figure 1: (a) Peripheral river system of Dhaka city (b) Sampling points along Tongi Khal

The water sampling was done following APHA standard protocol (APHA, 1989). Grab sampling at those four distinct locations was employed to collect water samples using an automatic water sampler. The depth of collection of water was two feet below the surface to avoid floating debris. Properly acid washed plastic containers were used as sample containers. From each sampling point around two liters of sample was collected. Then the sample containers were sealed properly and brought to the laboratory for analysis, placing them surrounded with ice box.

2.2 Water quality parameters assessment

The Collected water samples were tested for several physical, chemical and biochemical parameters. Water quality parameters were measured both in in-situ and in the laboratory. The pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), electrical conductivity (EC), total dissolved solids (TDS) and temperature were measured in-situ with HACH HQ 40d multi-parameter meter. In laboratory, color was measured with a spectrophotometer, ammonia (NH_3-N) was measured by the Nessler method, nitrate (NO_3-N) by the cadmium reduction method, nitrite (NO_2-N) by the USEPA Diazotization method, phosphate (PO_4^{3-}) by the ascorbic acid method, sulfate (SO_4^{2-}) by the SulfaVer 4 method, and sulphide (S^{2-}) by the methylene blue method, using a spectrophotometer (Hach, Model DR6000). Other parameters were measured following Standard Methods (APHA, AWWA).

3. RESULTS AND DISCUSSIONS

Surface water of Tongi khal has been found to be heavily polluted during both pre-monsoon and winter season, and the water quality resembles that of untreated domestic sewage. Dry period water quality in Tongi khal exhibits significant spatial and temporal variation. In general, the water quality of Tongi khal is characterized by high concentration of organic matter (BOD_5, COD), ammonia, phosphate, sulfate and sulphide. Very low concentration of dissolved oxygen (DO), low ORP (redox potential) and high sulfide concentrations indicate anoxic condition in the river. The summary of the water quality parameters is presented in Table 1. Very high COD (up to about 212 mg/L) and BOD_5 (over 90 mg/L) was recorded in water samples of Tongi khal near the industrial establishments (location S2 and S3); very high color (over 500 Pt.-Co. unit), sulfide (up to 176 μg/L) and ammonia (over 25 mg/L) concentrations, and low DO (as low as 0.16 mg/L) and ORP (redox potential, -333 mV) were also recorded at these locations. High concentration of dissolved solids (TDS up to 766 mg/L, EC up to 1579 µS/cm) and suspended solids (up to 166 mg/L) were found in the surface water of Tongi khal.

Comparison of water quality of Tongi khal with Bangladesh National Standard (ECR 1997) shows that most of the water quality parameters (except pH) do not meet the standards. Measured dissolved oxygen (DO) remained below 1 mg/L during the dry period at four different measurements along the Tongi khal, which is well below the limit of 5 mg/L set in ECR 1997.

Table 1: Physiochemical characteristics of water samples collected Tongi khal

Parameters	Pre-Monsoon Season	Winter Season
pH	7.5 ~ 8.4	7.6 ~ 8.2
Temperature (^{0}C)	25.4 ~ 32.1	22.3 ~ 25.8
ORP	(-218) ~ (-333)	(-249) ~ (+53.2)
DO (mg/L)	0.17 ~ 0.25	0.16 ~ 0.91
EC (µS/cm)	1122 ~ 1579	587 ~ 1220
TSS (mg/L)	81 ~ 166	26 ~ 103
Color (Pt-Co Unit)	144.5 ~ 464	208.5 ~ 521.5
Ammonia, NH_3-N (mg/L)	9.99 ~ 25.2	1.65 ~ 13.8
Nitrate, NO_3^-N (mg/L)	0.2 ~ 1.4	0.6 ~ 3.2
Nitrite, NO_2^-N(mg/L)	0.0108 ~ 0.4	0.0019 ~ 0.0218
Phosphate, PO_4^{3-} (mg/L)	0.75 ~ 8.3	2.2 ~ 7.2
Sulfate, SO_4^{2-} (mg/L)	108 ~ 198.5	89 ~ 295
Sulfide, S^{2-} (µg/L)	62.5 ~ 177.5	0.0275 ~ 30
Chloride, Cl^-(mg/L)	96.1 ~ 186.2	46.1 ~ 108.1
Alkalinity (mg/L as $CaCO_3$)	298.3 ~ 400.4	167.2 ~ 361.3
COD (mg/L)	79 ~ 212	33 ~ 146
BOD_5 (mg/L)	7.5 ~ 91.9	5.6 ~ 62.5

All water samples from Tongi khal have BOD_5 values, well above the standard of 2 mg/L or less, set in ECR 1997. Most of the water samples also contained high concentrations of ammonia, exceeing the the maximum limit of 1.2 mg/L (considering water used for pisiculture) in ECR 1997.

3.1 Spatial variation Tongi khal water quality during dry period

Figure 2 through 4 shows water quality characteristics of Tongi khal during the sampling period. Data presented in Figure 2 to Figure 4 clearly show that water quality of Tongi khal deteriorates as one moves from upstream to downstream. This is clearly due to the discharge of industrial as well as domestic effluents from establishments close to sampling locations S2 and S3. For example, at sampling location S1, BOD_5 in March 2017 was around 7.5 mg/L; at that time, BOD_5 at S2, S3 and S4 locations were around 30, 40, 40 mg/L, respectively. Similar trend was observed in April 2017, December 2017 and January 2018. For a particular sampling time, BOD_5 values at S3 location was 1.4 to 5.3 times higher than those at S1 location. A similar trend was observed for COD. For example, COD value of water at S1 location in March 2017 was 118 mg/L; the value was 212 mg/L at S2, 171 mg/L at S3 and 206 mg/L at S4 location. In January 2018, the COD values at S1, S2, S3 and S4 locations were 59, 111, 123 and 146 mg/L, respectively.

Ammonia (NH_3-N) concentration in Tongi khal also shows strong temporal variation throughout the sampling period. In March and April (2017), ammonia concentration increased significantly in the downstream locations; for example, at S1 location, ammonia concentration in March and April were around 10.5 and 10 mg/L, respectively; while at S4 location corresponding concentrations were 25.2 and 24.6 mg/L, respectively. In January 2018, ammonia concentration at S3 and S4 locations were lower compared to that at S2 location. This could be due to algal uptake of ammonia and conversion of ammonia to nitrate. Similar spatial trend (i.e., increasing concentration of pollutant downstream) was observed for color, sulfide and phosphate. No particular trend was observed for pH, ORP, TDS and EC. Recorded DO values were very low (~ 0.2 mg/L) throughout the sampling period, except in December, when relatively higher values (0.4 to 0.9 mg/L) of DO were recorded.

Figures 2, 3 and 4 illustrate the spatial and temporal variation of the measured physical, inorganic nutrients and miscellaneous water quality parameters, respectively at four distinct monitoring points during March 2017, April 2017, December 2017 and January 2018.

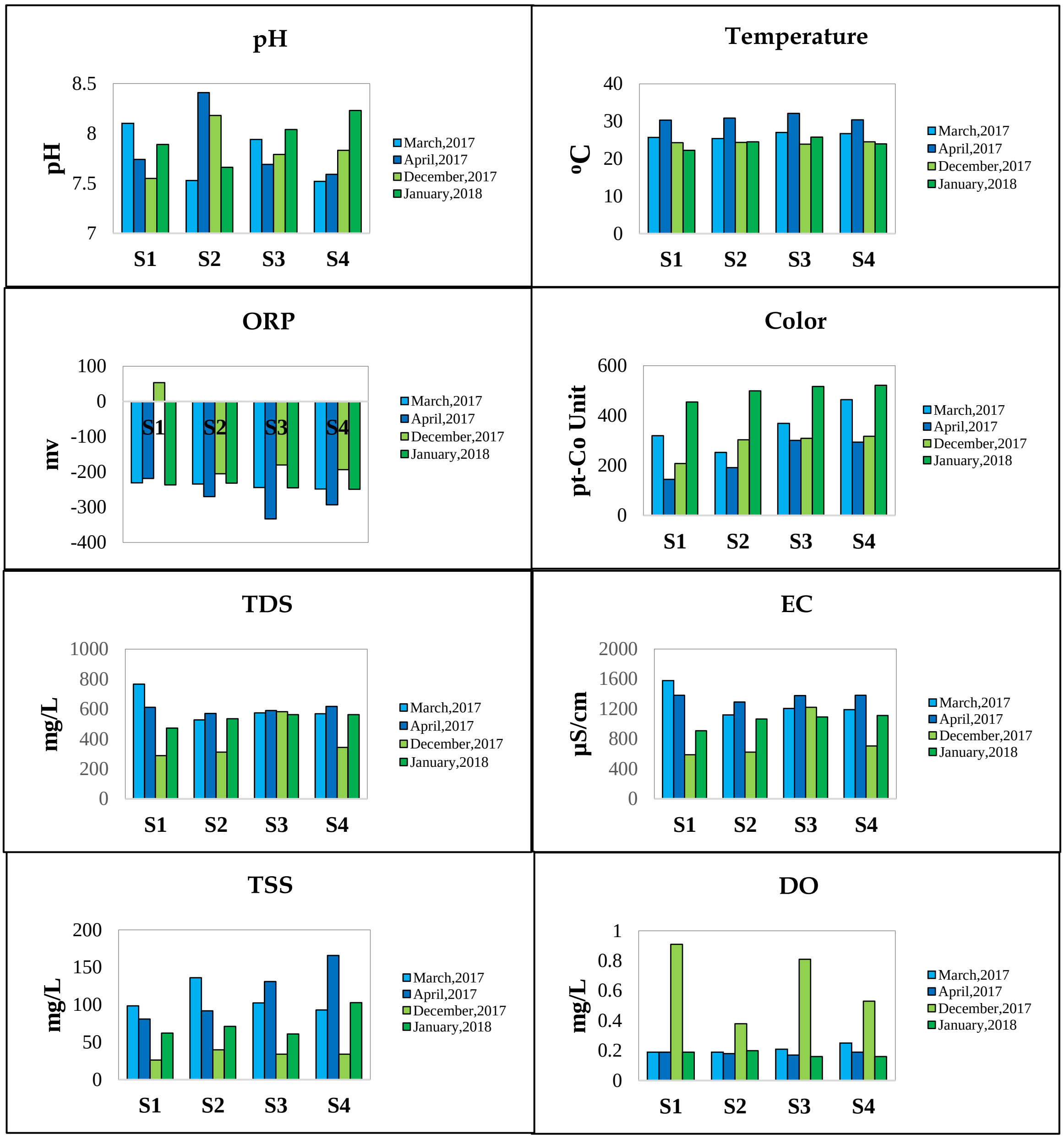

Figure 2: Spatial and temporal variation of physical water quality parameters of Tongi khal during dry season.

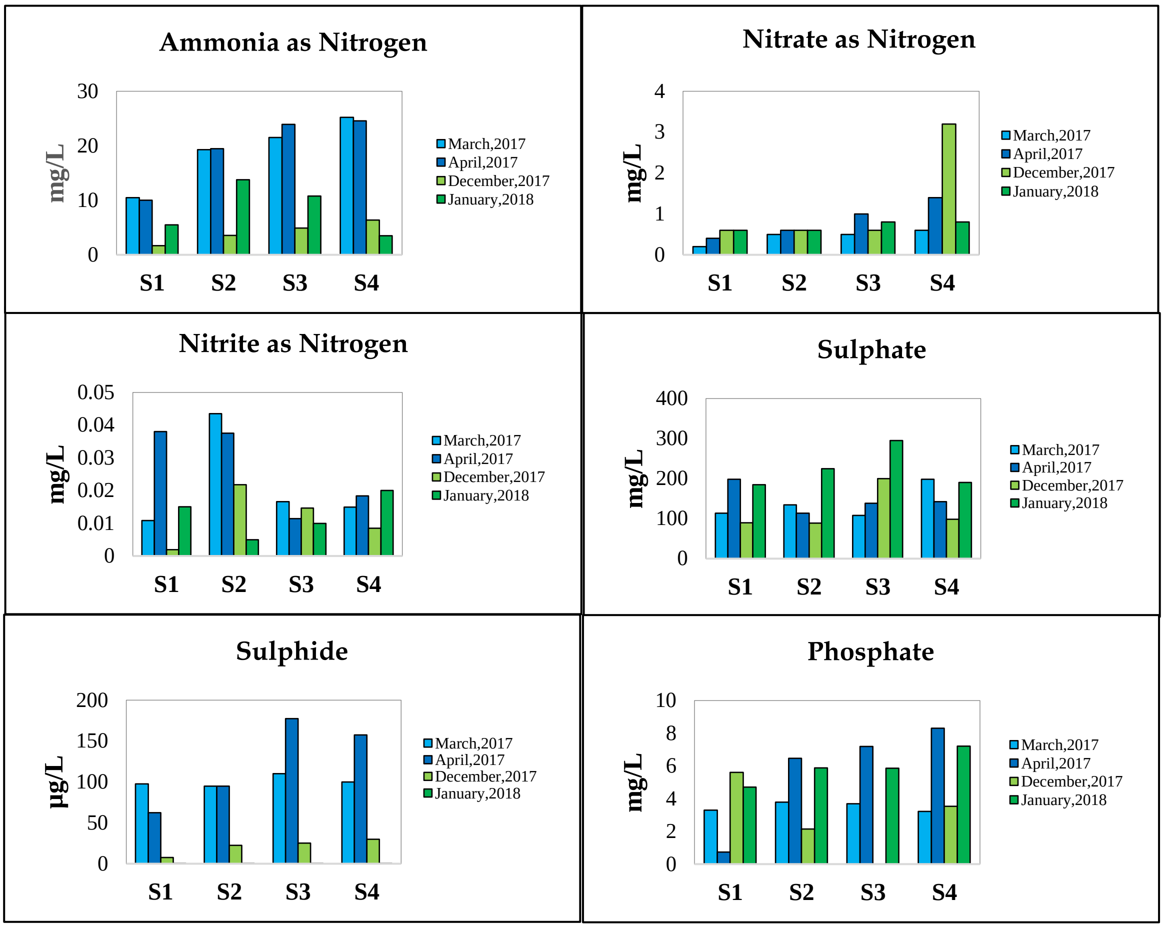

Figure 3: Spatial and temporal variation of inorganic nutrients in Tongikhal water during dry season.

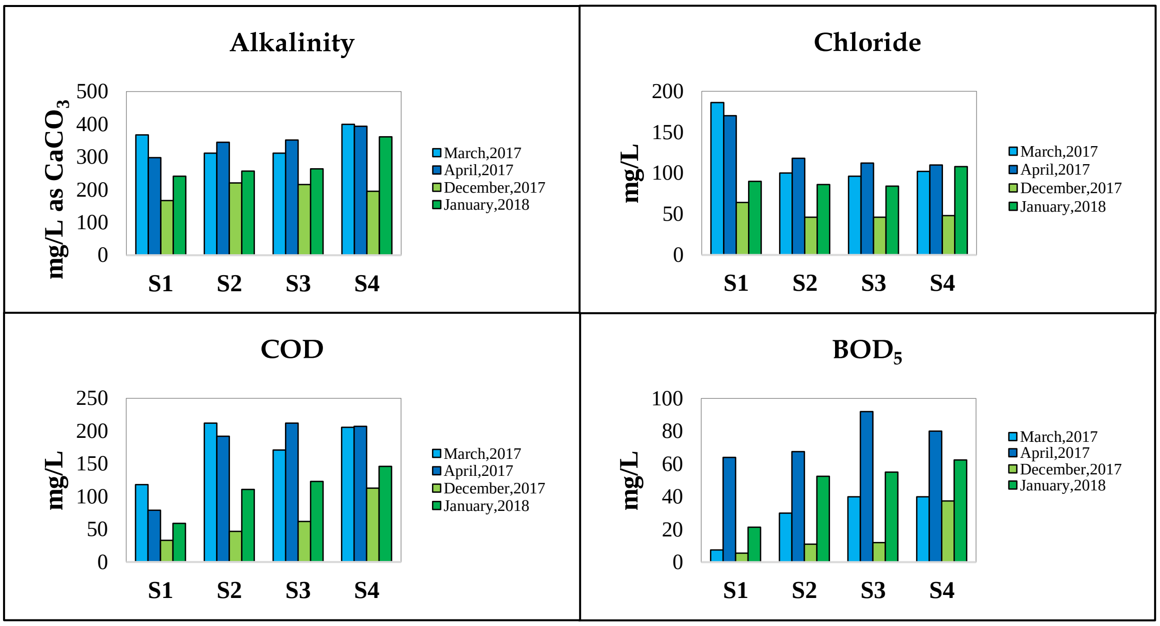

Figure 4: Spatial and temporal variation of Alkalinity, Chloride, COD and BOD_5 in Tongi khal water during dry season.

3.2 Temporal variation Tongi khal water quality during dry period

The water quality data of Tongi khal presented in Table 1 shows significant temporal variation of water quality within the dry season. In Bangladesh, November-December marks the beginning of the dry season, while March-April marks the end of the dry season. Analysis of the water quality data suggests that water quality of Tongi khal becomes worse (with respect to most parameters considered in this study) at the end of the dry season (i.e., March-April). During March-April (i.e., pre-monsoon), highest BOD_5, COD and ammonia concentration in Tongi khal water were 91.9 mg/L, 212 mg/L and 25.2 mg/L, respectively; the corresponding values for the samples collected during December-January (i.e., winter) are 62.5 mg/L, 146 mg/L and 13.75 mg/L, respectively. Sulfide and TSS concentrations were also found to be higher in March-April. However, higher values of color and sulfate was recorded for samples collected during winter (i.e., November-December).

4. CONCLUSIONS

The major findings of this study are-

- The Tongi khal becomes highly polluted during the dry season by both the industrial and domestic wastes. Due to drying up of surface water and relatively low flow situation, the pollution becomes more intense in this period of time. The concetrations of some of the water quality parameters reach those commonly found in untreated domestic and industrial wastewater. During the dry season, the water quality appears to reach a critical state (e.g. highly anoxic) that is unlikely to support any aquatic organism.

- Bangladesh government is planning to restore the peripheral rivers of Dhaka.This program includes dredging of the rivers to ease the navigability as well as augmenting flow during the dry season. However, to make this program effective and successful, the baseline pollution scenario needs to be assessed. Only then an effective restoration program could be designed. This study provides a baseline surface water quality of Tongi khal during dry season.

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