POLLUTION STATUS OF TURAG RIVER: SPATIAL AND TEMPORAL VARIATION OF WATER QUALITY

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ABSTRACT
This study was undertaken in order to identify the major sources of pollution along the Turag river and the spatial and temporal variation of water quality along the river stretch. Sources of pollution were identified and categorized through survey and water samples were collected from different locations along the river through a half-year duration to understand the seasonal impact. Industrial waste constituted the major point source while human waste, solid waste and run off constituted non-point sources of pollution. Among the various parameters, pH, dissolved oxygen, ammonia, nitrate, phosphate, conductivity, sulphate, dissolved solids did not comply with standards during dry season, but levels of these parameters were mostly acceptable during wet season. Coliforms and other disease causing bacteria were detected in the river water. Heavy metal contamination was not significant in selected locations. Such spatial characterization of Turag river at a broader scale would enable selecting multiple suitable intake points for water treatment and distribution purpose.

Keywords: Turag River; pollution; waste water

INTRODUCTION
Turag River, passing through the northwestern part of Dhaka city originates from the Bangshi River, an important tributary of the Dhaleshwari River, flows through Gazipur and joins the Buriganga at Mirpur in Dhaka District. Due to rapid urbanization, Bangladesh is one of those polluted countries, which currently holds 1176 industries that discharge about 0.4 million m^3 of untreated waste to the rivers in a day (Rabbani and Sharif, 2005). Around Turag river there are 152 polluter industries that include 56 dyeing and textile industries, 50 chemicals and pharmaceuticals, nine food processing and 37 other engineering industries. Huge quantities of industrial effluents, solid waste from river-side settlements, petroleum products from ships, launches, cargoes, boats, untreated sewage etc. regularly get dumped into the rivers which are already severely polluted (Khan *et al*., 2007). As the fluvial environment of Bangladesh is mainly controlled by seasonal fluctuations, it is important to characterize the seasonal change for evaluating the temporal variations of water pollution (Bhuyan *et al*., 2010). The Turag River has been declared as ecologically critical areas (ECA) by the Department of Environment on September, 2009. Thus monitoring of pollution status of this river is crucial to save the aquatic ecosystem of this river. The main objectives of this study are as follows:

1. Identification of the major sources of pollution of Turag river and their categorization.
2. Evaluation of the spatial and temporal variation of water quality along Turag river.

METHODOLOGY
The study was conducted between the area of Tongi Bridge and 2.6 km towards upstream such as Location 1 (Tongi Bridge), Location 2 (Tongi Railway Bridge), Location 3 (Azmeri Composite Knit), Location 4 (Tongi Nodi Bondor) and Location 5 (Hossain Dyeing).

Survey and analysis of water samples
Various point sources and non-point sources of pollution were identified along the river through survey. Monthly samples were collected from five locations (Fig. 1) along the river during wet (wet 1-September, wet 2-October) season and dry season (Pre Dry-November, Dry 1-December, Dry 2-January, Dry 3-February) for a 6 month's period. Collected samples were analyzed for important

water quality parameters (pH, Color, Turbidity, Iron, Arsenic, Electrical Conductivity, DO, Total Hardness, Chloride, BOD_5, Salinity, total dissolved solids (TDS), total suspended solids (TSS), NH_3-N, NO_2-N, SO_4, PO_4, faecal and total coliforms etc). Bacteriological analysis was conducted in the laboratory of Department of Pharmecy and certain heavy metals such as Pb, Cd, Cr, Cu, and Zn were analyzed for location 2 in the river in the laboratory of Department of Public Health Engineering (DPHE). Seasonal and spatial variation of water quality was evaluated further.

RESULTS AND DISCUSSIONS

Sources of pollution

The major point sources of pollution included waste from dying industries such as Azmeri Knit Composite, Hossain Dyeing, Mehmud Industries Limited etc. and waste from fish market. Domestic and human waste generated from slum and storm water runoff is the main non-point source of pollution into Turag river.

Fig. 1: Satellite image of sampling points along Turag River (inset shows the sampling stretch of the river on the map of Dhaka city)

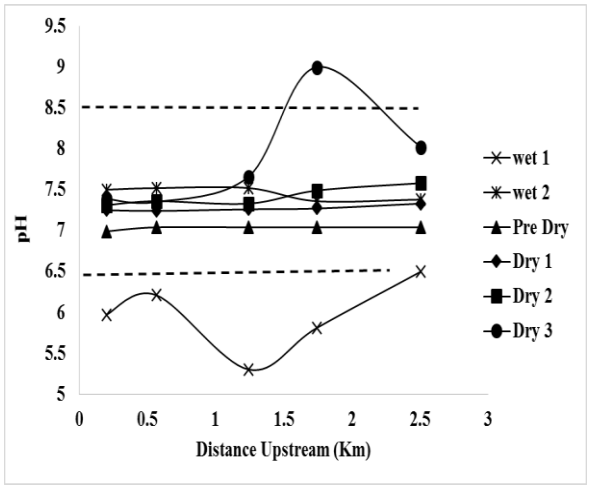
Water quality parameters

Summary of levels of water quality parameters measured for Turag river that did not comply with the standards to maintain aquatic ecosystem are provided in Table 1. The parameters were obtained towards the lower end of the ranges during wet season and those were mostly above the standard ranges during the dry season. Blackish color of water was seen in Turag River during dry season.

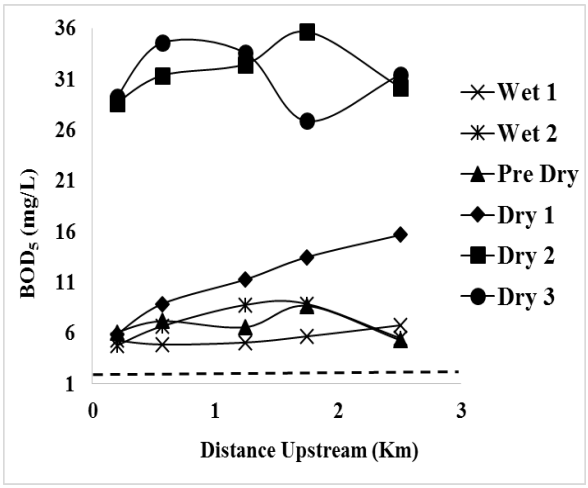
Fig. 2 shows the profiles of pH, 5-day biochemical oxygen demand, dissolved oxygen, ammonia and total dissolved solids along the river stretch.

Table 1: Ranges of concentrations of physical parameters along Turag river

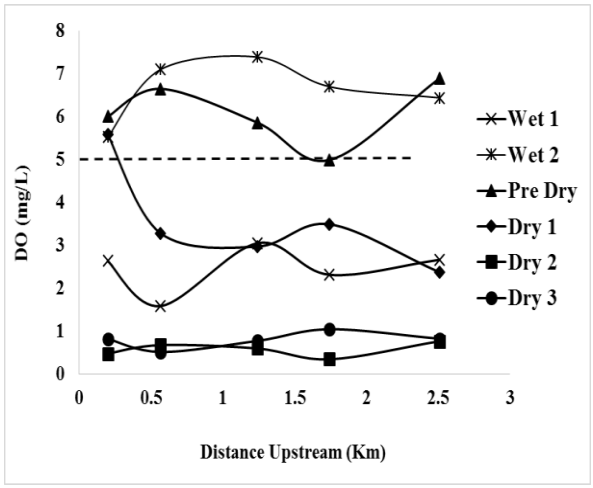
Parameters	Range of Concentration	DOE standards to maintain aquatic Ecosystem	Parameters	Range of Concentration	DOE standards to maintain aquatic Ecosystem
pH	5.3 - 9.0	6.5-8.5	NH_3 (mg/L)	0.11 – 8.16	0.5
BOD_5 (mg/L)	4.8 - 35.7	2	NO_3 (mg/L)	0.4 - 0.8	0.1
DO (mg/L)	0.34 -7.39	5	SO_4 (mg/L)	6.0 - 69	22
Conductivity (µS/cm)	88 - 1296	350	Cl_2 (mg/L)	77 - 166	13
PO_4 (mg/L)	2.0 - 16.2	6	TDS (mg/L)	41.7 - 641	165



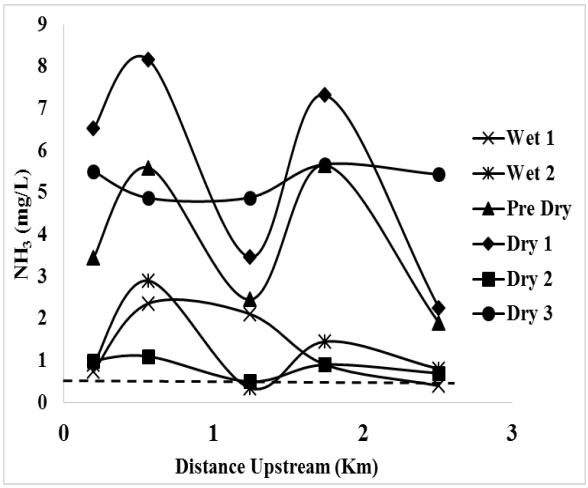
(a) pH



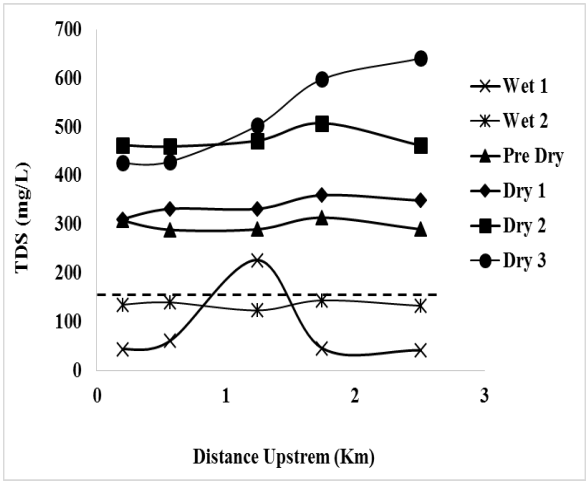
(b) Biochemical Oxygen Demand



(c) Dissolved Oxygen



(d) Ammonia



(e) Total Dissolded Solids

Fig. 2: Profiles of water quality parameters (a) pH; (b) Biochemical Oxygen Demand; (c) Dissolved Oxygen; (d) Ammonia and (e) TDS] along the river stretch at sampling periods starting from Sep 2015-Feb 2016 (Dotted line shows DoE standards for surface water quality)

As shown in Fig. 2, pH is within the standard range mostly except for early monsoon. BOD_5 reaches above 30 mg/L level during dry season. Accordingly, dissolved oxygen is adequate during wet season and below 2 mg/L during dry sampling periods. Oxygen demanding wastes get assimilated in the river easily during wet season whereas low flow conditions during dry season makes the recovery of the river zones from organic pollution difficult. Ammonia levels are measured above standard ranges at all instances, but reaches above 7 mg/L during dry seasons with considerable fluctuations along the stretch. Dissolved solids get diluted with the onset of monsoon and increases above 600 mg/L as the dry season proceeds.

Coliform test was done for one sampling in the month of December 2015 for Location 2 (Tongi Railway Bridge). Faecal and total coliforms were obtained at 1210 cfu/100 ml and 2180 cfu/100 ml respectively. Pathogenic contamination is significant in the river water possibly due to sewage pollution. This implies that Turag river water can be suitable for distribution only after conventional treatment (Ahmed and Rahman, 2000). Four species of bacteria were identified in the river water through bacteriological analysis such as *E. coli, S. typhimurium, Shigella spp. and Salmonella spp.*, which can impart health problems like diarrhoea, dysentery and skin disease etc.

Levels of five heavy metals (Pb, Cd, Cr, Cu, and Zn) were determined in the DPHE (Department of Public Health Engineering) laboratory from the location at Tongi Railway Bridge in Turag river. The heavy metal concentrations for the sampling site found in this study are shown in Table 2 along with the Bangladesh standards for the heavy metals.

Table 2: Heavy metal analysis results

Location	Bangladesh Standard	Unit	Concentration Present	Analysis Method	LOQ
Cadmium(Cd)	0.005	mg/L	0.001	AAS	0.00015
Copper(Cu)	1.0	mg/L	<LOQ	AAS	0.26
Chromium(Cr)	0.05	mg/L	0.007	AAS	0.001
Lead(Pb)	0.05	mg/L	0.009	AAS	0.002
Zinc(Zn)	5.0	mg/L	0.09	AAS	0.08

Note: LOQ = Limit of Quantitation, AAS = Atomic Absorption Spectrophotometer

The results of the study indicated that the heavy metal contents were within the range of standards. But the usages of these contents is increasing day by day, if the industries do not treat these contents seriously it would become a great concern soon. Future study is needed to identify heavy metal contents into the other locations of the river.

Comparison with previous studies

A number of studies have looked into the quality of the rivers around Dhaka city including Turag river. Some investigations that reported the status of Turag river water quality since last ten years have been summarized in table 3. Comparison of the previously analyzed water quality parameters with present study have led to the conclusion that the river water quality is deteriorating with respect to pH, EC, DO, BOD_5 and TDS. Multiple sampling points (both spatial and temporal) have been averaged and reported with standard deviation among the number of samplings in order to ascertain the variability in the levels of the concerned water quality parameters. The greatest variability along the river can be observed for the BOD_5 and TDS levels. This should of course be attributed to the locations of pollution sources along the riverside.

Table 3: Comparison of physical parameters with previous studies of Turag river with mean±standard deviation

Name of the Study	Year of study	pH	EC	TDS	DO	BOD_5	Alkalinity	Hardness
(Banu et al., 2013)	2006	7.1	98 (mg/L)	342 (mg/L)	6 (mg/L)	2.8 (mg/L)		
(Banu et al., 2013)	2010	7.5	1800 (mg/L)	812 (mg/L)	0 (mg/L)	22 (mg/L)		
(Meghla et al., 2013)	October 2011 to September 2012	5.69 ± 0.33	736.3 ± 41.52 (µs/cm)	398.9 ± 25.63 (ppm)	1.12 ± 0.50 (mg/L)	4.38 ± 3.57 (mg/L)	404.0 ± 30.19 (mg/L)	132.4 ± 13.53 (mg/L)
(Islam et al., 2012)	2012	7.40 ± 0.14	1273 ± 905.39 (µS/cm)	748.60 ± 549.78 (ppm)	2.36 ± 0.96 (ppm)	-0.98 ± 0.81 (ppm)		
(Mobin et al., 2014)	April 2013 to July 2013	6.76 ± 0.06	52.42 ± 10.47 (µS/cm)	319.92 ± 62.28 (ppm)	1.72 ± 0.53 (ppm)	1.15 ± 0.13 (ppm)	268.36 ± 28.31 (ppm)	127.09 ± 17.97 (ppm)
Present Study	September 2015 to February 2016	7.06 ± 0.56	577.47 ± 331.82 (µS/cm)	281.23 ± 163.18 (mg/L)	3.5 ± 2.52 (mg/L)	13.35 ± 12.13 (mg/L	53.03 ± 82.61 (mg/L)	130.67 ± 81.57 (mg/L)

Spatial Characterization of Turag River

This study involved sampling from different locations. Locations were chosen either near the industries or pollution sources or also at locations where no visible pollution sources existed in order to ascertain how much they contribute to pollute the water. Based on the water quality analyses, should Turag River be considered as a source of water for future treatment for drinking purpose, as the population is increasing and the scarcity of fresh water is getting higher, location 3 (Azmeri Composite Knit) could be a good option as the water quality was comparatively better from other locations as the results suggested. Most of the time the DO values were found higher in that point of sampling, which is also good for aquatic animals living in the water. Most of the water quality parameters for location 3 were closer to standard values than the other locations. Absence of non-point sources in the vicinity might be one of the causes for the parameters to be within the range. For subcritical flow conditions, sometimes the pollution cannot travel from upstream to downstream (downstream conditions are unaffected by upstream conditions). This along with other flow characteristics of the river might be the possible explanation for the location being less polluted than other locations. But further study is needed to identify better locations with more certainty.

CONCLUSIONS

- This study shows that the reasons behind the variations of water quality in different points of the river are mainly due to pollution as well as flow of water. At the points where the flow of water is less, the water there becomes more polluted than at the points where the flow of water is high.
- The major types of wastewater/ storm water outfalls contributing to the pollution of Turag river include: storm sewer pipes, open channels and small/big private outfalls.
- The major point sources of pollution are sewer lines and industries.
- The major non-point sources of pollution are human wastes, agricultural waste, indiscriminate dumping of untreated wastes, flood and runoff due to heavy rainfall.

- The investigated pH values were slightly high from DoE standards in dry season. Biochemical oxygen demand increased through the dry season, which was congruent with the decreasing levels of dissolved oxygen with the advancement of dry season. Electrical conductivity and total dissolved solids were above the DoE standard during dry season. Phosphate and ammonia levels were mostly higher from the DoE standard.
- All of the heavy metal Concentration values were within the range of Bangladesh Standard. So sampling locations were less polluted by heavy metals.
- Faecal coliforms and Total coliforms were analyzed for one location and the values were found to be 1210 CFU/100 ml and 2180 CFU/100 ml. Thus, water from Turag river can be considered for distribution purpose only after conventional treatment.
- Four species of bacteria were found through bacteriological analysis, which can impart diseases like diarrhea, dysentery and skin diseases.
- Spatial characterization of Turag River at a broader scale would enable selecting multiple suitable intake points for water treatment and distribution purpose.

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