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ASSESSMENT OF PHYSICOCHEMICAL CHARACTERISTICS OF INDUSTRIAL EFFLUENTS AND WATER BODY AT TONGI REGION, GAZIPUR, BANGLADESH

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Abstract

Samples were collected from ten different locations at Tongi region, which were analyzed by using different standard procedures. Different physicochemical parameters such as temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), and heavy metals such as Zn, Pb, Fe, Mn, Cu and Cd were determined. The study revealed that pH, TDS, EC and BOD were ranged from 6.60 to 8.30, 913 to 1431 mgL^{-1}, 100 to 192 μScm^{-1} and 0.75 to 1.83 ppm, respectively. DO of all collected samples were varied between 1.40 to 2.90 mgL^{-1}, which were below the standard level and thus affects the aquatic life. In respect to heavy metals Zn, Fe and Cu concentrations were in permissible level for fishes, irrigation and other purposes, whereas, most of the samples of Pb, Mn and Cd were exceeded the permissible limits and therefore, rendering the river useless for domestic, agriculture and industrial purposes.

Keywords: Effluent, industry, heavy metals, pollution, Turag River

Introduction

Bangladesh is one of the developing countries, which is being threatened by water pollution through uncontrolled industrial effluents. Huge quantities of industrial effluents; solid waste from river-side settlements; petroleum products from ships, launches, cargoes, boats and untreated sewage regularly get dumped into the Buriganga, Balu, Turag and Shitalakhya rivers, which are already severely polluted (Meghla *et al.,* 2013). Rapid urbanization and industrial development during last decade have provoked serious concerns for the environment. Large industrial establishment and their indiscriminate discharges pose a great threat to our environment (FAO, 2003). Industrial effluents may cause alteration of the physical, chemical, and biological properties of water bodies by continuous change in pH, BOD, temperature, odor, noise, turbidity etc. that is harmful to agricultural crop production, public health, livestock, wildlife, fish, and other biodiversity. Trace metals enter in the river water from variety of sources, which could be either natural or anthropogenic (Akoto *et al.,* 2008). Metals enter into river water from industrial areas through various ways such as mine discharge, run-off, chemical

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weathering of rocks and soils, wet and dry fallout of atmospheric particulate matter (Venugopal *et al.*, 2009). The Turag River is the upper tributary of the Buriganga, a major river in Bangladesh. Both the organic and inorganic wastes and effluents that discharged into the water body of Turag River are seriously deteriorating the water quality of the river (Meghla *et al.*, 2013).

The major pollution sources of Turag River water are various consumer goods industries (soap and detergent), garment industries, pharmaceutical industries, tanneries, dyeing industries, aluminum industries, battery manufacturing industries, match industries, ink manufacturing industries, textile, paint, iron industries, pulp and paper factories, chemical factories, frozen food factories and steel workshops etc. (Rahman *et al.*, 2012). Therefore, the objectives of the study were to examine the physicochemical parameters and heavy metals concentrations of the industrial effluents at Tongi region and to determine the present status of Turag River at different industrial points of Tongi Region.

Materials and Methods

Study Area

The study was conducted at Tongi Pourashava in Gazipur district, which lies between longitude 90°18'-90°28' E and latitude 23°54'-23°58' N. The Pourashava has an overall area of 33.68 km^2 and a core urban area of approximately 13 km^2 (Banglapedia, 2012).

Fig. 1. Map showing the study area (Source: Google earth, 2016).

Data Collection

Primary and secondary data sources were used to carry out the study. Primary data were attained through field observation and water sample analysis in laboratory. However, the collection of secondary data was also very significant to carry out the study. Secondary data were collected from different published articles relevant to this study (Akoto *et al.*, 2008; Meghla *et al.*, 2013; Rahman *et al.*, 2012; Irshad *et al*., 2011; Islam *et al*., 2010 and Bakali *et al.*, 2014).

Water Sample Collection

A total of ten samples (8 effluent samples and 2 river water samples) were collected from Tongi industrial area during the period of July to December, 2013 following the sampling techniques as outlined by APHA, 1995 and Sincero and Sincero, 2004. To prevent the loss, the samples were collected carefully and transported to the laboratory as quickly as possible in a preserved condition. For BOD samples were preserved adding with $FeCl_2$, buffer (pH 7.0), $MgSO_4$ and $CaCl_2$. In case of heavy metals samples were preserved adding with 0.1N HNO_3. From each sampling stations, 500 ml of water sample were collected into a plastic bottles. Before sampling, the bottles were cleaned with detergent and then washed with copious of distilled water. After sampling, the bottles containing samples were sealed immediately to avoid exposure to air and marked with necessary information. In order to analyze the pH, EC, TDS, DO, BOD, hardness and transparency water samples were carefully carried to the laboratory of the Department of Environmental Science and Resource Management (ESRM), Mawlana Bhashani Science and Technology University (MBSTU), Tangail. In order to analysis the heavy metals, samples were filtered through Whatman filter paper no. 42. After filtration 150 ml sample was taken and a few drops of concentrated HNO_3 (extra-pure) was added into the samples and then kept in the freeze. Then the samples were cautiously transported to Department of Agricultural Chemistry, Bangladesh Agricultural University (BAU), Mymensingh for chemical analysis. In the laboratory, the bottles were kept in a clean, cool and dry place to avoid contamination.

Analytical Methods

To analyze the physicochemical parameters of the effluents and water samples standard methods were followed and a number of instruments were used. For instance, pH was determined by the pH meter (WTW pH 522, Germany). Electrical conductivity (EC) of the samples were determined by the EC meter (WTW CF 521, Germany) following the method as outlined by Ghosh *et al.* (1983) and Singh *et al.* (1999). Total dissolved solid (TDS) was obtained by evaporating 50 mL filtered water sample in a porcelain dish. The solid residues were obtained by evaporating the samples to dryness according to the procedure as mentioned by Chopra and Kanwar (1980). Dissolve oxygen (DO) was determined through the titration with sodium thiosulphate solution and manganous sulphate solution. The biochemical oxygen demand (BOD) was measured by two steps where initial BOD (BOD_0) was measured immediately after the sample collection and after 5 days BOD (BOD_5) was measured by incubation in the dark condition at 20°C for 5 days. Then the total BOD (BOD_0-BOD_5) was measured according to Trivedy and Goel (1984). The concentrations of heavy metals (Fe, Zn, Cu, Mn, Pb and Cd) were analyzed by atomic absorption spectrophotometer (AA-7000, Shimadzu, Japan) by using the single element hallow cathode lamp at the wavelengths of 248.3, 213.9, 324.7, 279.5, 283.3 and 228.8 nm, respectively following the procedure described by APHA, 1995.

Results and Discussion

Analysis of Physicochemical parameters

The color of the collected samples were appeared slightly black, which is totally unsuitable not only for aquaculture but also for domestic and agricultural purposes. The study conducted by Rahman *et al.* (2012) asserted that the collected samples from the Turag river and different sewerage line were black in color because of contamination of industrial effluents. The temperatures of all collected samples were within the range of 31.2 to 34.4°C and average of 32.0°C (Table 1).

Table 1. Physico-chemical parameters of industrial effluents and water samples at Tongi region.

Sampling point	Parameters						
	Temperature (⁰C)	pH	TDS (mg/l)	EC (µS/cm)	Transparency (cm)	DO (mg/l)	BOD (ppm)
P-1	34.4	6.9	941	100	2.3	2.5	1.63
P-2	31.3	7.5	978	162	1.4	2.9	0.75
P-3	31.5	6.6	1028	170	2.0	1.7	1.24
P-4	31.2	6.8	913	151	1.9	1.9	1.16
P-5	31.3	7.8	1010	173	1.2	2.1	0.92
P-6	32.2	6.7	960	150	2.4	1.4	1.83
P-7*	32.1	8.3	1147	160	2.6	2.0	1.6
P-8*	32	7.5	932	124	3.0	2.3	1.35
P-9	31.3	7.2	1431	180	1.7	2.2	1.18
P-10	32.5	6.7	1054	192	2.2	2.4	1.76
Max.	34.4	8.3	1431	192	3.0	2.9	1.83
Min.	31.2	6.6	913	100	1.2	1.4	0.75
Mean ± SD	32.0 ± 0.97	7.2 ± 0.56	1039.4 ± 153.99	156.2 ± 27.14	2.07 ± 0.55	2.14 ± 0.42	1.34 ± 0.36

Note: SD= Standard deviation

The results of the study revealed that pH of the samples were fluctuated at 6.60 to 8.30 (Table 1). On the basis of measured pH of all the collected samples showed that the values were within the acceptable range (6.5 to 8.5) as defined by the ECR (1997). However, a similar observation was reported by Rahman *et al.* (2012) for the seasonal variations in the Turag River water quality.

The EC of all collected effluent samples were within the range of 100 to 192 µScm^{-1} with an average of 156.2 µScm^{-1}. The highest EC was recorded as 192 µScm^{-1} and lowest was 100 µScm^{-1} (Table 1). TDS of the collected samples were within the range of 913 to 1431 mgl^{-1} (Table 1). It revealed from the study that TDS of all of the collected samples were within the acceptable range. For instance, the acceptable standard of TDS for inland surface water is 2100 mgl^{-1} (ECR, 1997) whereas ADB (1994) defined the acceptable standard of TDS for industrial water is 1500 mgL^{-1}and irrigation water is 2000 mgl^{-1}. However, water that contains less than 500 ppm of dissolved solid is generally satisfactory for the domestic use and other industrial purposes and water containing more than 1000 ppm of dissolved solids usually contains minerals that give it a distinctive taste or make it unsuitable for human consumption (Irshad *et al*., 2011).

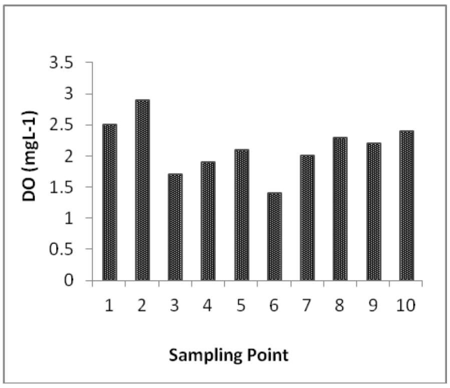

Fig. 2. DO at different sampling points.

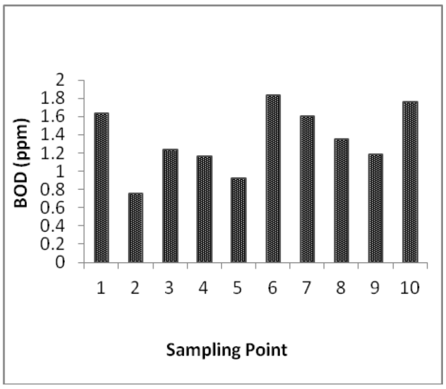

Fig. 3. BOD at different sampling points.

The DO of all collected effluent samples were within the range of 1.40 to 2.9 mgl^{-1} with an average value of 2.11 mgl^{-1} (Table 1). The lowest DO concentration was measured as 1.40 mgL^{-1} and the highest was measured as 2.9 mgL^{-1} (Fig. 2). The DO values prescribed by the Environmental Quality Standard (EQS) as 6.0 mgL^{-1} for drinking, 4.0 to 5.0 mgl^{-1} for recreation, 4.0 to 6.0 mgl^{-1} for fish and livestock and 5.0 mgl^{-1} for industrial application (Rahman *et al.,* 2012) whereas Bangladesh Environment Conservation Rule (ECR, 1997) defined the DO values for the inland surface water as 4.5-8.0 mgl^{-1}. The study showed that the measured DO values of all water samples were not within the acceptable range, which may due to wastewater contamination from different industries and therefore affecting the aquatic environment. For instance, as dissolved oxygen levels in water drop below 5.0 mgl^{-1}, aquatic life is put under stress, which explain that the DO of industrial water is very low than the other sources of water due to the presence of different organic and inorganic matters in the water (Sawyer *et al.,* 2008). This implies that the effluent discharge from different industries might have released high oxygendemanding wastes (Emongor, 2005). Adequate DO is necessary for good water quality, survival of aquatic organism and decomposition of waste by microorganism (Islam *et al*., 2010; Rahman *et al*., 2012). However, environmental implication of low DO causes the death of aquatic organisms (Chapelle and Petts, 2004).

The BOD at different sampling points were recorded as 0.75 to 1.83 ppm (Table 1). The highest BOD was measured as 1.83ppm (Fig. 3), which might be due to discharge of organic materials at that point. The biodegradation of organic materials exerts oxygen tension in the water that directly affects the BOD of the water body (Akoto, 2008). When BOD is lower free oxygen is available and can be consumed by the microbial activity (Sawyer *et al.,* 2008). The study revealed that the measured BOD of all of the collected samples were within the standard level (50 mg/l) as defined by the ECR (1997) for the inland surface water.

Analysis of heavy metals

The concentration of zinc in the samples ranged from 0.04 to 0.24 mgL^{-1} with an average value of 0.12 mgl^{-1} (Table 2). Ayers and Westcot (1985) asserted that the maximum permissible limit of Zn in irrigation water is 2.00 mg/l whereas ECR (1997) recommends the standard of Zn as 5.00 mgl^{-1} for inland surface water. Considering these limits as standard, all samples were found suitable for irrigation and all other purposes. A similar observation was reported by Rahman *et al*. (2012), for the seasonal variations in the Turag river water quality as well as Bakali *et al.* (2014) for water quality evaluation of Tongi area in Bangladesh.

Table 2. Heavy metals of industrial effluents and water samples at Tongi region.

Sampling Point	Parameters					
	Zn (mgL^{-}1)	Pb (mgL^{-}1)	Fe (mgL^{-}1)	Mn (mgL^{-}1)	Cu (mgL^{-}1)	Cd (mgL^{-}1)
P-1	0.07	0.12	0.6	0.17	0.01	0.03
P-2	0.04	0.2	0.18	0.25	0.05	0.04
P-3	0.09	0.23	0.07	0.31	0.07	0.03
P-4	0.24	0.08	0.35	0.43	0.04	0.02
P-5	0.11	0.05	0.88	0.23	0.05	0.04
P-6	0.18	0.13	0.67	0.25	0.02	0.03
P-7*	0.1	0.03	0.61	0.35	0.02	0.05
P-8*	0.09	0.14	0.14	0.22	0.04	0.01
P-9	0.16	0.18	0.04	0.28	0.06	0.02
P-10	0.08	0.11	0.09	0.48	0.03	0.06
Max.	0.24	0.23	0.88	0.48	0.07	0.06
Min.	0.04	0.03	0.04	0.17	0.01	0.01
Mean ± SD	0.12± 0.06	0.13± 0.06	0.36± 0.3	0.3± 0.1	0.04± 0.02	0.03±0.01

Note: SD= Standard deviation

The concentration of Pb in the samples fluctuated between 0.03 to 0.23 mgl^{-1} (Fig. 4) with an average value of 0.13 mgl^{-1} (Table 2) whereas the Bangladesh Environment Conservation Rule (ECR, 1997) defined the acceptable range of Pb is 0.1 mgl^{-1} for inland surface water. The standard of Pb for domestic water supplies is < 0.05 mgl^{-1}as stated by USPH and 0.01 mgL^{-1} by ISI (De, 2005). The standard of Pb for drinking water is 0.05 mgl^{-1}, industrial water is 0.01 mgL^{-1} and irrigation water is 0.05 mgL^{-1} (ADB, 1994). Considering these limits as standard Pb concentration in most of the samples were not within the suitable range for all purposes. A similar observation was reported by Rahman *et al*. (2012), for the seasonal variations in the Turag river water quality as well as Bakali *et al.* (2014) for water quality evaluation of Tongi area in Bangladesh. The concentration of Fe in the samples fluctuated between 0.04 to 0.88 mgl^{-1} (Fig. 5) with an average value of 0.36 mgl^{-1} (Table 2). According to Bangladesh Environment Conservation Rules (ECR, 1997) the acceptable range of Fe is 2.0 mgl^{-1} for inland surface water. However, Ayers and Westcot (1985) recommended the maximum concentration of Fe in irrigation water is 5.0 mgl^{-1} whereas an international standard for inland surface water is 1.0 mgL^{-1} as recommended by WHO (2008). Considering this limit as standard, concentration of Fe in all samples were found within the permissible limit and therefore suitable for irrigation and fish culture. A similar observation was reported by Bakali *et al.* (2014) for water quality evaluation of Tongi area.

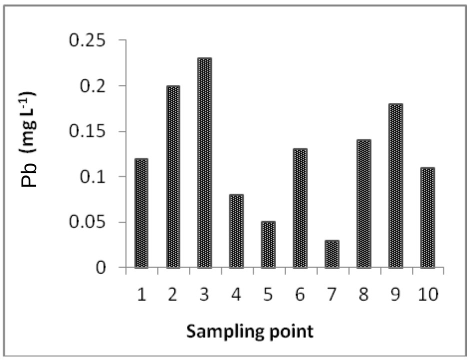

Fig. 4. Pb concentration at different sampling sampling points.

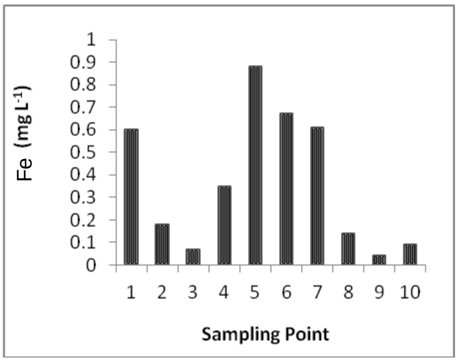

Fig. 5. Fe concentration at different sampling sampling points.

The concentration of Mn in samples varied between 0.17 to 0.48 mgL^{-1} (Fig. 6) with an average value of 0.30 mgL^{-1} (Table 2). According to Ayers and Westcot (1985), maximum recommended limit of Mn in irrigation water is 0.20 mg L^{-1}. The standard of Mn for domestic water supplies is <0.05 mgL^{-1} as recommended by USPH (De, 2005). Considering this limit, Mn concentration in samples exceeded the maximum acceptable level, which was not suitable for irrigation as well as domestic water supplies. Copper (Cu) concentration in samples varied between 0.01 to 0.07 mgL^{-1} (Fig. 7) with an average value of 0.05 mgl^{-1} (Table 2). According to Bangladesh Environment Conservation Rule (ECR, 1997) the acceptable range of Cu is 0.5 mgl^{-1} for inland surface water. A similar observation is reported by Meghla *et al.* (2013) for the assessment of physicochemical properties of water from the Turag river in Dhaka city. However, the Cu concentration in all of the samples were found within the recommended limit (0.20 mgL^{-1}) for irrigation as described by Ayers and Westcot (1985). The National Academy of Science has recommended that for continuous use irrigation effluent water should contain no more than 0.2 mgl^{-1} Cu (Gibeault and Cockerham, 1985).

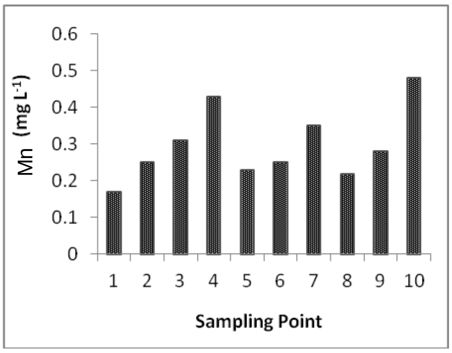

Fig. 6. Mn concentration at different sampling points.

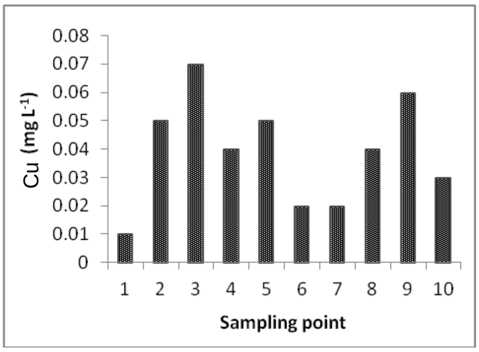

Fig. 7. Cu concentration at different sampling points.

The concentration of Cadmium (Cd) in the samples ranged from 0.01 to 0.06 mgL^{-1} (Fig. 8) with an average value of 0.03 mgl^{-1} (Table 2). The standard of Cd for drinking water is 0.005 mgL^{-1}, irrigation water is 0.01 mgl^{-1} and livestock water is 0.5 mgl^{-1} (ADB, 2004). However, according to Bangladesh Environment Conservation Rules (ECR, 1997) the acceptable range of Cd is 0.50 mgl^{-1} for inland surface water.

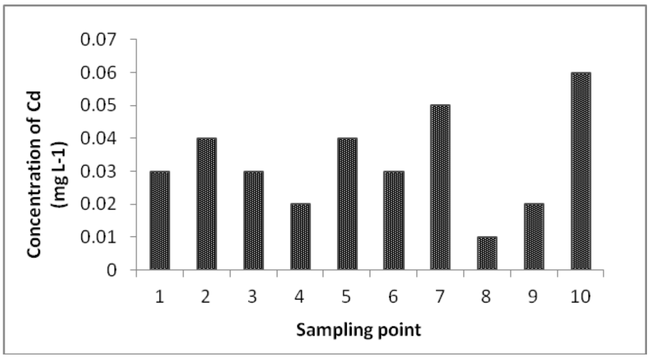

Fig. 8. Cd concentration at different sampling points.

Conclusion

The study focuses on the concentration of physicochemical parameters and heavy metals resulted from the effluent discharges by the industries at Tongi region. It revealed from the study that the physicochemical parameters such as pH, TDS, EC and BOD were within the permissible limit and therefore suitable for irrigation and other purposes. However, the DO of all the collected samples were varied between 1.40 to 2.90 ppm, which was below the standard level and thus affects the aquatic life. The BOD of all collected samples was within the range of 0.75 to 1.83 ppm. The study showed that the concentration of heavy metals such as Zn, Fe and Cu were within the permissible limit whereas Pb, Mn and Cd exceeded the permissible limit, which pose a serious threat for the aquatic environment. This study suggests that wastewater from the industries should be treated before being discharge into the water body. Moreover, necessary measures should be taken to prevent the water pollution whereas the development of industrial waste management systems can improve the situation and safeguard the natural water bodies in the country.

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