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Physico-Chemical Properties of Tannery and Textile Effluents and Surface Water of River Buriganga and Karnatoli, Bangladesh

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Abstract: The physico-chemical properties of tannery and textile effluents and water of adjacent river (Buriganga and Karnatoli, Dhaka) at three different locations were studied. The physico-chemical properties such as Biological OxygenDemand (BOD), salinity, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Sodium (Na^+), Potasium (K^+), Calcium (Ca^{2+}), Iron (Fe^{3+}), Phophate (PO_4), Chloride (Cl^-), Nitrite (NO_2) and Nitrate (NO_3) of tannery effluent were 92.12-100.6, 4.05-5.83, 3200-5355, 850-1103.9, 1737.62-1835.0, 65.5-72, 188.5-273.1, 0.26-0.32, 50.85-66.88, 79.41- 88.79, 0.66-1.22 and 0.48-4.63 mg/l, respectively whereas in textile effluent, the sevalues were 46.9-58.5, 0.75-1.03, 984.0-1148, 872.75-1282.4, 390.0-411.1, 12.4-31.0, 37.21-54.82, 0.12-0.18, 18.25-19.88, 72.21-135.87, 0.07-0.74 and 0.47-1.02 mg/l, respectively. Anions in the effluent showed a decrease in concentration with distance from point source. The concentration of the parameters in the surface water of tannery adjacent to river Buriganga were 25.58-36.87, 0.3-0.56, 175.0-259.5, 170.0-531.5, 55.5-91.0, 25.0-40.5, 13.84-26.84, 0.032-0.088, 1.08-2.32, 59.4-69.18, 0.22-0.37 and 0.43-0.91 mg/l, respectively whereas in the surface water of textile adjacent to river Karnatoli the values were 24.5-37.5, 0.0-0.5, 90.7-180.0, 78.35-111.8, 8.6-177.7, 3.18-9.0, 18.1-24.46, 0.0-0.038, 0.54-0.81, 17.18-33.53, 0.14-0.31 and 0.45-1.16 mg/l, respectively. In conclusion, all the parameters in the tannery and textile effluents were higher than the DoE Standard recommended for open water, however, except BOD_5 these values were lower in the surface water of Buriganga and Karnatoli rivers.

Key words: Physico-chemical properties · Tannery effluent · Textile effluent · River Buriganga · River Karnatoli

INTRODUCTION

Local topography, hydrology, biology and geology in catchments areas, as well as local precipitation levels and climate determine the wide range of water chemistry conditions observed in lakes and streams. In addition, anthropogenic influences *viz.* urban, industrial and agricultural activities, increasing exploitation of water resources, together determine the quality of surface water in a region [1, 2]. Surface waters are most vulnerable to pollution due to their easy accessibility for disposal of wastewaters. Rivers play a major role in assimilation or carrying off the municipal and industrial wastewater and run-off from agricultural land. The industrial areas in Bangladesh are situated in the midst of densely populated regions, along the banks of the rivers. Industries cause environmental degradation throughout the life cycle of a product starting from exploration of raw materials and energy resources to disposal of wastes and end products [3].

Industries such as textiles, engineering, electronics and tannery etc. are flourishing in recent years [3]. Textile industries are one of the largest water users and polluters resulting in high wastewater generation [4, 5]. The tannery operation consists of converting of the raw hide or skin into leather, consequently, make it as a potentially pollution intensive industry. Tannery and textile effluents offer the alteration of physical, chemical and biological properties of aquatic environment. Apart from the most toxic heavy metals like Chromium (Cr) chemical impurities of tannery effluents mostly comprises of the following dissolved substances such as inorganic salt cations (Fe, Zn, Cu, Ca, Na, etc.); anions such as SO_4^{2-}, NO_3^-, PO_4^{2-}; and parameters such as DO, TSS, TDS [6].

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Dyes contributed to overall toxicity at all process stages having high level of BOD, salinity, color, toxicity, surfactants, fibers and turbidity and may contain heavy metals [7, 8]. AEPA [7, 8] reported that the presence of metals and other dye compounds inhibit microbial activity and some cases may cause failure of biological treatment system.

EPA [9] reported that the pollution parameters in industrial effluents are suspended solids, BOD, nitrogen, phosphate, temperature, heavy metals, pH, alkalinity-acidity, oils and grease, sulphides etc. In this study an attempt was made to assess the levels of some water quality parameters such as BOD, salinity, TSS, TDS, Na, K, Ca, Fe, PO_4, Cl, NO_2 and NO_3 of two industrial effluents (tannery and textile) and their adjacent river (Buriganga and Karnatoli) water as these properties are important factors and influences the growth and physiological activities.

MATERIALS AND METHODS

Two industries i.e., tannery (Nur Bhai Tannery, Rayer Bazar, Dhaka) and its adjacent river Buriganga as well as textile (Doyel Complex, Savar, Dhaka) and its adjacent river Karnatoli were selected. Water samples were collected from three stations of each industries: one from the effluent and another two samples from two different locations (point source and surface water) of the adjacent river (Figs. 1 and 2).

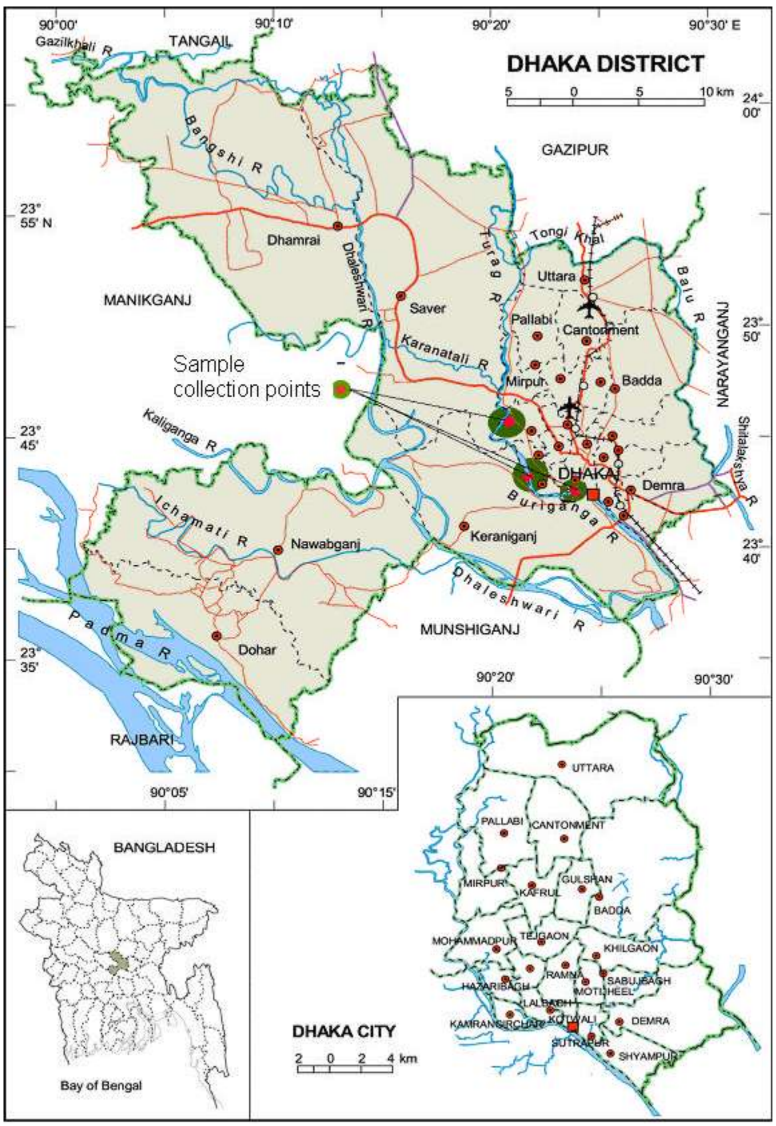

Fig. 1: Sampling points at Buriganga River

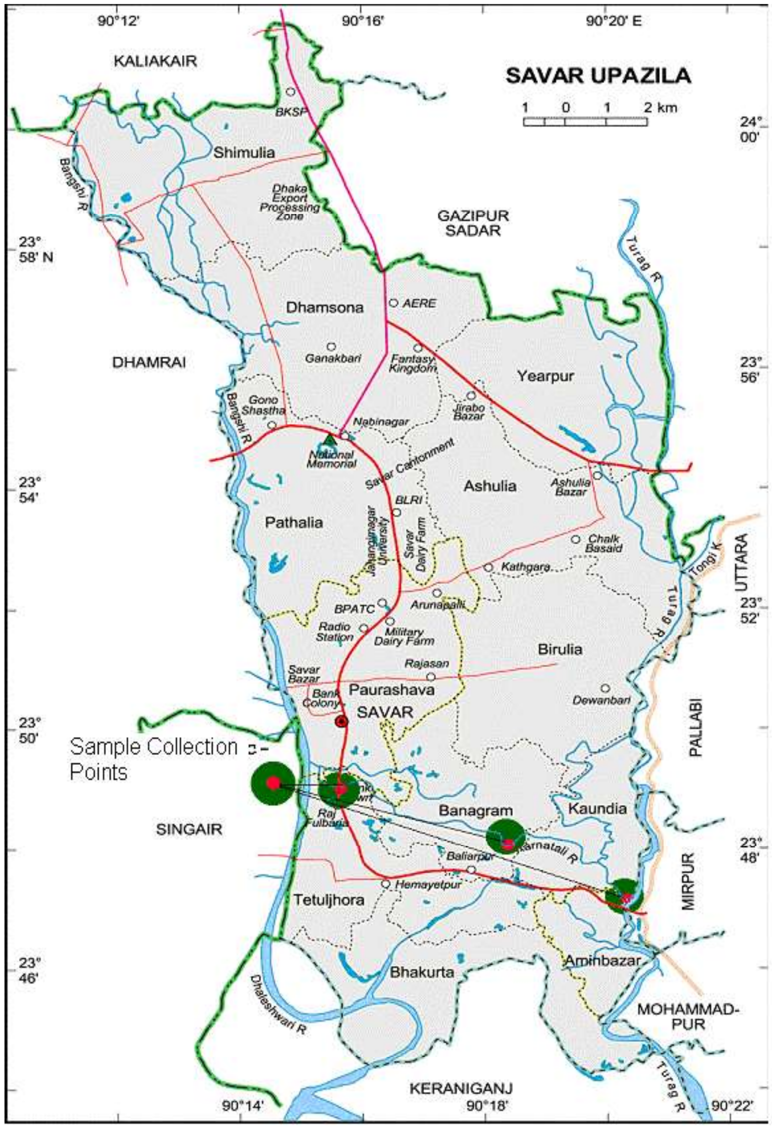

Fig. 2: Sampling points at Karnatali River

Water samples were collected from the stations in rainy, dry and summer seasons during September, 2006 to August, 2007. The water samples were collected from a depth of 0.5m below the surface using Nansen type water sampler and kept in polyethylene containers (washed with dilute HNO_3 and de-ionized distilled water). In the laboratory the water samples were filtered using fine filter paper (Whatman Filter Paper 41, Diameter 125 mm) to remove the suspended materials. The filtrate was kept in polyethylene container for anion analysis. The sample was analyzed for 11 physicochemical parameters following standard methods such as (BOD_5) by Fixed control dilution method, TDS and TSS by Hanna Instruments H19143: Salinity using salinity meter (Hanna Instruments H19143): Na and K by flame photometer: Fe and Ca using Atomic Absorption Spectrophotometer (AA-6401 F, SHIMADZU, Japan): PO_4, NO_2, NO_3, Chloride (Cl^-) by ion chromatography (Shimadzu Class-VP V6.14 SP1). The data were presented as mean ± standard deviation of the replicated samples.

RESULTS AND DISCUSSION

Biochemical Oxygen Demand (BOD): BOD level seasonally varied a bit in both textile and tannery effluents, but in the dry season it was two times higher in tannery effluent compared to the textile effluents. In case of Buriganga river water BOD during rainy, dry and

Table 1: BOD, TSS, TDS and Salinity of Tannery Effluents and Adjacent Buriganga River Water

	BOD (mg/l)			Salinity (mg/l)			TDS (mg/l)			TSS (mg/l)		
Sites	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum
Ta1	92.22±9.58	100.6±6.99	92.12±1.23	4.05	5.83	4.5	4810±438.4	5355±219.1	3200±141.4	1000±141.4	1103.9±146.9	850±28.2
Ta2	55.3±13.6	74.0±6.33	48.85±1.4	0.6	1.9	1.3	943.5±787.0	2188±230.2	290±7.0	700±14.1	899.6±140.8	500±70.7
Ta3	25.58±2.85	36.87±11.8	27.56±0.08	0.3	0.56	0.3	175±70.7	259.5±190.2	175±7.0	325±35.3	531.5±468.8	170±7.07

Ta 1=Tannery effluents, Ta 2 and Ta 3= Buriganga river water

Table 2: BOD, TSS, TDS and Salinity of Textile Effluents and Adjacent Karnatoli River Water

	BOD (mg/l)			Salinity (mg/l)			TDS (mg/l)			TSS (mg/l)		
Sites	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum
Te1	52.4±14.0	46.9±2.26	58.5±0.7	0.75	1.03	0.9	1148±436.9	1021.5±122.3	984.0±14.14	1057±152.0	1282.4±60.6	872.85±3.32
Te2	36.2±18.38	28.55±1.48	48.3±0.42	0.3	0.56	0.2	371.45±409.4	245.5±9.19	457.0±4.24	173.7±88.3	303.4±170.06	250.27±2.86
Te3	28.9±9.3	24.5±1.55	37.5±1.4	0.0	0.5	0.0	90.7±41.3	152.0±32.5	180±14.1	78.35±7.28	111.8±19.09	96.4±1.55

Te1= Textile effluents, Te2 and Te3=Karnatoli river water.

summer season ranged from 25.58-55.31, 36.87-74.0 and 27.56-48.85 mg/l, respectively (Table 1) and in Karnatoli river water BOD in rainy season ranged from 28.9 - 36.2 mg/l, in dry season 24.5 - 28.55 mg/l and 37.5 - 48.3 mg/l during summer season (Table 2). The mean BOD (36.87±11.8) of the surface water of Buriganga was highest during dry season whereas in Karnatoli River the highest BOD (37.5±1.4) was found in summer season. Hadiuzzaman [10] found 11-16 mg/l BOD in Sitalakhya river and 22-54 mg/l in Balu River. The findings from present study are nearly similar with Balu River.

Tannery and textile industries use organic substances as raw materials and high levels of dissolved organic matter consume large amounts of oxygen and increase BOD level, which undergoes anaerobic fermentation processes leading to formation of ammonia and organic acids. Hydrolysis of these acidic materials causes a decrease of water pH values [11]. Das *et al.* [12] reported lower pH (7.2) and DO (1.77±0.67 mg/l) level in the surface water of Buriganga in dry season and in Karnatoli (pH 7.5 and DO 3.9±0.56) during summer. Low pH and DO values in a river affect aquatic lives as low pH might allow toxic elements and compounds to become mobile and available for uptake by aquatic plants and animals whereas low DO level could result in the non maintenance of conditions favorable to the gill-breathing aquatic organisms and increase the sensitivity of fish to chemicals [13]. The BOD level of tannery effluents and waste receiving point of Buriganga river are higher than the DoE standard for open water (50 mg/l) [14] whereas BOD level of textile waste samples were below the DoE standard.

Total Suspended Solids (TSS) and Total Dissolved Solids (TDS): TSS value ranged from 170 - 325 mg/l in Buriganga, while it varied from 78.35-111.8 mg/l in Karnatoli River. In rainy season the surface water of Karnatoli river contain lower TSS value (78.35 ± 7.28) as compared to Buriganga, though textile effluent contain higher TSS in the same season than the tannery effluent (Tables 1, 2). The TSS of tannery and textile effluents were higher than the Bangladesh standard of effluents (150 mg/l). The Bangladesh Center for Advanced Studies [15] found that TSS of Sitalakhya river was 110 mg/l in 1980 and a higher value of 1440 mg/l in 1998. Alam *et al.* [16] studied TSS content of major rivers of Bangladesh and found TSS in Buriganga river (near Hazaribagh) ranging from 0.01 to 0.03 g/l during dry season and 0.1 g/l in rainy season, while TSS near Badamtoli was 0.01 to 0.04g/l in dry season and 0.3 to 0.6 g/l in rainy season. The TSS value found in the present investigation is nearly similar to the findings of Alam *et al.* [16].

Higher TDS value was measured in tannery effluent than the textile effluent, with a maximum of 5355 ±219 mg/l in dry season. In the present investigation the seasonal variation in TDS concentration in both rivers were found. The TDS attained to its maximum value in the period of dry season and the lowest value was found during summer. During dry season the mean value of TDS was 2188 ±230.2 mg/l in point source and 259.5±190.2 mg/L in surface water of Buriganga whereas in the surface water of Karnatoli River, it was 152.0±32.5 mg/l. The Bangladesh Center for Advanced Studies [15], analyzed that TDS of Sitalakhya River cross the limit and TDS raised 216 to 446 mg/l from 1980 to 1998. Alam *et al.* [17] studied on water quality parameters of the four-river system in the Sundarban and found the TDS seasonally varied from 0.43 to 44.4 g/l. Rahman *et al*. [18] studied on water quality characterization of the Sundarban Reserve Forest (SRF), Khulna, for biodiversity consideration and found the TDS of the Passur-Sibsa river system varied from 8.9 to 42.2 g/l. The values of TDS in the surface water collected from Bhairab river, Khalishpur were in the range of 0.3 to 0.5 g/l [19]. Faruque [20] studied on industrial waste discharge into the river Bhairab and Rupsha, Bangladesh and found the TDS seasonally varied from 2.12 to 2.59 g/l. The present investigation well agrees with the previous findings [17-20]. The concentration of TDS in effluents in all the seasons were higher than the DoE standard (2100 mg/l) and in river water the concentrations were lower than the DoE standard except dry season.

High TSS and TDS detected could be attributed to the high color (from the various dying stuffs being used in the textile mills) and they may be major sources of the heavy metals as increased heavy metals concentrations in river sediments could increase suspended solids concentrations [21]. It is uncertain what effect of high TDS values might have on fish, but any increase in free ion concentrations in the external environment as well as concentrations of other environmental stressors would lead to osmoregulation imbalances. However, if the concentrations of the ions increase in plasma and then adverse effects on the heart rate and nerve excitability will occur.

There is an inverse linear correlation between TDS value and DO level, therefore, high TDS values always corresponds to low DO level [22]. In this study high TDS was found in textile (1021.5 ±122.3) and tannery effluent (5355 ±219 mg/l). However, Das *et al.* [12] reported lower DO in tannery (0.87±0.31) and textile effluent (1.26±0.014) during the same period. Such occurrences might be possible due to the presence of high concentration of TDS and turbidity from suspended solids that reduce water clarity and cloudy water absorbs more heat and blocks light penetrations. Therefore, increased turbidity increases water temperature and prevents photosynthesis which in turn reduces the concentration of DO as warm water hold less DO than cold water.

Salinity: Salinity was higher in tannery effluent (5.83 mg/l) and its adjacent river (0.56 mg/l) compared to textile effluent (1.03 mg/l) and its adjacent river (0.0 mg/l) (Tables 1, 2). In surface water of Buriganga salinity ranged from 0.3-0.56 mg/l while in Karnatoli river it ranged from 0.0-0.5 mg/l. High salinity was recorded in dry season in both rivers. Salt is the preliminary ingredient of tanning and the maximum salinity (5.83 mg/l) was found in tannery effluents during dry season which was the peak period for tannery business in Bangladesh. Salt also used in textile industries with dyes. However, high salinity might lead to high EC. According to Das *et al.* [12] the EC of tannery effluent was 10455 ± 2722.36 μS/cm and in Buriganga and Karnatoli river were 614.5 ± 275.0 and 175.6 ±82.5 μS/cm, respectively. In fresh water environment high salinity has detrimental effect on fresh water organisms, especially osmotic imbalance and impairment of homeostasis process in aquatic lives.

Inorganic Salt Cations: The data presented in Tables 3 and 4 shows that inorganic salt cations (Na^+, K^+, Ca^{2+} and Fe^{3+}) were higher, in all the seasons, in tannery effluent than those of the textile effluent. In tannery effluent Na^+, K^+, Ca^{2+} and Fe^3 seasonally and spatially varied from 1737.62-1835.0, 65.5-86.5, 188.5-273.1 and 0.26-0.32 mg/l, respectively. Whereas in textile effluent these salt cations varied form 390.0-402.5, 12.4-14.35, 37.21-40.34 and 0.12-0.18 mg/l, respectively. Highest concentrations of inorganic salt cations were recorded in dry season in both the river water. Na^+, K^+, Ca^{2+} content of tannery and textile effluents were higher than the DoE standard for open water [200 mg/l for Na^+, 12.0 mg/l for K^+, 75.0 mg/l for Ca^{2+}] [14] but the surface water of Buriganga and Karnatoli contained lower values set by DoE. Inorganic salt cations increase the salinity regime as well as electrical conductivity of water which is revealed in the present investigation. Higher salinity in tannery effluent and in a recent work [12] showed high EC in tannery effluent.

Anions: Phosphate level in tannery effluents in Buriganga River ranged from 1.08–66.88 mg/l whereas it varied from 0.54 to 19.88 mg/l in textile effluent and Karnatoli River. In Buriganga river water PO_4 during rainy, dry and summer season were 1.08±0.08, 2.32 ± 0.32 and 1.25 ± 0.07 mg/l, respectively and in Karnatoli river water PO_4 in rainy season was 0.54 ± 0.47mg/l, in dry season was 0.77 ± 0.29 mg/l and 0.81 ± 0.05 mg/l in summer season. Alam *et al.* [16] studied on the toxic metal and nonmetal status in the major river system of Bangladesh and found phosphate level 116±2.4 mg/l during dry season and 109.2 ±2.0 - 114.4 ±2.5 mg/l during rainy season in Buriganga river water which was much higher than the present study. However, Hadiuzzaman *et al.* [10] found 1.91-5.32 mg/l from Balu river and 0.43 to 1.93 mg/l from Sitalakhya river which is in conformity with the present findings.

Table 3: Inorganic Cations of Tannery Effluents and Adjacent Buriganga River Water

	Sodium (mg/l)			Potassium (mg/l)			Calcium (mg/l)			Iron (mg/l)		
Sites	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum
Ta1	1824.73±66.08	1737.62±53.2	1835.0±16.9	65.5±14.8	86.5±12.02	72.0±4.24	208.3±57.2	273.1±21.9	188.5±14.3	0.265±0.02	0.32±0.04	0.265±0.02
Ta2	228.0±39.5	707.7±554.6	365.0±14.14	46.0±8.48	53.5±9.19	50.0±5.65	32.0±10.09	46.7±16.39	25.36±4.97	0.078±0.087	0.135±0.02	0.11±0.014
Ta3	69.5±36.06	91.0±8.48	55.5±3.53	26.5±2.12	40.5±6.36	25.0±2.82	13.84±1.32	26.84±17.1	20.54±0.72	0.032±0.045	0.088±0.045	0.068±0.012

Table 4: Inorganic Cations of Textile Effluents and Adjacent Karnatoli River Water

	Sodium (mg/l)			Potassium (mg/l)			Calcium (mg/l)			Iron (mg/l)		
Sites	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum
Te1	390±119.5	411.1±128.8	402.5±17.67	14.35±0.21	31.0±19.79	12.4±1.72	40.34±1.67	54.82±15.18	37.21±1.35	0.12±0.007	0.18±0.04	0.13±0.014
Te2	44.0±41.01	321.8±214.7	90.0±4.24	4.17±0.6	14.25±11.6	7.12±1.08	23.89±5.85	29.58±8.2	22.32±1.07	0.027±0.038	0.09±0.04	0.09±0.004
Te3	8.6±6.22	177.7±67.5	38.5±4.94	3.18±1.43	9.0±7.7	4.95±0.49	18.1±2.46	24.46±5.11	18.42±1.31	00	0.038±0.05	0.03±0.004

Table 5: Anions of Tannery Effluent and Adjacent Buriganga River Water

	Phosphate (mg/l)			Chloride (mg/l)			Nitrite (mg/l)			Nitrate (mg/l)		
Sites	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum
Ta1	66.88±5.13	61.78±5.28	50.85±3.66	79.41±1.2	88.79±8.68	83.64±1.42	1.22±0.91	0.66±0.11	1.17±0.10	4.63±4.24	0.48±0.053	0.7±0.2
Ta2	2.27±0.46	3.47±0.58	2.39±0.2	70.51±10.27	78.81±4.87	73.8±2.04	0.95±0.007	3.46±3.16	0.66±0.27	5.38±3.33	1.5±1.52	1.38±0.219
Ta3	1.08±0.08	2.32±0.32	1.25±0.07	60.74±6.34	69.18±2.11	59.4±1.19	0.37±0.26	0.23±0.002	0.22±0.04	0.917±0.47	0.43±0.61	0.68±0.14

Table 6: Anions of Textile Effluents and Adjacent Karnatoli River Water

	Phosphate (mg/l)			Chloride (mg/l)			Nitrite (mg/l)			Nitrate (mg/l)		
Sites	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum	Rainy	Dry	Sum
Te1	19.88±0.51	18.25±4.23	19.28±0.7	135.87±95.63	75.21±14.19	72.25±5.66	0.07±0.1	0.74±0.12	0.134±0.03	0.47±0.67	1.02±0.053	0.75±0.14
Te2	7.5±1.69	7.9±2.34	5.3±0.45	40.62±20.16	23.81±18.06	21.00±1.9	0.34±0.48	0.86±0.06	0.28±0.049	0.73±1.03	3.06±2.59	1.84±0.39
Te3	0.54±0.47	0.77±0.29	0.81±0.05	33.53±19.33	17.18±11.97	22.3±5.73	0.31±0.28	0.145±0.05	0.30±0.03	0.45±0.32	1.16±0.40	0.76±0.11

Maximun Cl^- measured in tannery effluents was 88.79 mg/l (Table 5) in dry season while that in textile was 135.87 mg/l (Table 6) in rainy season. In Buriganga river water Cl^- content during rainy, dry and summer seasons were 60.74 ± 6.34, 69.18 ± 2.11 and 59.4 ± 1.19 mg/l, respectively and in Karnatoli river water Cl^- content was 33.53 ± 19.33, 17.18 ± 11.97 and 22.3 ± 5.73 mg/l during rainy, dry and summer season, respectively. Alam *et al.* [16] found the concentration of Cl^- in rainy season from 196.4 - 470.0 mg/l and in dry season from 98.0 - 107.6 mg/l in Buriganga river water which is well above the present study.

Tannery effluent contains higher load of NO_2 measuring 1.22±0.91 mg/l than textile effluent. NO_2 content in surface water of Buriganga river during rainy, dry and summer season were 0.37±0.26, 0.23±0.002 and 0.22±0.04 mg/l, respectively and in Karnatoli river water its load was 0.31±0.28, 0.145±0.05 and 0.30±0.03 mg/l during rainy, dry and summer seasons, respectively. Alam *et al.* [16] found that the NO_2 concentration of Buriganga river ranged from 5.0 ±0.05 - 7.0 ±0.04 mg/l in rainy season and 0.01±0.01 mg/l in dry season. The present investigation is more or less similar to the findings of Alam *et al.* [16].

NO_3 content was higher in textile effluent than the tannery effluent except in rainy season (Tables 5, 6). NO_3 load of Buriganga river water during rainy, dry and summer season were 0.917 ± 0.47, 0.43 ± 0.61 and 0.68± 0.14 mg/l, respectively and that in Karnatoli river water were 0.45 ± 0.32, 1.16 ± 0.40 and 0.76 ± 0.11 mg/l, respectively. Hadiuzzaman *et al.* [10] reported NO_3 concentration in Balu river was 0.4 -1.05 mg/l and Sitalakhya river was 0.1-3.5 mg/l, which is similar to the present findings. However, Alam *et al.* [16] found that the concentration of NO_3 in Buriganga river ranged from 8.0 ±0.5 - 12.2 ±0.4 mg/l in rainy season and 8.0±0.5 - 12.2 ± 0.4 mg/l in dry season.

Anions in the effluent showed a decrease in concentration with distance from point source which might be due to dilution with river water and self purification of this anion along the sampling point or absorption of these anions within the wall of the discharged channel. Another possibility may also be due to the denitrification of river water. Correlation matrix (Tables 7, 8) among BOD, TDS, TSS, PO_4, NO_2 and NO_3 revealed both tannery and textile effluents and in their adjacent river water has a strong positive correlation

Table 7: Correlation chart between physicochemical parameters of tannery effluents and adjacent river water

	BOD	TDS	TSS	PO4	NO2	NO_3
BOD	1					
TDS	0.9411	1				
TSS	0.9511	0.894	1			
PO4	0.866	0.942	0.76	1		
NO2	0.438	0.2836	0.511	0.0335	1	
NO3	-0.05	-0.145	0.058	-0.21	0.0049	1

Table 8: Correlation chart between physicochemical parameters of textile effluent and adjacent river water

	BOD	TDS	TSS	PO_4	NO_2	NO_3
BOD	1					
TDS	0.865	1				
TSS	0.728	-0.24	1			
PO4	0.797	0.968	0.942	1		
NO2	-0.288	-0.1156	0.105	0.0277	1	
NO3	-0.285	-0.27	-0.19	-0.1414	0.6633	1

among BOD, TDS, TSS and PO_4. In conclusion, all the parameters in the tannery and textile effluents were higher than the DoE Standard recommended for open water, however, except BOD_5 these values were lower in the surface water of Buriganga and Karnatoli rivers.

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