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Assessment of Physico-chemical Characteristics of Textile Effluent at Different Stages of Treatment Process

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Abstract

The study was conducted to observe effluent management technique, physico-chemical characteristic (BOD, TDS, DO, pH, EC, temperature, color, odor, transparency and heavy metals) at different steps of effluent treatment process and compare those with standards of Bangladesh Environmental Conservation Rules (ECR)-1997. Nine effluent samples were collected from Impress Newtex Composite Textile Ltd Industries at Gorai under Mirzapur Upazila during the month of January to June 2013. The color and odor of the inlet effluent samples were highly colored and emit foul smell, respectively but in case of outlet effluent samples very low. The DO, BOD, TDS, EC, pH, temperature, transparency value of all collected samples from ETP outlet were 5 mg/l, 42 mg/l, 2245 mg/l, 192 µs/cm, 6.5, 31.2 cm, respectively which fulfils ECR (1997) standards for inland surface water, public sewerage water and land for irrigation excepts the value of TDS. In case of heavy metal (Pb, Zn &Ni) assessment the concentrations of all collected samples were within the permissible limit according to ECR, 1997 accepts Pb for inland surface water and land for irrigation. Different types of dyes and chemicals were used during fabrics dyeing. As a result, the values of different physico-chemical parameters were more in inlet effluent but due to treatment its shows less value at the outlet effluent which fulfils ECR (1997) standards requirement. Only best management practices can ensure the best effluent quality discharged into the environment as well as best performance of ETP.

Key words: Effluent, Textile industry, Heavy metals

Introduction

Bangladesh has emerged, in just under decade, as the twelfth largest garment-manufacturing nation in the world, thanks largely to the Multi-Fiber Agreement (MFA) and the Generalized System of Preferences (GSP) of the European Union that conferred significant quota benefits to the country. The garment sector now accounts for about 77% of the country's foreign exchange earnings and 50% of its industrial work force (European Commission, 2009). Textile is the most important sector of Bangladesh's economy because these are the supplier of fabrics to garments. Textile industry uses large quantity of water in its production processes that are discharged highly polluted and toxic waste waters into sewers and drains without any kind of treatment (Chindah *et al*., 2004; Emonger *et al*., 2005). In Bangladesh, industrial units are mostly located at waterside. A complex mixture of hazardous chemicals, both organic and inorganic, is discharged into the water bodies from all these industries, usually without treatment. Thus, industrial units drain effluents directly into the rivers without any consideration. Over three-fourth of fresh water draw by the domestic and industrial sector, return as domestic sewage and industrial effluents which inevitably end up in surface water bodies or in the groundwater, affecting water quality (Mukherjee and Nelliyat, 2006). Some of the major known toxic bio-accumulative metal pollutants discharged from industrial sectors which are particularly dangerous such as Mercury, Lead, Arsenic, Chromium, Nickel, Copper, Zinc and Cadmium (Faisal *et al*., 2004). Textile and dyeing industrial effluents may cause alteration of the physical, chemical and biological properties of aquatic environment by continuous change in temperature, odor, noise, turbidity etc that is harmful to public health, livestock, wildlife, fish and other biodiversity. The presence of dyes in surface and subsurface water is making them not only aesthetically objectionable but also causes many water borne diseases viz. mucous membrane, dermatitis, perforation of nasal septum and severe irritation of respiratory tract (Islam *et al*., 2011; Sultana *et al.*, 2009). Developing countries like Bangladesh, where less attention is paid to environmental protection, environmental regulations are not effectively implemented and pollution control techniques are not yet fully developed. In this situation, pollution and the public health problem caused by the textile dyeing along with other industries in Bangladesh has been focused recently and the gravity of installation of Effluent Treatment Plant (ETP) has drawn attention. Amid huge public criticism against textile dyeing and processing units for polluting water-bodies and farmland by releasing toxic chemical wastes, the government is trying to deal with the matter by setting deadlines to pressure the industries to set up ETPs (Sultana *et al*., 2013). Although most of the industries are supposed to have effluent treatment plant, however, so far only a few industries have installed the plants. Even then most of the plants operate only occasionally. In Gorai industrial area under Mirzapur Upazila of Tangail District in Bangladesh, most of the textile knitting, dyeing industries generate large amount of effluents, sewage sludge and solid waste materials everyday which are being directly discharged into the surrounding channel, agricultural fields, irrigation channels, surface water and these finally enter in to Bonsi River which responsible for various water borne diseases like mucous membrane, dermatitis, perforation of nasal septum and severe irritation of respiratory tract. But Impres Newtex Composite Textile Ltd has an ETP with the capacity of 2000 m³/day which treat a large amount of effluents that generated during coloring the fabrics and cotton. After the treatment effluents are discharged into near the Bonsi River through a canal. To keep this point in mind, the study of ETP performance of Impres Newtex Composite Textile Ltd is done. Therefore, the study was conducted to observe the physico-chemical parameters (color, odor, transparency, temperature, pH, DO, BOD, EC, TDS) and heavy metals (Pb, Ni, Zn) at different stages of effluent treatment processes in Impress Newtex Composite Textile Ltd. and comparison of these parameters values with Bangladesh Environment Conservation Rule, 1997 standards for waste water from industrial unit or projects waste.

Materials and Methods

A total of 9 effluent samples were collected from Impres Newtex Composite Textile Ltd at nine different stages of the ETP under the Mirjapur Upazila in Tangail District of Bangladesh during January to June, 2013 following the sampling techniques as outlined by APHA (1995) and Sincero and Sincero (2004) shown in Table 1. Each effluent samples were collected by 500 ml narrow-mouth high density polyethylene bottles. Each bottle were cleaned in the laboratory with dilute HCl (1:1) and then rinsed twice with distilled water. Before sampling, bottles were also rinsed with the sampled effluent. After sampling, the bottles containing samples were sealed immediately to avoid exposure to air and marked with necessary information. Then all the effluent samples were analyzed for color, temperature, transparency, pH, EC, TDS, BOD and DO at the laboratory of Department of Environmental Science and Resource Management (ESRM), Mawlana Bhashani Science and Technology University (MBSTU), Tangail. The samples for the analysis of trace metals (Pb Ni, Zn) were carefully taken to the Bangladesh Institute of Nuclear Agriculture (BINA). In this study different types of instruments such as, digital pH, DO, EC and TDS meter were used in pH, DO, EC and TDS determination respectively. Thermometer and secchi disk were used in temperature and transparency analysis. Color was detected by eye sight observation. BOD was measured by two steps where initial BOD (BOD_1) measured immediately after collection and after 5 days BOD (BOD_5) was measured by incubation in the dark condition at 20^0C for 5 days. Then the total BOD ($BOD_1 - BOD_5$) was measured according to Huq and Alam (2005). Atomic Absorption Spectrometer was used in heavy metal (Pb Ni, Zn) analysis following the method of Clesceri *et al.* (2005). Further the results of the analyses were interpreted using Microsoft Excel Programme-2007.

Table 1. Description of the sampling point of the study area

SI. No.	Sampling point	Location of the sampling point
1	Es_1	Screening pit
2	Es_2	Auto screening unit
3	Es_3	Equalization tank
4	Es_4	Anaerobic reaction chamber
5	Es_5	Anaerobic clarifier
6	Es_6	Aerobic biological reaction chamber
7	Es_7	Secondary clarifier
8	Es_8	Sludge thickener tank
9	Es_9	Outlet tank

Note: Es= Effluent Sample

Results and Discussion

The results of the analysis of effluents samples collected from ETP of Impress Newtex Composite Textile Limited are given in Table 2 & 3.

Physicochemical properties of effluent

pH

The pH of all collected effluent samples were fluctuated between 6.50 to 7.80 with a mean value of 7.17 (SD±0.46) indicating acidic to alkaline of effluent (Table 2). The pH of inlet effluent (6.5) is more than the outlet effluent because of addition of oxygen with the effluent during biological treatment in ETP. According to Bangladesh Environment Conservation Rule (ECR)-1997, the acceptable range of pH for waste water discharged from industrial unit or projects waste is 6 to 9 for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. The measured pH of all collected effluent samples were within the permissible limit. So, it was not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Table 2. Physicochemical parameters of various sampling point of ETP in Impress Newtex Composite Textile

Sampling Point	Temper-ature (^{0}C)	pH	TDS (mg/l)	DO (mg/l)	EC (µs/cm)	BOD (mg/l)	Transparency (cm)	Color	Odor
Es_1	36.5	7.8	2824	0.8	185	210	1.2	Wine Red	None
Es_2	36.4	7.7	2478	0.9	188	174	2	Wine Red	Fishy
Es_3	35.2	7.4	2574	1.2	192	143	1.9	Wine Yellow	Pungent
Es_4	31.2	7.5	2498	1.7	191	166	1.4	Wine Red	Pungent
Es_5	31.3	7.2	2371	1.6	192	88	2.4	Dark Red	Pungent
Es_6	32.2	6.9	2412	3.6	193	91	2.6	Brown	Fishy
Es_7	32.1	6.5	2418	3.5	190	64	2.3	Grew	Pungent
Es_8	32	6.8	2365	3.6	191	39	2.9	Greenish	Fishy
Es_9	31.3	6.7	2245	5	192	42	3	Wine Red	Fishy
Max	36.5	7.8	2824	5	193	210	3		
Min	31.2	6.5	2245	0.8	185	39	1.2		
Mean	33.13	-	2465	2.43	190.44	113	2.18		
SD	2.23	-	163.65	1.51	2.51	62.11	0.62		

Temperature

The temperature of all collected effluent samples were within the range of 31.20^{o}C to 36.50^{o}C with an average of 33.13^{o}C (SD±2.23) (Table 2). The inlet effluent sample's temperature (36.50^{o}C) was high comparatively others because of raw effluent. According to ECR (1997), the acceptable limit of temperature for waste water discharged from industrial unit or projects waste is 40^{o}C for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. The measured temperature of all collected effluent samples were within the permissible limit. So, it was not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. It has been reported that textile and other dye effluent products are produced at relatively high temperature.

Dissolve oxygen (DO)

Dissolve oxygen analysis measures the amount of gaseous oxygen dissolve in an aqueous solution. The DO value of all collected effluent samples fluctuated between 0.80 to 5.00 mg/l within a mean value of 2.43 mg/l (SD±1.45) (Table 2). The DO of outlet effluent (5.00 mg/l) is more than the inlet effluent because of addition of oxygen with the effluent during biological treatment in ETP. According to ECR (1997), the acceptable range of DO for waste water discharged from industrial unit or projects waste is 4.50 to 8.00 mg/l for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. Most of the DO values were below the acceptable range (Table 2). So, it is problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Electrical conductivity (EC)

The EC of all collected effluent samples were within the range 185.00 to 193.00 µs/cm with an average value of 190.44 µS/cm (SD±2.51) (Table 2). According to ECR (1997), the acceptable limit of EC for waste water discharged from industrial unit or projects waste is 1200 µs/cm for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. On the basis of measured EC, all collected effluent samples were within the permissible limit. So, it was not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Total dissolved solids (TDS)

TDS values of the different sampling points of ETP were ranged from 2245 to 2824 mg/l with the mean value of 2465 mg/l (SD±163.65) (Table 2). The TDS of inlet effluent (2824 mg/l) is more than the outlet effluent because of addition of different dyes and chemicals. According to ECR (1997), the acceptable range of TDS for waste water discharged from industrial unit or projects waste is 2100 mg/l for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. On the basis of measured TDS, all collected effluent samples were not within the permissible limit. So, it was problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Biological oxygen demand (BOD)

The BOD of all collected effluent samples were fluctuated between 39.00 mg/l to 210.00 mg/l with an average value of 113.00 mg/l (SD±62.11). The BOD, of inlet effluent (210.00 mg/l) is more than the outlet effluent because of addition of oxygen with the effluent during biological treatment in ETP. According to ECR (1997), the acceptable range of BOD for waste water discharged from industrial unit or projects waste is 50.00 mg/l, 250.00 mg/l and 100.00 mg/l for inland surface water, public sewerage system connected to treatment at second stage and irrigated land, respectively. On the basis of measured BOD, all collected effluent samples were within the permissible limit for public sewerage system connected to treatment at second stage but some collected effluent samples for inland surface water and irrigated land exceeds the limit. The BOD at the outlet of ETP was within the permissible limit.

So, it was not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Transparency

The transparency of all collected effluent samples were fluctuated between 1.20 cm to 3.00 cm with an average value of 2.28 cm (SD±0.62). The transparency of inlet effluent is less than the outlet effluent because of removal of sludge and color after treatment of effluent. On the basis of measured transparency, all collected effluent samples were not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land. High transparency indicates pure water.

Table 3. Trace element concentration of various sampling point of ETP in Impress Newtex Composite Textile Limited, Tangail in Bangladesh

Sampling Point	ES_1	ES_2	ES_3	ES_4	ES_5	ES_6	ES_7	ES_8	ES_9	Max	Min	Mean	SD(±)
Pb (mg/l)	0.97	0.64	0.69	0.39	0.48	0.37	0.42	0.33	0.36	0.97	0.33	0.52	0.21
Zn (mg/l)	1.21	1.28	1.07	1.02	0.97	0.84	0.86	1.02	0.69	1.28	0.69	1	0.18
Ni (mg/l)	0.95	0.87	0.78	0.48	0.56	1.04	0.26	0.21	0.15	1.04	0.15	0.59	0.34

Lead (Pb) concentration

The Pb concentration in all collected samples were ranged from 0.33 to 0.97 mg/l with the mean value of 0.52 mg/l (SD±0.21) (Table 3). According to ECR (1997), the acceptable range of Pb for waste water discharged from industrial unit or projects waste is 0.10 mg/l for inland surface water and irrigated land as well as 1 mg/l for public sewerage system connected to treatment at second stage. On the basis of measured Pb, all collected effluent samples were not within the permissible limit excepts Pb for public sewerage system connected to treatment at second stage. So, it was problematic for inland surface water and irrigated land and not problematic public sewerage system connected to treatment at second stage.

Zinc (Zn) concentration

The concentration of Zn of all collected effluent samples were varied from 0.69 to 1.28 mg/l with a mean value of 0.99 mg/l (SD±0.18) (Table 3). According to ECR (1997), the acceptable range of Zn for waste water discharged from industrial unit or projects waste is 5 mg/l for inland surface water and 10 mg/l for public sewerage system connected to treatment at second stage and irrigated land. On the basis of measured Zn, all collected effluent samples were within the permissible limit. So, it was not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Nickel (Ni) concentration

The Ni content in all collected effluent samples were ranged from 0.15 to 1.04 mg/l with the mean value of 0.59 mg/l (SD±0.34) (Table 3). According to ECR (1997), the acceptable range of Ni for waste water discharged from industrial unit or projects waste is 1 mg/l for inland surface water and irrigated land and 2 mg/l for public sewerage system connected to treatment at second stage. On the basis of measured Ni all collected effluent samples were within the permissible limit. So, it was not problematic for inland surface water, public sewerage system connected to treatment at second stage and irrigated land.

Table 4. Comparison of experimented values with the values of Bangladesh Environment Conservation Rule, 1997 standards

Sl. No.	Water Quality Parameters	Unit	Inland Surface Water	Public Sewerage Water	Irrigation Water	Present study at the outlet of the ETP
01	PH	-----	6-9	6-9	6-9	6.7
02	DO	mg 1	4.5-8	4.5-8	4.5-8	5
03	TBS	ms 1	2100	2100	2100	2245
04	$(BOD)_5$	mg 1	50	250	100	45
05	EC	µs/cm	1200	1200	1200	192
06	Temperature	°C	40	40	40	31.3
07	Pb	mg/l	0.10	1	0.10	0.36
08	Zn	mg/l	5	10	10	0.69
09	Ni	mg/l	1	2	1	0.15

From the values of Table 4 we can observe that all the parameters are within the permissible limit according to ECR (1997) excepts TDS for inland surface water, public sewerage water and land for irrigation and Pb for inland surface water and land for irrigation.

Relationship between water quality factors and ionic constituents

Correlation matrix for analyzed parameters of effluents were calculated to see if some of the parameters were interrelated with each other and the results are presented in Tables 5. Examination of the matrix also provides clues about the carrier substances and the chemical association of ionic constituents in the study area (Jaquet *et al*., 1982). Considering the relationship between ionic constituents of effluent, the combinations of pH vs BOD, TDS vs BOD, DO vs Transparency, Temperature vs Pb ; pH vs Pb ; TDS vs Pb ; BOD vs Pb ; Temperature vs Zn ; pH vs Zn; BOD vs Zn showed positive significant correlation Table 5 which indicates that the parameters were interrelated with each other and may be originated from the same source. On the contrary, the combinations of pH vs DO ; DO vs BOD ; pH vs Transparency ; TDS vs Transparency ; EC vs Pb ; DO vs Zn showed negative significant correlation with each other. Other relationships among the ionic constituents of water were insignificant Table 5.

Table 5. Relationship between ionic constituents of effluent (n = 9) collected from various sampling point of ETP in Impress Newtex Composite Textile Limited, Tangail in Bangladesh

Parameters	pH	TDS	DO	EC	BOD	Transparency	Pb	Zn	Ni
Temperature	0.707 ^{NS}	0.752 ^{NS}	-0.680 ^{NS}	-0.724 ^{NS}	0.735 ^{NS}	-0.556 ^{NS}	0.881**	0.798*	0.656 ^{NS}
PH		0.745 ^{NS}	-0.904**	-0.588 ^{NS}	0.940**	-0.810*	0.758*	0.847*	0.664 ^{NS}
TDS			-0.749 ^{NS}	-0.749 ^{NS}	0.854*	-0.872*	0.895**	0.712 ^{NS}	0.634 ^{NS}
DO				0.534 ^{NS}	-0.871*	0.820*	-0.749 ^{NS}	-0.882**	-0.626 ^{NS}
EC					-0.663 ^{NS}	0.636 ^{NS}	-0.780*	-0.698 ^{NS}	-0.305 ^{NS}
BOD						-0.929**	0.797*	0.791*	0.707 ^{NS}
Transparency							-0.720 ^{NS}	-0.678 ^{NS}	-0.514 ^{NS}
Pb								0.714 ^{NS}	0.617 ^{NS}
Zn									0.543 ^{NS}

Legend: ** = Significant at 1% level; * = Significant at 5% level; ^{NS} = Not Significant; tabulated values of r with df is 0.875 at 1% level of significant and 0.754 at 5% level of significant.

Conclusions

The color and odor of the inlet effluent samples were highly colored and emits foul smell respectively. But outlet effluent samples showed very low. The DO, BOD, TDS, EC, pH, Temperature, Transparency value of all collected samples from ETP outlet were 5 mg/l, 42 mg/l, 2245 mg/l, 192 µs/cm, 6.5, 31.2 cm, respectively which fulfils ECR (1997) standards for inland surface water, public sewerage water and land for irrigation excepts the value of TDS. In case of heavy metal (Pb, Zn, Ni) assessment the concentrations of all collected effluent samples were ranged from 0.33 to 0.97 mg/l, 0.69 to 1.28 mg/l and 0.15 to 1.04 mg/l, respectively which indicates all the trace metals were within the permissible limit according to ECR (1997), for inland surface water, public sewerage water and land for irrigation excepts Pb for inland surface water and land for irrigation. Different types of dyes and chemicals were used during fabrics dyeing as a result the values of different physio-chemical parameters were more in inlet effluent but due to treatment by ETP outlet effluent shows lower value which fulfils ECR (1997) standards requirement. Only best management practices can ensure the best effluent quality discharged into the environment as well as best performance of ETP.

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