International Journal of Science, Environment and Technology, Vol. 5, No 4, 2016, 1842 – 1849

ISSN 2278-3687 (O)
2277-663X (P)

EXPERIMENTAL EVALUATION OF PHYSICAL CHEMICAL TREATMENT OPTIONS FOR DENIM PROCESSING WASTEWATER

Nadim Reza Khandaker[1], Md. Sarker[2] and Iffat Afreen[3]
[1,3]Department of Civil and Environmental Engineering, North South University, Plot 15, Block B, Bashundhara, Dhaka, Bangladesh
[2]Department of Civil Engineering, Military Institute of Science and Technology, Mirpur Cantonment, Dhaka, Bangladesh
E-mails: [1]nadim.khandaker@northsouth.edu [2]siddique63bd@gmail.com
[3]easha1993@yahoo.com

Abstract: This article reports on an experimental program designed to investigate the efficacy of physical and chemical treatment of wastewater generated from textile processing facilities to reduce colour and solids. The treatment options that were investigated were, settling, acid hydrolysis, base hydrolysis, chemical oxidation, and adsorption.
Keywords: Textile wastewater, Physical chemical Treatment, Environment.

1. INTRODUCTION

The textile industry of Bangladesh is a significant contributor to the gross domestic product of Bangladesh. A major problem this industry is facing is facing negative publicity due to bad operational practices. Of concern is untreated or not completely treated discharge of wastewater to the water bodies leading to sever negative impacts [1,2]. Of concern is the chroma associated with the untreated or not effectively treated textile processing wastewater. The chroma is due to the presence of organic dye in the textile processing wastewater. Wastewater containing chroma when discharged into water bodies prevents the penetration of light thus hampering the growth of aquatic life. Also, textile dyes are known to have toxic properties both to aquatic life and human health [3,4,5].

The objective of the experimental program was to look at different physical and chemical sustainable pre-treatment treatment options using locally available processes and chemicals to remove or reduce colour from textile processing wastewater. Under controlled laboratory conditions different methods of pre-treatment to reduce colour and total suspended solids (TSS) were investigated. The processes that were studied were settling, hydrolysis using inorganic and organic at different pH ranges, partitioning using organic solvent as a treatment option, oxidation using hypochlorous acid and activated carbon adsorption. The experimental

*Received June 5, 2016 * Published Aug 2, 2016 * www.ijset.net*

program was conducted with a twenty four hour time proportioned composite sample obtained from the equalization basin of a wastewater treatment facility treating blue denim processing wastewater.

It is intended that the results of the experimental program would lead to application of pre-treatment methods with locally available chemicals and process to enhance colour and total suspended solids removal in wastewater treatment systems in Bangladesh treating textile processing wastewater.

2. MATERIALS AND METHODS

2.1 Textile wastewater sample collection

For this experiment program blue denim processing textile wastewater was used. The textile wastewater sample was collected from the equalization basin of a blue denim textile processing wastewater treatment plant. A time proportion composite sample was collected for twenty four hours of operation.

1.2 Settling study

The settling study was conducted by aliquoting 1000 ml of the collected wastewater sample into a 2.0 L beaker. The sample was steered for 3.0 min at 400 rpm by an overhead paddle stirrer. The stirring was then stopped and the sample was allowed to settle for 150 min. At time equal to 0 minute and then every 30 minute interval sample was collected for analysis of color and total suspended solids (TSS) from the surface of the wastewater in the beaker. The experiment was repeated three times and the average value reported.

2.3 Mineral acid hydrolysis test

The mineral acid hydrolysis test was conducted by aliquoting 1000 ml of the collected wastewater sample into a 2.0 L beaker. The sample was continuously steered at 400 rpm by an overhead paddle stirrer. Drop wise 98% sulfuric acid was by using a pipette with simultaneous monitoring of pH. The pH was dropped from 8.50 ± 0.01 to 1.71 ± 0.01 stepwise and samples were collected for analysis of color and total suspended solids (TSS) from the surface of the wastewater in the beaker at six preset pH intervals. The experiment was repeated three times and the average value reported.

2.4 Perchlorate oxidation test

The perchlorate oxidation test was conducted by aliquoting 250 ml of the collected wastewater sample into a 500 mL beaker. The sample was continuously steered at 400 rpm by an overhead paddle stirrer. Drop wise 70% perchloric acid was added by using a pipette and the volume of perchloric acid added was monitored real time. Samples were collected at

0.1, 0.2, 0.5, 1.0, 10.0, and 20.0 ml of perchloric added for analysis of color and total suspended solids (TSS) from the surface of the wastewater in the beaker. The experiment was repeated three times and the average value reported.

2.5 Partitioning test

The partitioning test was conducted by aliquoting 20 ml of the collected wastewater sample into a 50 mL partitioning shake flask to which 20 ml of standard diesel ($C_{12}H_{23}$) was added subsequently continuously shaken for 20 minutes to attain equilibrium and then left standing for the two liquid phases to separate. Samples were then collected after equilibration and phase separation and analyzed for color. The experiment was repeated three times and the average value reported.

2.6 Batch Equilibrium Studies with Activated Carbon Adsorption

Batch equilibrium studies were conducted using activated carbon and blue denim textile dyeing wastewater. 10 ml blue dye wastewater was equilibrated for 48 hours with varying mass of activated carbon. The varying mass of activated carbon used was 0.5, 0.7, 1.0, and 1.5 gm. After 48 hours equilibration in a shaker, the test-tube containing the dye waste equilibrated with activated carbon was centrifuged at 1500 rpm for 10 minutes. The supernatant was then decanted and analyzed at the laboratory for residual color and total chemical oxygen demand (COD). The Adsorption Isotherm for COD removal and color removal was then derived and plotted.

2.7 Analysis

Chemical oxygen demand was measured by HACH method-Reactor Digestion Method (Method 8000) digestion 0–1500 mg/L range [6]. Color was measured by HACH method-Platinum-Cobalt Standard Method (Method 8025) adapted from Standard Methods [7] for the Examination of Water and Wastewater and National Council for Air and Stream Improvement (NCASI) Methods Manual. Residual chlorine was measured by HACH method-USEPA DPD Method (Method 8167) adapted from Standard Methods for the Examination of Water and Wastewater. This Procedure is equivalent to USEPA and Standard Method 4500-Cl G for drinking water and wastewater analysis. Total suspended solid was measured by Standard Method [7]. Total dissolved solid (TDS) and pH was measured using a combined pH/TDS probe and meter.

2. RESULTS AND DISCUSSION

3.1 Wastewater characterization

The time proportion composite textile wastewater sample collected from the equalization basin of the blue denim textile processing wastewater treatment plant is characterized below in Table 1. The parameters of interest that can be reduced potentially by physical chemical treatment such as settling, partitioning, acid hydrolysis, perchloric acid oxidation, and activated carbon adsorption are TSS, and colour, and in the case of activated carbon the reduction in soluble COD. The Government of Bangladesh wastewater discharge standards for inland water bodies for TSS, colour, and COD are: TSS < 150 mg/L, colour < 150 ptco, and COD < 200 mg/L [8, 9]. Although the Government of Bangladesh dose set a limit for colour of < 150 ptco, international textile buying agencies norms require that the colour of in the direct discharge in general it should not exceed 60 times the intake water colour which in surveys done in Bangladesh supply water ranging between 25 to 70 ptco. The collected wastewater sample from the equalization basin though within limit has a definite blue colour to it and as such it would be desirable to remove the colour, because colour hampers the photosynthesis process of water bodies [4].

Table1. Characteristics of the composite textile wastewater sample collected from the equalization basin of a blue denim textile processing wastewater treatment plant.

Sample Location	TSS (mg/L)	pH	Colour (ptco)	TDS (mg/L)	COD (mg/L)	BOD_5 (mg/L)
Equalization Basin	144	8.6	660	2470	371	228

3.2 Settling study

The settling study was conducted with the time proportion composite textile wastewater sample collected from the equalization basin of a blue denim textile processing wastewater treatment plant that there was as expected a correlation between settling time and reduction in total suspended solids (TSS) and colour (Refer to Figure 1 and Figure 2). At 2.5 hrs of settling based on the recommended design retention time for primary clarifiers treating textile wastewater [8,9] there was a substantial reduction of total suspended solids. The reduction of total suspended solids was 71% with reduction of colour of 43%. The settled effluent with a TSS value of 31.0 ± 0.0 and colour of 237.3 ± 1.2 is well within the discharge guidelines of the government of Bangladesh. This implies that primary treatment alone can serve as an effective treatment option with regards to discharge compliance for certain textile dyeing wastewaters with respect to colour and total suspended solids.

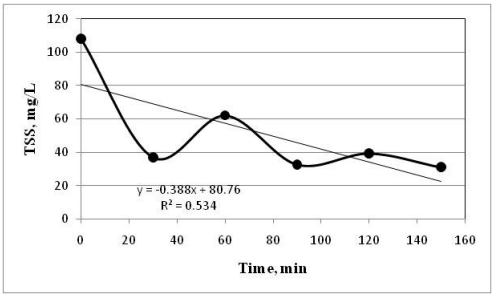

Figure 1. Graph of total suspended solids (TSS) verses settling time for blue denim dyeing wastewater.

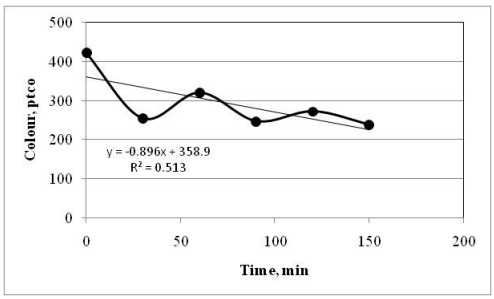

Figure 2. Graph of colour verses settling time for blue denim dyeing wastewater.

3.3 Partitioning test

The partitioning test conducted to investigate the potential for colour removal using an organic solvent gave a log partitioning coefficient value approximately to 1.0, indicating that the colour causing compounds cannot partitioned away using an organic solvent and that the colour causing compounds present in the wastewater is hydrophilic and homogeneously mixed.

3.4 Mineral acid hydrolysis test

The mineral acid hydrolysis test conducted by dropping the pH from 8.50 ± 0.01 to 1.71 ± 0.01 using concentrated sulphuric acid did not produce any discernable change in colour or total suspended solids. The colour causing chemicals or the solids present were not being hydrolyzed by the mineral acid.

3.5 Perchlorate oxidation test

The perchlorate oxidation test showed that addition of perchloric acid produced a direct decrease in colour (Refer to Figure 3) with increase in the amount of perchloric acid added. Maximum removal of colour was noticed with the maximum addition of perchloric acid. A 45% decrease in colour was observed with the addition of 1:12.5 v/v of 77% perchloric acid to the wastewater. The colour decreased from 462.6 ± 4.2 to 256.6 ± 3.0. Perchloric acid oxidation is a definite method of removing colour from textile dyeing wastewater.

There was no decrease in total suspended solids (TSS) with the addition of perchloric acid, indicating that the solids present were not being oxidized. Perchloric acid oxidation is a definite method of removing colour from textile dyeing wastewater.

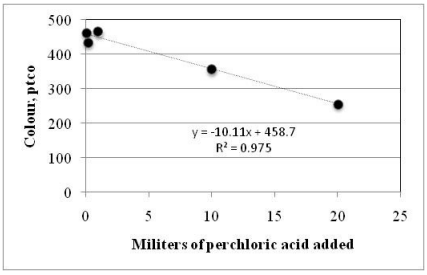

Figure 3. Graph of colour verses addition of perchloric acid to blue denim dyeing wastewater.

3.6 Batch Equilibrium Studies with Activated Carbon Adsorption

Batch equilibrium studies conducted using granular activated carbon and blue denim textile dyeing wastewater showed that the activated carbon was able to completely remove the colour from the blue denim dyeing wastewater at the granular activated carbon ratio of 1:10 mass/mass and at the unadjusted pH of 8.6. The activated carbon was also able to reduce the chemical oxygen demand (COD) of the textile dyeing wastewater. The linearized Freundlich adsorption isotherm for COD removal with granular activated carbon for the textile dyeing wastewater is shown in Figure 4 below. In the linearized Freundlich isotherm defined by equation 1; where: q_e represents the amount adsorbed per amount of adsorbent at the equilibrium (mg/g), C_e represents the equilibrium concentration (mg/L), and K_f (adsorption capacity) and n (adsorption intensity) are parameters that depend on the adsorbate and adsorbent [10].

(1) $\ln q_e = \ln K_f + 1/n \ln C_e$

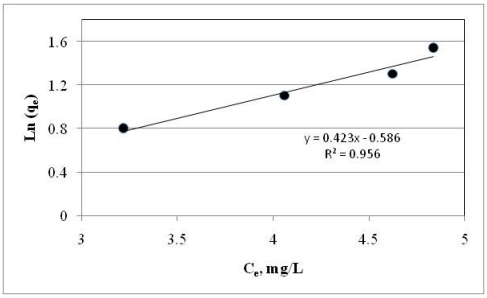

Figure 4. Linearized Freundlich adsorption isotherm for soluble COD removal with granular activated carbon for the textile dyeing wastewater

The linearized Freundlich adsorption isotherm defined well the granular activated carbon adsorption of the chemical oxygen demand (COD) of the textile dyeing wastewater with a R^2 value of 0.956, with the adsorption capacity of the COD defined by the adsorption capacity ($K_{f)}$ = 0.56 mg/g, and adsorption intensity (n) = 2.36. The batch adsorption study indicates that the potential of using activated carbon to remove the colour from the wastewater and at the same time reduce the COD of the wastewater.

4.0 Conclusions

This experimental program investigated the efficacy of different physical treatment methods for treatment of textile blue denim dying wastewater. Those results indicated that different options have different successes in removing colour, total suspended solids, and soluble chemical oxygen demand. Primary settling alone can serve as an effective treatment option with regards to discharge compliance for certain textile dyeing wastewaters with respect to colour and total suspended solids. Hydrolysis with hypochlorous acid show substantial decrease in the colour of the wastewater indication that the compounds responsible of the colour was being broken down by the hypochlorous acid. Activated carbon adsorption was able to completely remove the colour from the wastewater and simultaneously reduce the soluble chemical oxygen demand of the wastewater.

REFERANCES

[1] Islam, M.M., Mahmud, K., Faruk, O.,Billah, M.S. (2011). Textile Dyeing Industries in Bangladesh for Sustainable Development. International journal of Environmental Science and Development, 428-436.

[2] Zongping Wang, Miaomiao Xue, Kai Huang and Zizheng Liu (2011). Textile Dyeing Wastewater Treatment, Advances in Treating Textile Effluent, Prof. Peter Hauser (Ed.), ISBN: 978-953-307-704-8, InTech, Available from: http://www.intechopen.com/books/advances-in-treating-textile-effluent/textile-dyeing-wastewatertreatment.

[3] Sultana, M.S., Islam, M.S., Sahaa, R. and Al-Mansur, M.A., (2006) "Impact of Effluents of Textile Dying Industries on the Surface Water Quality Inside D.N.D. Embankment, Narayanganj, Bangladesh", Journal of Scientific and Industrial Research, 44(1), pp.66.

[4] Joseph Egli Italia srl (2007). Wastewater treatment in the textile industry. *Dyeing Printing Finishing* 10(2007)60-66.

[5] Ventura-Camargo B., Marin-Morales M. Azo Dyes: Characterization and Toxicity – A Review. *Textiles and Light Indust. Science and Technol*. 85-103. 2013.

[6] Hach. Calorimeter Procedures Manual. Hach Chemical Company. Denver, Colorado. 2013.

[7] APH-AWWA-WEF. Standard Methods for the Examination of Water and Wastewater. 20th edition. American Public Health Association/American Water Works Association/Water Environment Federation, New York, USA, 1998.

[8] Government of the People's Republic of Bangladesh Ministry of Environment and Forest. The Environment Conservation Rules. Bangladesh. 1997.

[9] Department of Environment and Forest Bangladesh. Guide for Assessment of Effluent Treatment Plants. 1st edition. Dhaka, Bangladesh. 2008.

[10] Alok Mittal, Lisha Kurup, Jyoti Mittal Freundlich and Langmuir adsorption isotherms and kinetics for the removal of Tartrazine from aqueous solutions using hen feathers Journal of Hazardous Materials 146 (2007) 243–248.