ECOLOGICAL IMPACT OF EFFLUENTS DISCHARGED AFTER DYEING COTTON KNIT FABRIC WITH REACTIVE DYES

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Abstract: *This study mainly refers to investigate the environmental impact of textile effluents discharged after dyeing cotton knit fabric with eight different reactive shades. By this work it was possible to evaluate the influence of each shade on the present ecological system. Textile effluents generated after dyeing with eight shades were collected to analyze the ecological parameters, including acidity or alkalinity (pH), amount of dissolved oxygen (DO), total dissolved solids (TDS), temperature and visual colors. From the experimental data it can be said that the effluents produced from the dyeing process comprising primarily more alkalinity, less DO, more TDS, high temperature and nearly black color which have indubitably adverse effects on the biological system. Furthermore, all reactive dyes were not found to be equally responsible to affect the surroundings. Hence, this research work becomes vital to recommend a suitable reactive dye having low impact on the environment.*

Keywords: *Reactive dye, Textile effluent, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), pH (potentiality of Hydrogen), Visual color.*

1. Introduction

In last few years, textile industry produces immense quantities of highly colored effluents which are the result of the utilization of synthetic chemical dyes in different phases of textile product processing, coloring of materials, printing and after processing. Textile dyeing is a major consumer of water and producer of contaminated aqueous waste streams as dyeing processes are generally conducted in water-based dyeing baths and require the addition of colorants, auxiliaries, including dispersants, leveling agents, acids, alkalis, salts, heavy metals etc. Those dyes containing mechanical toxic effluents can never easily be destructed by normal processing and are also one of the major cause of lethal soil, water bodies, sea-going environments [1-5]. Almost 700,000 tons of approximately 10,000 types of dyes and pigments are produced annually worldwide, of which about 20% are assumed to be discharged as industrial effluent during the textile dyeing processes [6]. The color arises from chromophore and auxochrome groups in the dyes cause pollution and again another cause of pollution is the auxiliary chemical substances including carcinogenic amines, toxic heavy metals, pentachlorophenol, halogen carriers, free formaldehyde, biocides, softeners and so on [7-8].Most of the dyes used are complex structured polymers and among all reactive dyes cause special environmental concern as up to 50% may be lost directly into effluent [9-11]. More than 50% of ecological friendly cotton is dyed with reactive dyes as because of their high wet fastness, brilliance, range of hues and simplicity of dying process [12-14]. During dyeing dye exhaustion occurs as the cotton fiber assumes a negative charge on its surface in aqueous solution due to the use of salt [15]. On the other hand use of reactive dyes cause certain problems when dyeing continued with high concentrations of electrolyte (salt) and organic substances; resulting in a highly colored effluent, due to the inefficient dyeing process and the nature of the dyes, which after hydrolysis do not react with the fiber [1, 3]. Water reacted or hydrolyzed dyes due to hot alkaline dye bath are another important cause of heavily polluted wastewater after reactive dyeing. So, The wastewater from a typical cotton textile industry is characterized by high values of color, pH, dissolve solids and if this highly colored waste waters is directly discharged into the surface water sources can cause depletion of dissolve oxygen by obstructing the entrance of daylight and oxygen (key for the survival of different sea-going structures) [16-17]. The high alkalinity and high color renders the water unfit for use at the downstream of the disposal point; can increase the toxicity and adversely affect the aquatic life [18-20].

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Based on one American journal an investigation was carried out on the effluent characteristics of organic cotton fabric dyeing which shows alkaline pH, high TDS and less DO in the collected effluent after dyeing and suggests that DO values can be increased for dyeing within the limit by Bangladeshi standard with a balanced pH by using eco-friendly dyes and chemicals [21].Another research work published by Eurasian publication shows lower values of dissolved oxygen and suggests using low impact reactive dyes to maintain high DO values in the effluent [22]. However, the first part of this paper highlighted on the collection of textile effluents after dyeing with different shades of reactive dye and the second part underscored on the analysis of ecological parameters of the collected effluents such as pH, DO, TDS, temperature and visual color.

2. Experimental details

2.1 Sample specification

For this research work pretreated (scoured, bleached and mercerized) cotton knit fabric was selected. The entire study was conducted mainly with 100% cotton single jersey fabric having two yarn counts, including 20/2 and 32/2, respectively.

2.2 Dyeing process

In this study, eight cotton samples were shaded in the range of blue, black, navy and WEO with reactive dyes and collected. Afterwards, selected samples were analyzed by spectrophotometer (Data color) to formulate the dye recipes found mostly with Sunfix and Sunzol reactive dyes, Glauber salt, alkali etc. Here, medium and hot brand reactive dyes were used for dyeing cotton fabric by exhaust method to reproduce dyed samples and investigate the produced effluents. The recipes used in dyeing are stipulated in the following table 1 and 2 where auxiliaries such as Gilmax-90A (chelating agent) and Periwet WDP (wetting agent) were also used for uniform dyeing.

Table 1 Shade composition found from selected samples by spectrophotometric analysis.

Sl. No.	Shade	Name of Reactive Dye	Dye Concentration (%)	Fabric Composition
1	Navy P-25	Sunfix Yellow SPD	0.36	20/2 100% cotton
		Sunfix Red SPD	0.96	
		Sunfix N Blue SS	1.93	
2	Dark Navy	Sunfix Yellow SPD	0.82	32/2 100% cotton
		Sunfix Red SPD	0.98	
		Sunzol Black B 133%	2.24	
3	Mid Night Blue 003	Sunfix Yellow S-3R	0.54	32/2 100% cotton
		Sunfix Red MFD	0.40	
		Sunzol Black DN	5.19	
4	Black 09-090	Sunfix Yellow S-3R	0.49	20/2 100% cotton
		Starfix Red ED	0.25	
		Sunzol Black DN	4.43	
5	Black E-001	Sunfix Yellow S-3R	0.64	20/2 100% cotton
		Sunzol Black DN	5.72	
6	Blue Canard	Sunfix Supra Yellow S4GL-150%	0.27	20/2 100% cotton
		Sunfix Blue SBR-150%	0.86	
		Sunzol Turquoise Blue G 266%	0.83	
7	Blue 110	Sunfix Red SPD	0.02	20/2 100% cotton
		Sunfix Navy Blue SPD	1.50	
		Novacron Ocean S-R	0.45	
8	WEO	Sunfix Supra Yellow S4GL-150%	0.29	32/2 100% cotton
		Sunzol Turquoise Blue G 266%	0.85	
		Sunfix Navy Blue SPD	0.40	

Table 2 Dye bath recipes for dyeing with reactive dyes.

Sl. No.	Shade	Dye Quantity (%)	Glauber Salt(g/l)	Soda Ash(g/l)	Caustic Soda(g/l)	Dyeing Temperature (°C)	Dyeing Time (minutes)	pH	Liquor Ratio
1	Navy P-25	3.25	70	20	0	60	50	11.7	1:6
2	Dark Navy	4.04	80	20	0	60	50	11.5	1:6
3	Mid Night Blue003	6.12	100	5	1.2	65	60	12.2	1:6
4	Black 09-090	5.17	100	5	1.2	65	60	12.6	1:6
5	Black E-001	6.36	100	5	1.2	80	60	12.3	1:6
6	Blue Canard	1.96	39	13	0	80	40	11.1	1:6
7	Blue 110	1.97	30	9	0	80	40	11.1	1:6
8	WEO	1.55	32	9	0	80	40	11.2	1:6

2.3 Wastewater Collection

After dyeing process the effluents were collected in a beaker to analyze effluent parameters such as visible colors, temperature, pH, dissolve oxygen (DO) and total dissolved solids (TDS). During processing those parameters were measured with the help of thermometer, pH, DO and TDS meters respectively.

2.4 Methods of Assessment

2.4.1 Assessment of acidity/alkalinity in textile effluent

pH is the potentiality of hydrogen ions which also indicates the acidity or alkalinity of wastewater. Here, textile effluents were taken in beakers to determine the values of pH and the port of digital pH meter was dipped into the waste water and kept for few seconds until the result was shown in the display.

2.4.2 Assessment of DO in textile effluent

DO is an indication of amount of dissolved oxygen in water consumed by the organic and inorganic reducing matter. It is a very important parameter of waste water which was evaluated by the help of a digital DO meter. For this purpose, dye effluent was taken in a beaker and the indicator was dipped into the waste water and automatically after few seconds the desired value was directly displayed on the digital screen.

2.4.3 Assessment of TDS in textile effluent

In this work, TDS of the effluent samples were determined by gravimetric method where Total solids (TS) in the effluents were found by evaporating and drying at a specified temperature of 103-105^{0}C. Wastewater samples were filtered through a standard filter and the mass of the residue was used to calculate Total suspended solids (TSS). Then TDS in the effluent was calculated by subtracting TSS from TS according to the formula given below.

TDS (mg/l) = TS (mg/l)-TSS (mg/l)

2.4.4 Measurement of temperature of the textile effluent

Temperature of the water is a very important factor which inversely affects the rate of gaseous oxygen into dissolved oxygen and the temperature of dye effluent was measured in this work by a thermometer at degree Celsius (^{o}C) unit.

2.4.5 Assessment of visual color of textile effluent

Although color was not included in the Environment Conservation Rules (1997), it is an issue in dye house effluent because unlike other pollutants it is so visible. Reducing color is therefore important for the public perception of a factory. Consequently, international textile buyers are increasingly setting discharge standards for color. However, as a health and environmental issue color is less of a concern than many of other parameters. Experimental values of effluent samples were recorded and shown in the Table 3.

3. Results and Discussions

The calculated values of different parameters are illustrated in the table 3 for further analysis. Investigation of those data under various conditions were brought out with imperative findings.

Table 3 pH, DO, TDS, temperature and visual color of textile effluents collected after dyeing with reactive dye.

Parameters of Textile Effluent	Reactive Shades							
	Navy P-25	Dark Navy	Mid Night Blue 003	Black 09-090	Black E-001	Blue Canard	Blue 110	WEO
pH	11.2	11	11.8	12	12	11.1	11	11.1
DO	0	2.5	0	0.5	0.6	2.0	2.4	3.1
TDS (mg/l)	19840	15500	19850	19680	19620	16880	15740	13040
Temperature (^{o}C)	56.4	49.4	57.1	60.1	61.6	72.2	67.2	69.3
Visible Color	Black	Dark	Dark	Black	Dark Black	Dark Black	Dark Black	Black

3.1 pH values of textile effluents

pH values in textile effluents after dyeing were found in the range from 11 to 12. For every shade effluents were found constantly alkaline, because the dyeing processes were carried out in the alkaline medium and this alkalinity can be reduced by subsequent after-treatment processes, including washing, neutralization and so on. Here, most pH values (12) in the effluents were obtained for Black 09-090and Black E-001 shades whereas Dark Navy and Blue 110 represent the least pH values (11)in the collected effluents. On the other hand, for remaining four shades associated pH values in the effluents remain in between the range stipulated above.

3.2 DO values of textile effluents

The DO values in the effluents after dyeing were found extremely poor to zero and indicate outer range values according to any standard. During dyeing the heavily concentrated waste water are produced by reacting the fibers with a mixture of reactive dyestuffs, salt, alkali and auxiliary chemicals. The main reason is the liquor became more concentrated for containing extremely large amount of dyeing chemicals, hydrolyzed and unfixed dye molecules after dyeing process. Another cause of lower DO was the higher dyeing temperature. Temperature inversely affects the rate of transfer of gaseous oxygen into dissolved oxygen. On the other hand at higher temperature the metabolic rate of aquatic plants and animals increases producing an increase in oxygen demand and reduces the amount of DO. Entirely the most and least DO values were recorded in case of WEO (3.1) and Black 09-090 (0.5) shades, respectively whereas Navy P-25 and Mid Night Blue003 represent zero (0) dissolved oxygen.

3.3 TDS values in textile effluents

The nature of the effluents collected after dyeing without additional fixing treatment for all concentrations of eight colors, was found comparatively better. Though TDS values were found in range but this time indicate too much high TDS according to the waste water discharge quality standards at discharge point for industrial units. This happened because after dyeing process the effluents contained a gigantic amount of chemicals, including hydrolyzed dyes. Most TDS value in the collected effluent were recorded in case of Mid Night Blue 003 (19850) whereas effluents of Navy P-25, Black 09-090 and Black E-001 shades represent closer TDS values in the effluents, 19840, 19680 and 19620, respectively. Besides, least TDS values in textile effluent were found in case of WEO shade.

Statistical tool SPSS was used to find out the relation between Total dissolved solids (TDS) and dissolved oxygen (DO) values of textile effluents. To measure the relation Pearson correlation test was carried out and the following result is obtained.

Table 4 Correlation between Total dissolved solids (TDS) and Dissolve oxygen (DO)

Correlations			
		TDS	*DO*
TDS	Pearson Correlation	1	**-.975****
	Sig. (2-tailed)		.000
	N	8	8
DO	Pearson Correlation	**-.975****	1
	Sig. (2-tailed)	.000	
	N	8	8
**Correlation is significant at the 0.01 level (2-tailed).			

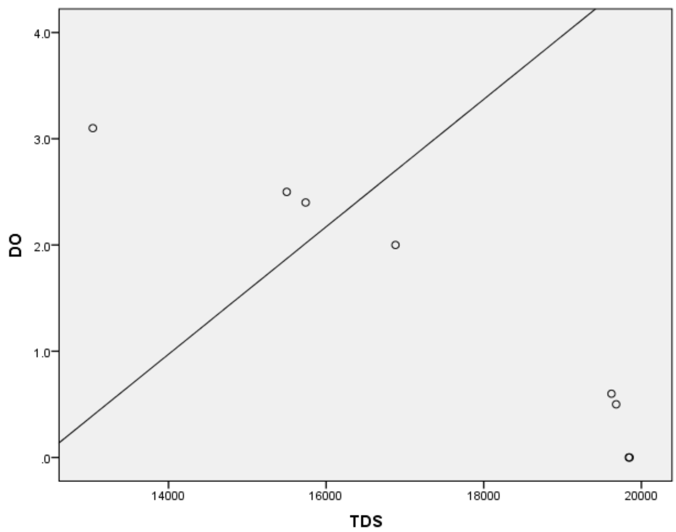

Figure 1: Scatter diagram showing correlation between TDS and DO of Textile effluents.

From the table 4 and figure 1, it can be said that at **0.000** significance level, there is strongly negative correlation **(-.975**) between TDS and DO values of the effluents for eight different shades. That is to say, the increase in Total dissolve solid (TDS) values in the effluents reduced the Dissolved oxygen (DO) significantly. So, more TDS in the effluents was responsible for resulting less DO.

3.4 Temperature and visual colors of textile effluents

Overall, for eight shades temperature of the effluents after dyeing was found more than the normal, because the dyeing process with reactive dyes were carried out between 60^0C and 80^0C. After measuring the temperature of the effluents, the most and the least values were recorded in case of Blue Canard (72.2^0C) and Dark Navy

(49.4^{0}C) shades, respectively. Visually dark colored effluents were generated after dyeing and the temperature was found higher for all cases.

4. Conclusion

This research has been conducted to assess the ecological impacts of the textile effluents coming from the dyeing process of cotton fabric with eight reactive shades in the range of blue, black, navy and WEO. The effluents were collected for investigating five ecological parameters, including pH (acidity or alkalinity), dissolved oxygen (DO), total dissolved solids (TDS), temperature and visual color. The results obtained from this study showed that the effluents remain hot and more alkaline in nature after dyeing process. Concentrations of solids containing oxygen was found very poor which was the major indication of high oxygen demands in the discharged water. Even zero DO values we rerecorded for Navy P-25 and Mid Night Blue 003 shades, which have more considerable impact on the ecological system comparing to other reactive shades. High TDS values in textile effluents were obtained and colors were found visibly dark for each shade. It is also found statistically that there is strongly negative correlation between TDS and DO. High TDS in textile effluents were accountable for lowering DO in the discharged water. The results of this study surely not suggest the suitable method of effluent treatment, but the main emphasis was to analyze the characteristics and ecological impacts of textile effluents discharged after dyeing with eight reactive shades and to recommend dye house people to select comparatively low impact dyes.

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