Textile dying and tannery industries effluent physico-chemicals conditions before discharge to river around Dhaka, Bangladesh

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Abstract-The study was carried out in order to assess physic-chemicals conditions of effluent before discharge to river of the industrial area Dhaka, Narayanganj, Demra (D.N.D) of Bangladesh. Physiochemical parameters such as total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), pH, electrical conductivity (EC), turbidity, alkalinity, salinity, biological oxygen demand (BOD), anionic parameters such as F^-,Cl^-, NO_2^- ,NO_3^- , Br^- and SO_4^{2-} and heavy metal such as Cu, Cd, Mn, Fe, Pb, Cr ,Ni and Zn of the samples were investigated by using various techniques. The results show that textile dyeing industries at D.N.D area discharges effluents composed of various physiochemical and anionic pollutants at considerably higher level compared to pollution limit. The results show that the effluent of textile dyeing industries have pH, EC, Salinity, TSS, TDS, BOD is higher than that of local standard (Department of environment (DoE), Bangladesh) and DO level is lower than DoE standard. pH of tannery industry is within permissible limits of DoE standard. F^- is present only in the effluent of one textile industry. Cr is found in the tannery effluent and is higher than that of DoE standard. The result indicates that the effluent being discharged into the river water have considerable negative effects on the water quality of the D.N.D area.

Key words-Textile dye industry, Tannery industry, Effluent, Physicochemicals, River, Surface water quality, Environmental impact.

1 INTRODUCTION

Dhaka the capital and the most populated city in Bangladesh and now a member of the 'mega- city' family of the world. Rapid and unplanned urbanization, commercial development along with population pressure have made Dhaka an environmentally polluted in the country.

In Bangladesh industrial units are mostly located along the banks of the rivers. Unfortunately industrial units drain effluents directly into the rivers without any consideration of the environment degradation.

The most problematic industrial for the water sector are textiles, tanneries, pulp and paper mills, fertilizer, industrial chemical production. Textile industries consume large volumes of water and chemical for wet processing of textile. The quantities and characteristics of effluents wastes discharged vary from mill to mill depending on the water consumption and the average daily production.

The textile industry is distinguished by raw material used and this determines the volume of water required for production as well as waste water generated. Production may be raw cotton, raw wool, and synthetic materials. In production stashing, bleaching mercerizing and dyeing are the major consumption activities as well as waste water generation. The nature of the processing exerts a strong influence on the potential impacts associated with textile manufacturing operations due to the different characteristics associated with these effluents [1].

An extensive use of dyes in textile has created problems of acute ecological effects except certain dye stuffs that exhibit non-toxic effect towards microbial population and carcinogenic potential to human being [2].

Highly colored components also lead to the reduction of sunlight penetration in rivers, lackes and lagoons which in turn decrease both photo synthetic activity and dissolved oxygen concentration causing detrimental effect on aquatic life [3]

The extent of color and metals contamination to the water environment has much concern because of potential hazards associated with the entry these substances into the food chain of humans and animals.

Industrial wastes are major problems of pollution in all environments and require on-site treatment before discharge into sewage system [4]. This phenomenon is very common where the polluting industries are textile dyeing, leather tanning etc. The effluent discharged by these industries leads to serious pollution of surface water sources, ground water, air, soil and ultimately effect the livelihood of the people.

Bangladesh, at present, has more than 30,000 industrial units of which about 24,000 are small and cottage industries [5]. The released organic compounds and heavy metals exert negative influences on man and environment causing toxicity to plants and other forms of biotic and abiotic that are continually exposed to potentially toxic heavy metals [6]. These heavily toxic effluents were discharging directly to adjacent soils and rivers [7]. The presence of pollutants in water alters different physico-chemical parameters from their normal prescribed levels [1]. Negative impacts on water quality includes increase in turbidity, color, nutrient load and addition of toxic and persistent compounds [8]. Soil is regarded as the ultimate sink for the pollutants discharged into the environment [5]. The contamination of soils with heavy metals or micronutrients in phytotoxic concentrations generates adverse effects not only on plants but also poses risks to human health [9]. As a part of biosphere pollution by the let-outs of the industries, plant growth has also faced a potential decrement in the development. Plants which grow in heavy polluted area were found to be affected by the toxic metals [10].

So, proper analysis is needed to assess the pollution level for the protection of environment and natural resources. Such information is important for the authorities to take proper action in preventing pollution of surrounding area of tannery industry near Buriganga and textile industry at fatullah and in Narayangonj sadar for the good health of the population. In the present study, we have tried to determine the extent of pollution level with respect to anionic (F^-, Cl^-, NO^{2-} , NO^{3-} , and SO_4^{2-}) and heavy metals (Cu, Cd,

Mn, Fe, Pb, Cr , Ni and Zn) concentrations of textile dyeing and tannery effluents. The secondary objective to draw the attention of industries and to increase the awareness of mass people about the possible long term effect of health hazard of toxicity.

2 MATERIALS AND METHODS

2.1 Study Area

Dhaka-Narayanganj-Demra (D.N.D) Embankment located mainly at Narayanganj District. The study area lies between 23º 38' and 23º 44' North latitude and 90º 26' and 90º 32' East longitude. The Total area of the D.N.D embankment is app. 30528.44 sq. m. Hazaribagh area adjecent to Buriganga river is located mainly at Dhaka district.

2.2 Sample collection

In this study, for the analysis of anions and heavy metals, samples were collected from some textile dyeing industries in Narayanganj (TAB-1) and tannery industries in Hazaribag (TAB-2) . The effluent samples were collected from the tannery and textile industry in clean plastic bottle and stored at 4ºC for the analysis.

TABLE 1 Sources of the sampling sites of the textile dyeing effluent samples with ID numbers.

Sl No.	Sources	Sample ID
1.	Discharge point of industry	**A-7328**
2.	Discharge point of industry	**A-7329**
3.	Discharge point of industry	**A-7330**
4.	Discharge point of industry	**A-7331**
5.	Discharge point of industry	**A-7332**
6.	Discharge point of industry	**A-7586**
7.	Discharge point of industry	**A-7587**
8.	Discharge point of industry	**A-7588**

1L plastic bottles were used for collecting samples. Prior to collection, the bottles were cleaned by detergent solution and then, it was treated with 5% nitric acid over night. They were finally washed with de-ionized water and dried in the air. During sampling the sample bottles were tightly screwed and marked with respective identification numbers. The effluent was directly collected from the outlet of the industry. Then samples were kept in ice bag tied well. Then, it was carried to the laboratories and stored in the refrigerator. Collection and analysis of the samples were performed in December, 2010 by proper sampling procedure.

TABLE 2 Sources of the sampling sites of the Tannery effluent samples with ID numbers.

Sl No.	Sources	Sample ID
1.	Discharge point of industry	A-7052
2.	Discharge point of industry	A-7053
3.	Discharge point of industry	A-7054
4.	Discharge point of industry	A-7055
5.	Discharge point of industry	A-7056
6.	Discharge point of industry	A-7583
7.	Discharge point of industry	A-7584
8.	Discharge point of industry	A-7585

2.3 Sample analysis

The physico-chemical tests, the determination of temperature, color was done at the sampling point and the other parameter turbidity, TDS, TSS, DO , pH, EC, BOD, salinity, heavy metals and anions of the samples were analyzed at institute of national analytical research and service (INARS) of BCSIR by following standard methods [12].

The mentioned physico-chemical parameters were measured; the temperature of water was recorded with the help of a thermometer calibrated from Cali-lab, India, colour was determined by using colorimeter (Jenway, model-6051), turbidity- 2100P turbidimeter, HACH, USA; pH, EC, DO, salinity were measured by portable multiparameter meter (Senion^{TM} 156, HACH, USA). BOD was measured by following BOD5 method.

TDS & TSS were determined gravimetrically by following standard methods mentioned in APHA (1998). A certain amount of samples were filtered by using Whatman 44 filter paper followed by drying at 180°C in a calibrated oven for measuring TDS. For TSS, a constant weight of a whatman 44 filter paper was taken; certain amount of water sample was filtered and dried at 103-105° C and taken the final weight of the sample.

Analysis of heavy metals (Cr, Cu, Cd, Pb, Mn, Fe, Ni, Zn) employed flame atomic absorption spectrometry. 100 mL samples were digested in 5 mL HNO_3 on a hot plate in fume hood. The sample was gently boiled to the lowest possible volume until digestion is completed as shown by a light color, clear solution. After complete digestion, cool sample was transferred to 100 mL volumetric and diluted up to the mark. The sample was then filtered and analyzed by flame atomic absorption spectrometer (AA240FS, Varian, Australia). In case of high concentration, the sample was diluted by using de-ionised water.

Anions (F^-, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}) were measured using Ion Chormatograph (SIC10AVP, Shimadzu, Japan). Samples were filtered through 0.22 micron filter to avoid dust particles. 1.3 mM Sodium carbonate (Na_2CO_3) and 1.7 mM Sodium bi-carbonate ($NaHCO_3$) mixer was used as a mobile phase to separate ions in a ionic chrotographic column (HIC 10A super).

2.4 Calibration standards used for sample analysis

During turbidity measurement, serial standard solutions (20NTU-100NTU) of turbidity were used to calibrate turbidimeter. Zero solution (5% $NaSO_2$ solution), buffer solutions (pH=4.0, pH=7.0), 1000 µS/cm of NaCl solution were used to calibrate portable multiparameter meter for determining DO, pH & conductivity, respectively.

1000 mg/L stock metals standard (Scharlau, Spain) solutions were used to prepare calibration standards. The stock standards were diluted to certain concentration of

calibration standards required to measure different metals by AAS (TAB-3 AND TAB-4).

TABLE 3 Preparation of metals calibration standard for AAS

Parameter	Conc. of stock standard (mg/L)	Conc. of calibration standards (mg/L)
Cr		0.2, 0.5, 1.0, 2.0
Cu		0.05,0.1,0.2,0.5,1.0
Cd		1.0,2.0,3.0
Pb		0.2,0.5,1.0,2.0
Mn	1000	0.05,0.1,0.2,0.5,1.0,2.0
Fe		0.2,0.5,1.0,3.0,5.0
Ni		0.2,0.5,1.0,2.0
Zn		0.1,0.2,0.5,1.0

A mix stock standard of anions (F^-=20mg/L, Cl^-=30mg/L, NO_2^-=1000mg/L, NO_3^- =100mg/L, SO_4^{2-} =150mg/L) was used for measuring anions in water. Calibration standards were prepared by diluting the stock standard.

TABLE 4 Preparation of anions calibration standard for IC

Parameter	Conc. of stock standard (mg/L)	Conc. of calibration standards (mg/L)
F	20	0.5,1.0,2.5,5.0
Cl	30	1.0,2.0,5.0,10.0
NO_2	1000	1.0,2.0,5.0,10.0
NO_3	100	3.0,6.0,15.0,30.0
SO_4	150	4.0,8.0,20.0,40.0

3 RESULTS AND DISCUSSION

3.1 Physicochemical charecteristics of the effluents of textile dyeing industries

The ranges of the physicochemical parameters of the effluents of Textile dyeing in the study area are shown in (TAB-3). The levels of pollution of the effluents were

determined by comparing the observed values of the various parameters with standard value recommended *by* DoE, Bangladesh (Department of Environment [DoE], 1997).

TABLE 5 Physicochemical parameters of Textile dyeing effluents

Sample ID	Temp (ºC)	pH	EC (µS/cm)	Salinity (ppt)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)	DO (mg/L)	BOD (mg/L)
A-7328	35.6	8.26	4170	2.2	48.9	141	2328	4.50	1.04
A-7329	38.9	8.21	6810	3.8	19.1	29	8180	4.53	1.21
A-7330	42.3	8.30	892	0.4	25.1	77	246	4.42	1.27
A-7331	40.2	11.2	7960	4.4	181	572	3252	3.24	108
A-7332	40.8	10.2	4210	2.2	383	658	1644	6.38	2.03
A-7586	32.3	9.11	811	0.4	26.4	85	304	3.93	20
A-7587	32.9	10.6	2650	1.3	386	280	2868	5.18	1.59
A-7588	45.7	9.28	3260	1.7	18.1	88	3984	4.85	1.88
DOE Standard(1997)	40	6-9	1200	-	-	150	2100	4.5-8	50

The pH values for textile and tannery effluents fluctuated between 8.2 to 11.2 4.3 to 9.5 respectively (TAB-1). The pH shows alkaline trend in case of textile effluent whereas in tannery effluents pH shows acidic to slightly alkaline conditions. The limit of pH value for industrial effluent is specified as 6-9 [11]. It is observed from experimental data of both textile and tannery effluent that pH of both effluents exceeds the permissible limit.

Electrical Conductivity (EC) values ranged from 811 to 7960 µS/cm for textile and 1411 to 73900 µS/cm for tannery effluents. The stipulated value for EC in industrial effluent is 1200 µS/cm (Department of Environment [11]. The measured EC of both textile and tannery are significantly higher than the DoE standard. Usually, higher EC values indicate the presence of higher content of dissolved salts in the effluents .

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. The standard turbidity value of industrial effluent is 5 to 25 NTU. In this study, the range of turbidity in textile dyeing effluents is 18.1-386 NTU and in tannery effluents is 34.1-399 NTU which are higher than the DoE standard.

The Total Dissolved Solids (TDS) in the textile and tannery effluents collected from eight industries varied from 246 to 8180 mg/L and 1428 to 76908 mg/L. The permissible limit for TDS in industrial effluent is 2100 mg/L. The data in table III show that TDS in five out eight textile industries exceed the limit. On the other hand, (TAB-4) shows that all tannery effluents except three samples contain very significant concentration of TDS and also exceed the permissible limit.

For Total Suspended Solids (TSS), (TAB-3 and TAB-4) show that TSS in tannery effluent
always show high concentration than textile effluents. In textile effluents, TSS varied
from a range of 29-658 mg/L whereas in tannery effluent, TSS varied from 415 to 2456 mg/L.
Dissolved Oxygen is a highly fluctuating factor in water. Table III shows that DO concentration of textile effluent was ranged from 3.24 to 6.38 mg/L. The observed data demonstrate that DO in textile effluent is nearer or within permissible limit of DoE standard (4.5 to 8 mg/L). However, the concentration of DO in tannery effluent is relatively lower and ranged from 0.30 to 3.68 mg/L (TAB-4) which are below the permissible limit. The overall DO concentration in tannery effluents was very low prabaly due to the presence of materials of high organic content leading to oxygen depletion.

Textile industries releases a lot of biochemical oxygen demanding wastes. BOD is an index of the biodegradable organics present within the system. Biochemical oxygen demanding wastes consumes the dissolved oxygen from water. Excessive BOD is harmful to aquatic animals like fish and microorganisms. It also causes bad taste to the drinking water. The average value of BOD of textile dyeing effluents (17.12 mg/L) is lower than DoE standard and that of tannery effluent (140.72 mg/L) are higher than DoE standard.

TABLE 6 Physicochemical parameters of Tannery effluents

Sample ID	Temp (°C)	pH	EC (µS/cm)	Salinity (ppt)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)	DO (mg/L)	BOD (mg/L)
A-7052	26.2	4.79	1411	7.6	62.1	433	1477	3.68	20.4
A-7053	26.5	7.19	2110	1.0	286	415	1428	1.03	110
A-7054	26.9	4.87	11070	6.3	242	756	4830	0.3	462
A-7055	27.6	4.30	73900	63	98.4	1114	76908	3.21	21.8
A-7056	27.3	6.28	2470	1.3	399	989	1966	0.55	113
A-7583	28.2	5.64	40700	26.1	45.9	1256	38776	2.37	117
A-7584	28.0	5.19	58700	40.2	34.1	2456	57560	3.49	42
A-7585	28.1	9.47	11600	6.6	53.0	2305	10560	0.92	236
DOE Standard (1997)	40	6-9	1200	-	-	150	2100	4.5-8	50

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lower than DoE standard and that of tannery effluent (140.72 mg/L) are higher than DoE standard.

3.2 Concentrations of the anions of the effluents of textile dyeing industries

The concentration ranges of the effluents of various areas are shown in (TAB-5) and (TAB-6).

TABLE 7 Anion concentration of textile effluents

Sample ID	F^- (mg/L)	Cl^- (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)	SO_4^{2-} (mg/L)
A-7328	nd*	0.64	nd	16.568	523
A-7330	nd	1.22	433	1.01	773
A-7331	nd	1.23	244	nd	79.5
A-7332	nd	0.86	248	17	19.4
A-7586	nd	1.59	284	33.380	43
A-7587	0.23	nd	164	15	16.0
A-7588	nd	0.59	1835	61	21.4
DOE Standard (1997)	7.00	600	<1.00	10	400

* nd = not detected

TAB-7 and TAB-8 show the concentration of anions in textile and tannery effluents respectively. It was observed that no samples except one contain only 0.23 mg/L o fluoride. Surface water generally contains less than 0.5 mg/L of fluoride. However, when present in much greater concentration, it becomes a pollutant.

From the presented data, it is clear that, textile effluents contain very lower concentration of chloride (1.59 mg/L) while tannery effluents contain very high amount of chloride and the concentration was a range from 0.96 to 29273 mg/L. The high concentration of chloride is attributed to the use of NaCl for processing of leathers.

All but one textile effluents carried significant concentration of nitrite containing compounds and the concentration was from 164 to 1835 mg/L. The reason of high concentration of nitrite may be done to the use of nitrite containing compounds (e.g. $NaNO_2$) for manufacturing azo dye in textile dyeing industry.

On the other hand, no tannery effluents except one contain nitrite ions. The Concentration in only nitrite containing sample was abruptly high and it was 2124 mg/L.

TABLE 8 Anion concentrations of tannery effluents:

Sample ID	**F^- (mg/L)**	**Cl^- (mg/L)**	**NO_2^- (mg/L)**	**NO_3^- (mg/L)**	**SO_4^{2-} (mg/L)**
A-7052	nd	1168	nd	nd	6212
A-7053	nd	255	nd	nd	438
A-7054	nd	733	nd	nd	5256
A-7055	nd	29273	nd	362	28380
A-7056	nd	207	nd	nd	651.5
A-7585	nd	0.961	2124	nd	nd
DOE Standard (1997)	7.00	600	<1.0	10	400

* nd = not detected

The limits of detection for anions were as follows: F^-, 0.5 mg/L; Cl^-, 1.0 mg/L; NO_2^-, 1.0 mg/L; NO_3^-, 3.0 mg/L and SO_4^{2-}, 4.0 mg/L.

3.3 Concentrations of the heavy metals in the effluents of textile dyeing industries:

The metals anlysed in both textile and tannery effluents include chromium (Cr), copper (Cu), cadmium (Cd), lead (Pb), Manganese (Mn), Iron (Fe), nickel (Ni) and zinc (Zn).

TABLE 9 Heavy metal contents of the textile dyeing effluent samples

Sample ID	Cr (mg/L)	Cu (mg/L)	Cd (mg/L)	Pb (mg/L)	Mn (mg/L)	Fe (mg/L)	Ni (mg/L)	Zn (mg/L)
A-7328	nd	0.091	nd	0.03	0.128	0.498	nd	0.204
A-7329	nd	0.061	nd	0.05	0.381	0.491	nd	0.187
A-7330	nd	nd	nd	0.05	0.203	0.442	nd	0.060
A-7331	nd	0.061	nd	0.03	0.293	1.45	nd	0.201
A-7332	nd	0.034	nd	0.03	0.285	0.973	nd	0.156
A-7586	nd	nd	nd	0.02	0.114	0.238	nd	0.021
A-7587	nd	0.105	nd	0.02	0.095	0.478	nd	0.049
A-7588	nd	nd	nd	0.02	0.333	0.315	nd	0.029
DOE Standard (1997)	0.5	0.5	0.05	0.1	5.0	2.0	1.0	5.0

* nd = not detected

TAB-9 shows that Cr, Cd and Ni were below the detection limit in all textile effluent samples. The range of Cu in the effluents varied from below detection limit (BDL) to 0.11mg/L. Pb in effluents varied from 0.02 to 0.05 mg/ L. Mn, Fe and Zn concentrations ranged from 0.10 – 0.38 mg/ L, 0.24 – 1.45 mg/L and 0.02 – 0.20 mg/ L respectively.

TAB-10 illustrates the concentrate of metals in tannery effluents. The effluents contain very high concentration of Cr which ranged from 76.3 to 16366 mg/L. Cu, Cd, Pb, Mn, Fe and Zn concentrations ranged from 0.02 – 0.09 mg/L, BDL – 0.04 mg/L, BDL-0.04 mg/L, 0.18 – 0.26 mg/L, 1.51 – 6.37 mg/L and BDL – 0.56 mg/L respectively. The presented data also showed that the concentration of Ni was BDL in all tannery effluents.

The limits of detection for metals were as follows: Cr, 0.02 mg/L; Cu, 0.02 mg/L; Cd, 0.01 mg/L; Pb, 0.01 mg/L; Fe, 0.03 mg/L; Ni, 0.02 mg/L and Zn, 0.02 mg/L.

TABLE 10 Heavy metal contents of the tannery effluent

Sample ID	Cr (mg/L)	Cu (mg/L)	Cd (mg/L)	Pb (mg/L)	Mn (mg/L)	Fe (mg/L)	Ni (mg/L)	Zn (mg/L)
A-7052	16366	0.023	nd	0.04	0.260	1.19	nd	nd
A-7053	128	0.087	nd	0.02	0.221	6.37	nd	0.562
A-7054	16196	0.022	nd	0.02	0.182	1.72	nd	0.408
A-7056	237	0.034	nd	nd	0.246	2.36	nd	0.249
A-7585	76.3	0.035	0.035	0.04	0.176	1.51	nd	0.117
DOE Standard (1997)	0.5	0.5	0.05	0.1	5.0	2.0	1.0	5.0

* nd = not detectable

4 CONCLUSION

From the analysis of the water samples, including industrial effluent samples, of the study areas, it can be inferred that the water quality has deteriorated. The average values of most of the physicochemical parameters have been found fluctuating over the standard value set by the DoE, Bangladesh. The major findings from the study are : (1)In textile dyeing and tannery industries physicochemical parameters like pH, EC, Salinity, TSS, TDS, BOD are higher than the DoE standard and DO level is lower than DoE standard. pH of tannery industry is within permissible limits of DoE standard. (2) Anions like Cl^-, NO_2^-, NO_3^-, and SO_4^{2-} are present in both industrial effluents but F^- is present only one textile industry. (3) Large amount of Cr is found in the tannery effluent. Zn, Pb, Cu, Mn, and Fe are present in the studied effluents.

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