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Treatment of Textile Liquid Waste by Chlorination Process and Evaluation of the Formation of Trihalomethane

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The rise in the number of industries in Bangladesh, including textile-dyeing operations, has seriously increased water pollution in the country. This research work was aimed at achieving knowledge on various issues related to chlorination of textile liquid waste. The influent and effluent characteristics and efficiency of ten chlorine based treatment plants were investigated in this study. The concentrations of untreated effluent was found ranged between BOD_5:96 -242mg/l, COD: 225-800mg/l: TDS: 228-2040mg/l ,TSS: 15-110mg/l ,Color 382- 205 (Pt-Co unit). The treated effluents meet the standards set as per Schedule 12-B of the Environmental Conservation Rules -1997 (ECR-1997, Bangladesh). THM Plus method (Method 10132) was used with Hach DR/2010 Spectrophotometer to investigate the formation of disinfection byproduct, trihalomethane (THM) in the treated effluent since these disinfection byproducts are suspected to cause cancer, liver and kidney damage, related fetus growth. The concentration of THM was found ranged between 62-130 shows that no significant amount of THM was formed in the chlorinated effluent. In Bangladesh chlorine is cheap or available as an otherwise unusable product from chlor–alkali plants, its use in the treatment of wastewater can be a desirable option.

Field of Research: Environmental Engineering

1. Introduction

In Bangladesh textile dyeing is categorized as a Red Category Industry under the Environmental Conservation Act (1995). In accordance with the Environmental Conservation Act (1995) and Environmental Conservation Rules (1997) it is mandatory for textile dyeing factories to install effluent treatment plants (ETPs) to treat the wastewater before it is discharged by the factory. There have been a number of treatment options available for the treatment of textile wastewater. In Bangladesh only two major types of ETPs are in use. Those are physico-chemical treatment and physico-chemical treatment followed by biological treatment (Akhtaruzzaman, 2006).The ETPs have been built on turnkey basis requiring investments ranging from several million to several cores taka, most of it being foreign currency.

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More than 12.91 million USD is spent for imported chemicals used in their operation. The owners of this sector have found dubious alternative for not operating the ETPs resulting in unabated pollution of surface water (Quader 2010). Chlorine is an oxidizing agent and can be used for the removal of color and other pollutional loads of textile wastewater (Hannan 2011).In Bangladesh chlorine is cheap or available as an otherwise unusable product from chlor–alkali plants (Quader,2010). The chlorination leads to the formation of disinfection by products. Trihalomethanes (THMs) are the major category of disinfection by-products in chlorinated water suspected to cause cancer, liver and kidney damage, related fetus growth (Violeta 2012). This paper depicts an investigation on various issues related to chlorination of textile liquid waste and the presence of THMs in the treated effluent. The study will help to assess whether the existing pollution level of the water bodies from the textile waste water will be significantly reduced the pollution level if this simple technology is adopted.

This paper is composed of as follows. Section 2 contains a concise and selective review of the relevant literature. Section 3 presents the methodologies of laboratory experiments designed in the study. Section 4 presents results and discussions and section 5 provides the conclusions and limitations of the study.

2. Literature Review

Textile industries produce wastewater, otherwise known as effluent, as a by-product of their production. Effluent from the textile industry is often a major source of environmental pollution, especially water pollution. Among the various stages of textile production, the operations in the dyeing plant, which include pre-treatments, dyeing and finishing, unused or partially used organic compounds and have a high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). They are often of strong color and may also be of high temperature.

The most important parameters in wastewater from textile industry are COD (Chemical Oxygen Demand), BOD_5 (Biological Oxygen Demand), TDS (Total Dissolved Solids), TSS (Total Suspended Solids) (Tufekci et al., 1998). Chlorination was reported to reduce Biochemical Oxygen Demand (BOD_5) of sewage as well as to control odors. Historically chlorine was effectively employed for treating industrial wastewater for almost one hundred years ago. The term chlorination is often used synonymously with disinfections. Chlorine may be used as an element (Cl_2), as sodium hypochlorite (NaOCl), also known as bleach, as calcium hypochlorite [$Ca(OCl)_2$], or as chlorinated lime ($CaOCl_2$). Chlorine accomplishes BOD reduction by oxidation of organic compounds present in waste waters. The oxidizing ability of chlorine is employed for odor control and color removal in treatment of many industrial effluents (beet sugar, cannery, dairy, pulp and paper, textiles (Quader 2010)

Reactions between natural organic matter (NOM) and chlorine during disinfecting drinking water form trihalomethanes (THMs) and other chlorinated by products (CBPs), some of which are possible carcinogen to human health. The Chemistry of the reactions between chlorine and the organic materials present in water is complex. The important factors include the type and concentrations of organic

materials in the raw water, the chlorine reaction time,temperature and chlorination pH.

A number of models have been developed to predict THMs formation since the discovery of THMs in drinking waters (S. Chowdhury et al. (2008)). In this study the effect of free residual chlorine, pH, temperature on THM was assessed using the correlation developed by Rodrigue(2000).

3. Methods and Materials

The influent and effluent characteristics and efficiency of ten chlorine based treatment plants were investigated in this study. Textile liquid waste samples were collected from the equalization tank of effluent treatment plant. All possible efforts were made to minimize the time lag between collection and analysis so that no significant change may occur in the quality of the samples. The collected samples were transported to the laboratory quickly and then samples were preserved in the refrigerator in accordance with the standard Methods.Finally the concentrations of BOD5, COD, TDS, TSS were analyzed in the environmental Engineering laboratory BUET according to the standard methods (APHA, 1998). To determine the THM in the treated effluent THM Plus method (Method 10132) was used with Hach DR/2010 Spectrophotometer. The effect of free residual chlorine, pH, and temperature on THM was assessed using the correlation developed by Rodrigue (2000).

4. Result and Discussion

A. Concentration of Influent and Effluent Stream and Removal Efficiency:
The test result of BOD_5 of different sample is presented in the figure 4.1. The concentration of BOD_5 of untreated effluent was found to vary from 180 to 1140 mg/l and COD: 525-1960mg/l. The concentration of BOD_5 of treated effluent was found to vary from 96 to 242 mg/l and COD: 225-800mg/l. The removal efficiency of BOD and COD by chlorination process is presented in the figure 4.1, 4.2, 4.3, 4.4. The effluent discharge standard for BOD_5 is 150mg/l indicates that these ETPs satisfy the standard.

The colour of untreated effluent was found to vary from 670 to 2015 Pt-Co units and 382 to 736 for the treated effluent. Though there is no standard limit of color for discharging treated effluent into inland surface water body but US (EPA) allowable limit for that is 150 Pt-Co units. Color content should be removed from effluent sample for the aesthetic reason.

The tests results of total dissolved solids (TDS) of the different sample are presented in Table 4.1. The concentrations of dissolved solids of untreated effluents were found 1338 - 6800 mg/1 and the concentration of treated effluent were found 467-2020mg/l.

Total suspended solids (TSS) are differentiated from total dissolved solids (TDS), in that the former cannot pass through a sieve of two micrometers and yet are indefinitely suspended in solution. Maximum concentrations of suspended solids in untreated effluent were varying from 46 -797 mg/L and in treated effluent the

concentration of TSS were 15-140 mg/l. Bangladesh industrial effluent standards (DOE, 1997) for suspended solids is 150 mg/l.

Figure 4.1: BOD Removal by Chlorination Process in Different Textile ETPs

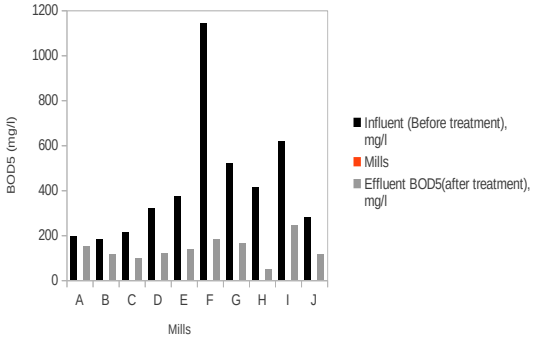


Figure 4.2: BOD Removal Efficiencies by Chlorination Process in Different Textile ETPs

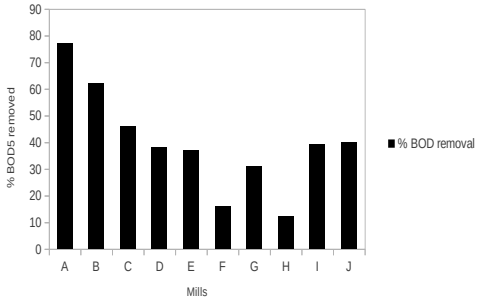


Figure 4.3: COD Removal by Chlorination Process in Different Textile ETPs

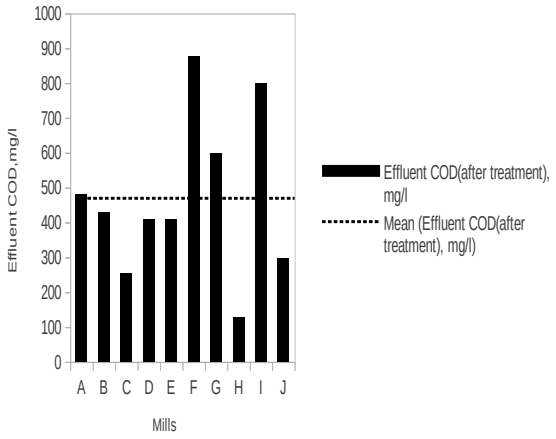


Figure 4.4: COD Removal Efficiencies by Chlorination Process In Different Textile ETPs

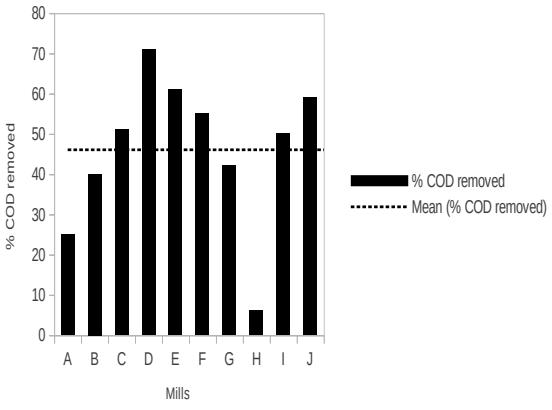


Figure 4.3: Color Removal by Chlorination Process in Different Textile ETPs

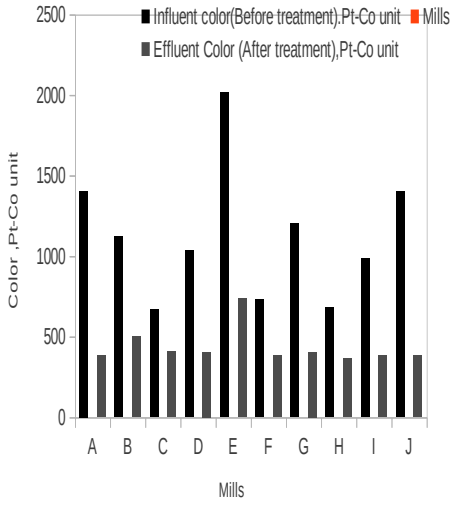


Figure 4.4: Color Removal Efficiencies by Chlorination Process in Different Textile ETPs

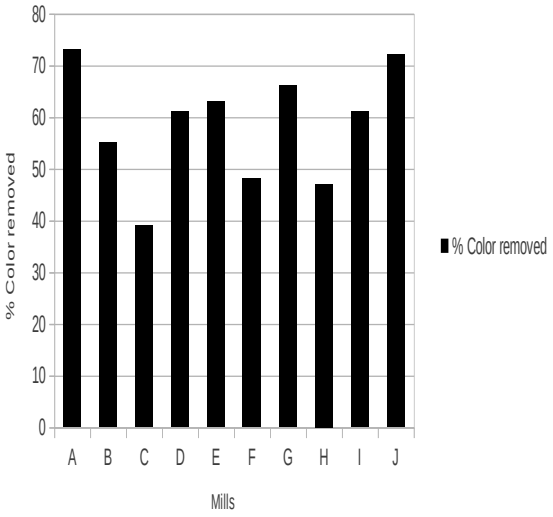


Table 4.1: Measured Influent and Effluent Values (TDS, TSS and Color) and Removal Efficiencies

Mills	TDS(mg/L)			TSS(mg/L)		
	Inlet	Outlet	% removal	Inlet	Outlet	% removal
A	2072	749	63	130	15	88
B	6648	1900	71	224	110	51
C	1338	925	31	220	65	70
D	6800	2020	70	56	69	increased
E	1519	725	52	46	34	26
F	2230	228	45	797	140	82
G	4390	2024	54	370	170	54
H	3260	1492	54	160	140	82
I	2043	1600	22	140	120	14
J	2100	1673	35	1400	382	7

Bangladesh industrial effluent standards (DOE, 1997) for TDS is 2100 mg/l and for TSS 150 mg/l . There is no standards limit of color for discharging treated effluent in Bangladesh but US (EPA) allowable limit for is 150 pt-Co unit.

The performance data of ten chlorine based ETPs are presented in figure Table 4.It is evident from these data that ETPs using chlorination are performing satisfactorily. The treated effluents from the ETPs meet the set standards Schedule 12-B of ECR'97.

B. Evaluation of Trihalomethane in Outlet Stream

The presence of THMs in all treated samples was confirmed in this study. However, the concentration of THMS in treated samples was found below the WHO guide line values.

Table 4.2: Trihalomethane Concentrations in Outlet Stream

Mill A	Mill B	Mill C	Mill D	Mill E	Mill F	Mill G	Mill H	Mill I	Mill J
120 ppb	160 ppb	96 ppb	196 ppb	102 ppb	120 ppb	180 ppb	40 ppb	110 ppb	140 ppb

The model developed by Rodriguez et al.(2000) has been used to find out the concentration of THM in the distribution line. The model is

$TTHM = 0.044(DOC)^{1.030}(t)^{0.262}\ pH^{1.149}(D)^{0.277}(T)^{0.968}$

Parameters TTHM= Total Trihalomethane, DOC= dissolved organic carbon (mg/l), t= contact time (min), D= Chlorine dose (mg/l), T= water Temperature (^{o} C)

Figure 4.5: Concentration of THM for Different Chlorine Dose at pH=6

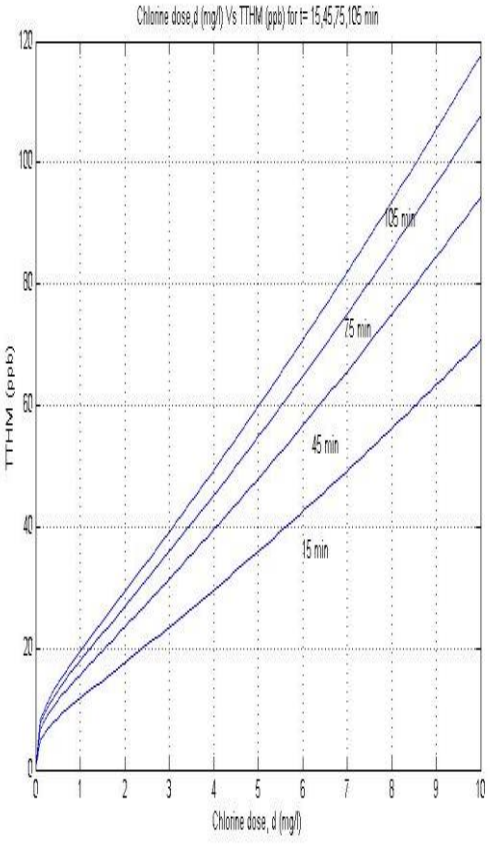


Figure 4.6: Concentration of THM for Different Chlorine Dose at pH=7

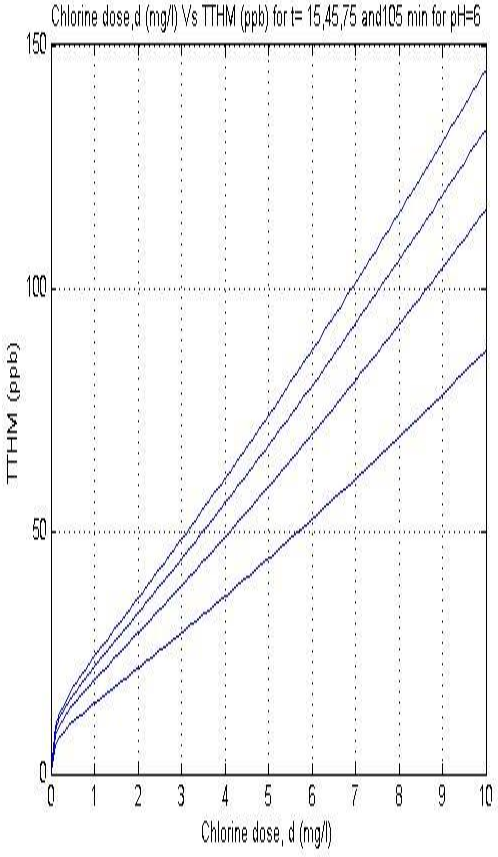


Figure 4.7: Concentration of THM for Different Contact Time at pH=6

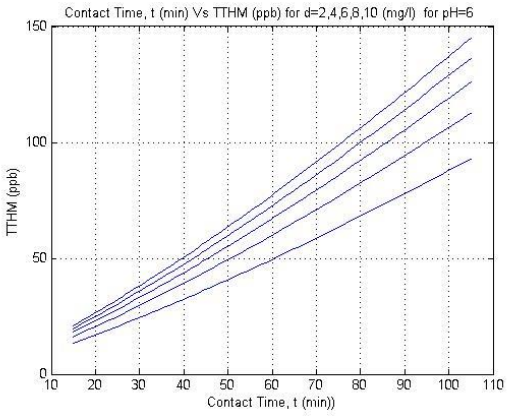


Figure 4.8: Concentration of THM for Different Contact Time at pH=7

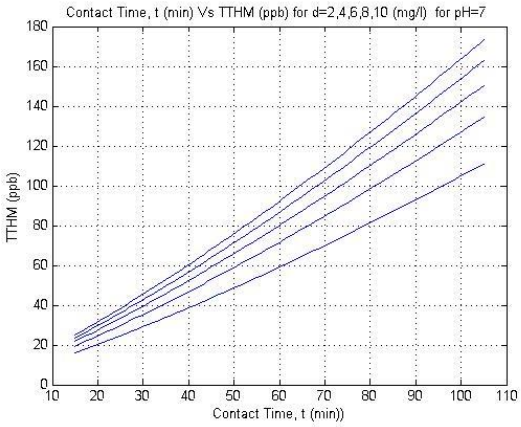


Figure 4.7: Concentration of THM for Different Temperature at pH=6

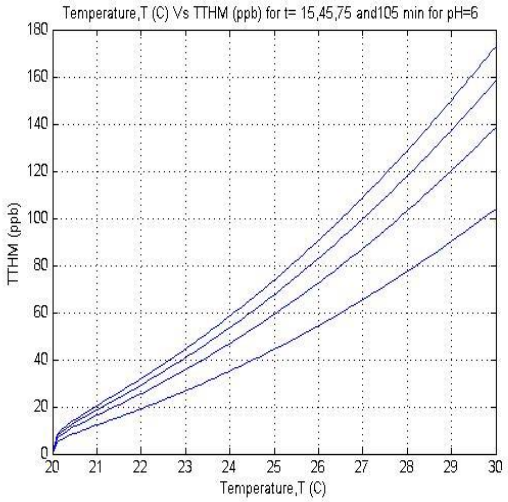
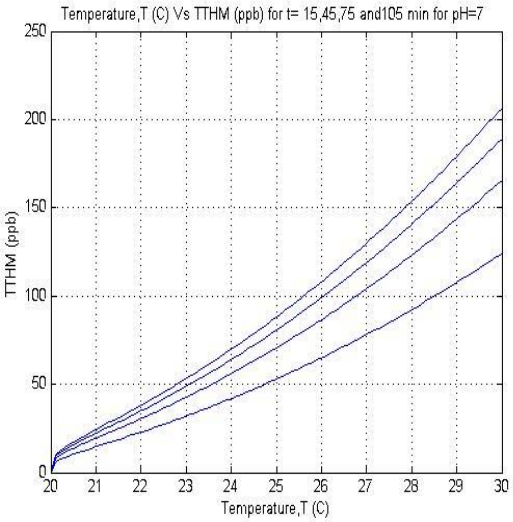


Figure 4.8: Concentration of THM for Different Temperature at pH=7



The above test results show that the THM concentration is below WHO standards (150ppb) as the origin of textile waste water is such that it contains a negligible amount of fulvic and humic acid. The further formation of THM will be remote if the residual chlorine is kept under 0.2 mg/l and the pH is maintained in the range of 7-8.

5. Conclusion

The test results show that chlorination of textile waste achieves all the objectives of its treatment such as reduction of BOD_5, COD and TDS, TSS and color removal. The treated effluents meet the standards set as per (ECR- 1997) Bangladesh. The presence of THM in all treated effluents was confirmed in this study but the

concentration of THM was found below the WHO guidelines value. The possibility of THM formation is remote since these tested samples contain a negligible amount of fulvic and Humic acid.

In this study no attempt was made for dechlorination of the treated effluents. Free chlorine can be removed by using activated carbon bed, by reacting with Sodium Sulfite (Na_2S0_3), Sodium Bisuifite($NaHSO_3$), Sodium Metabisulfite($Na_2S_2O_5$), Sodium Thiosulfate ($Na_2S_20_3$), Sulfur Dioxide gas(SO_2); by passing over a bed of gypsum, iron turnings or aeration. Experiment should be carried out to observe the performance of dechlorination with different dechlorinating compounds or materials.

The further possibility of the formation of THM will be in the range WHO guideline if the residual chlorine is kept under 0.2 mg/l and the pH is maintained in the range of 7-8. Therefore the existing pollution level of the water bodies from the textile wastewater will be significantly reduced if this simple technology is adopted. Thus the operation of ETPs using chlorine by the textile sector would be affordable.

References:

Akhtaruzzaman, M. (2006), 'Treatment of Textile Liquid Waste', M. Sc. Thesis, Dept. of Civil Eng., Bangladesh University of Engineering and Technology, Dhaka.

American Public Health Association (APHA-AWWA-WPCH) (1998). Standard Methods for The Examination of water and waste water .20th edition. APHA Washington D.C, P. 1270

Chowdhury, S. and Champange, P. (2008), 'An Investigation on Parameters for Modeling THMs Formations' *Global NEST Journal*, Vol 10, No 1, PP 80-91.

ECA 1995 and ECR 1997, Environment conservation Act, (1995) and Environment conservation Rules (1997); the Bangladesh Gazette, Extra-ordinary Issue, Department of Environment (DOE), Dhaa, Bangladesh.

Hannan, M. A. (2011) , 'An Investigation on the Effects of Bleaching Powder with Dyeing industries' Effluent' JCE (IEB) Vol. CE 39(1).Pp 77-89.

Karim, Z., Mumtaz, M. and Kamal, T. (2011), 'Evaluation of trihalomethanes in Tap water samples of Krachi City (Pakistan)' *Journal of basic and Applied Science* Vol.7 No.1 Pp 7-10

Quader, A. K. M. A (2010), 'Waste water Treatment in Textile Industries for Clean Environment', *Chemical Engineering Alumni Association Publication,* Bangladesh University of Engineering and technology (BUET), Dhaka. Pp. 11-42.

Rodriguez, M. J., Serodes, J. and Morin, M. (2000) 'Estimation of water utility compliance with trihalomethane regulations using a modelling approach' Aqua-Colchester, Vol 49(2), Pp.57-73.

Rodriguez, M., Milot, J., Serodes, J. B. and Pacaud, A. (2002) 'Estimation of bench-scale chlorine decay in drinking water using nth-order kinetic and back propagation Neural Network Models' Water Qual. Res. J. of Canada, 37(3), Pp. 613-635

Tufekci, N., Sivri, N. and Toroz, I. (2007), 'Pollutants of Textile Industry wastewater and assessment of its discharge Limits by water quality Standards' *Turkish Journal of Fisheries and Aquatic Sciences* ,VOL 7, Pp: 97-103

WHO (2005), 'Trihalomethane in drinking water' *Background document for development of WHO guidelines for drinking water quality. http//www.who.int/water_sanitation_health/*