

## **Reduction of Textile Industrial Waste water Pollution**

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### **ABSTRACT**

The purpose of this study is to evaluate the environmental performance and the impacts of the textile waste water from wet processing, and to find some approaches for pollution prevention or reduction. Taha Textile Mill at Khartoum North is taken as a case. The study includes the important parameters affecting pollution overload associated with the wet processing stages, such as, desizing, scouring, bleaching, dyeing, finishing and washing. Different industrial wastewater samples were taken at different intervals of time, and subjected to various tests, and analytical methods. The study proved that, the extensive use of chemicals, dyestuffs and water results in generation of highly polluted water differing in magnitude and quality, such as: COD, BOD, turbidity, heavy metals, anions, alkalinity, color, pH, TDS, electrical conductivity, strong smelling, high temperature, etc. When the obtained results are compared with some international standards such as (U.S EPA), Pakistan (NEQS); it is found that, they mostly exceed these international standard limits. The study proved that, pollution can be reduced by reduction of water consumption such as: effluent reuse, discoloration, precipitation with metal salts, carbon adsorption, oxidation, etc. The study proved that, dye bath from vat and sulfur dyes can be reused for four times; the obtained shades and color fastness are both good. High reduction in both color concentration of the residual wastewater and pH .nesses are both good is obtained, which will indicate that the other pollution parameters such as COD, BOD, TDS, etc. are reduced.

**Key words:** Dyestuff - Wastewater - Pollution - colorfastness - Fabric

## INTRODUCTION

Current concern over environmental issues is reaching fever pitch to the extent that it affects most of the working population to some degree, even in financial and banking circles. Governments are concerned with the protection of health and safety of people from potentially dangerous products. Many countries intended to produce a new generation of consumers and employees with a high level of awareness over environmental matters. (Carr, 1995).

The environmental effects of the textile industry have increased during the last decade with the introduction of fast fashion in which the media introduces new seasonal trends for each fashion season. The textile manufacturing process is characterized by a high consumption of resources: like water, fuel, and a variety of chemicals. The main environmental problems are associated with water body pollution caused by the discharge of untreated effluents, in addition to air emission of volatile organic compounds, and excessive noise. (Indian textile journal, 2009).

Textile manufacturing is one of the largest industrial wastewater producers approximately 160 liter of water per 1/kg fabric, (Amna, 2010).

In Sudan there are so many textile factories, some are capable of producing bleached, colored, and finished products. The coloration and finishing operations involve a lot of wet processing stages. Every single operation requires chemicals, dyestuffs, and auxiliaries. Some of these chemicals may have harmful effects to the environment, consequently much wastewater and effluents will be produced. Textile industries use different fibers, materials and processes. These processes include a series of stages of dry and wet processing. Among these series wet the environment. (Mutasim , 2006). Since most processing have the most adverse effects to of the factories have no proper treatment plants, the wastewater may directly be released to the environment, and this may lead to pollution overload.

In Sudan there are 45 textile factories, most of them have wet processing operations. The coloration and finishing operations involve a lot of wet processing stages. Wet processes require significant quantities of water, chemicals, auxiliaries and dyestuffs, (Abosalma, 2005). There is low knowledge and awareness about wastewater management and cleaner production technology. These defects are expected to generate hygienic diseases such as cancer and asthma.

## MATERIALS AND METHODS

Wastewater samples were collected at different processing operations from Taha Textile Factory (TTM) located at Khartoum north . The samples were taken at different periods of time (five batches). The samples were tested using different instruments and machines. Analytical and

spectrophotometric methods were carried out. The results were analyzed statistically and compared with some standard acceptable limits.

**The following Experiments and Tests were carried out:**

1. Tests for pH. Digital pH meter, model Hm – 20 E, Tokyo.
2. Spectrophotometric tests. UV-Spectrophotometer, model-450, Hach Company, Loveland
3. Determination of the total dissolved solids (TDS).
4. Determination of turbidity. Turbidity meter Hach, model –2100A, Hach Company, Loveland Co.
5. Reuse of wastewater. Automatic dyeing machine, type LA-121, Japan.
6. Measurement of color. Spectrophotometer 721 model (Fen Guang Duji Shanghai, China)
7. Measurement of the concentration of some heavy metals. Atomic Absorption Spectrophotometer 580, Hach, Loveland Co
8. Measurement of the biochemical oxygen demand (BOD) (COD) Chemical Oxygen Demand Reactor, Reflux Apparatus, Erlenm

**Dyestuffs:**

The following dyestuffs were used for the preparation of the standard solutions used to determine the dye concentrations of wastewater samples:- Sulfur black B. R, Bezathrene olive green B (vat dye), Bemacron yellow SERD (Disperse dye), and Direct Brown R.

**Chemicals:** All chemicals used are laboratory purpose reagents

**Test methods:**

Tests for pH: the samples were tested for pH in two ways, one by using litmus paper and the other by using a digital pH meter (model Hm 20E Japan; using method (J.I.S., L0886, 1978).

**Spectrophotometric Tests:**

The samples were tested for absorbance and transmittance using spectrophotometer (Model 721 Fen Guang Du Ji – Shanghai) (J.I.S., method L0869, 1971).

**Testing method for color fastness to washing , rubbing and light:**

The wastewater dyed samples were tested for color fastness to washing using a Japanese Industrial Standard (J.I.S.), method L0844, 1973.

**Measurement of the Color concentration:**

The test method is platinum-cobalt standard method (Hach 8025), adapted from standard methods for examination of water and wastewater (water research, 1996), using a UV-Spectrometer instrument.

**Measurement of anions (suphates ,chlorides):**

The instrument used was UV-Spectrometer. The collection of samples, the calibration of instrument, and the standard curve were performed according to the standard method (8051). (EPA, 1992).

**Measurement of the Concentration of Some Heavy Metals:**

Metals such as chromium and copper were traced in wastewater by using atomic absorption spectrophotometer. Nitric acid digestion method (APHA, 3030E) was used. After the samples were collected according to the standard method (within two hours before the test), the instrument was calibrated using standard solutions.

**Measurement of Biochemical Oxygen Demand (BOD):**

The method used was "ISO 5815", (1989), using 300ml incubator bottles, and air incubator, thermostatically controlled at 20 °C. The samples were collected from the factory according to the standard method (1hour before test), and the dilutions were made using air-saturated distilled water.

**Measurement of the Chemical Oxygen Demand (COD):**

The method used was standard method (ISO 6060, 1989), ([http://www.iso.org/iso/en/Catalogue Detail Page. Catalogue Detail](http://www.iso.org/iso/en/Catalogue+Detail+Page.Catalogue+Detail)). The samples to be tested were collected according to the standard method (1hour before test). Fabric sample; Bleached cotton fabric (100%).

**RESULTS AND DISCUSSION****Results of Concentrations and pH of wastewater samples**

Table (1) Calculated concentrations of dye wastewater samples and pH results .

Sample No.	Specification of wastewater	Absorbance	Concentration of dye g/l	Rang of pH
4	Vat dye	0.45 -1.52	0.2 -0.7	12.3 - 13.4
7	Sulphur dye	1.0 -1.6	1.0 -1.25	9.9 - 12.9
8	Direct dye	1.25	0.4	6 - 6.5
18	Disperse dye	0.35	0.24	4.6 - 5

From table 1, the highest dye concentration is achieved for sample No. 7 which is Sulphur dye wastewater, whereas the lowest one is for sample 18 which is disperse dye.

From the 19 samples tested only three samples are acidic, the rest are alkaline. On comparison of pH results with some standards, most of the samples are not within the accepted limit which is (6-9), where most of the aquatic life function best within this limit.

<http://www.2gharta.com/wastewater>)

**Results of colour fastness of the reused (vat and sulfur) dye wastewater.**

The concentrations of waste water from vat and sulfur dyes were calculated using a colorimeter. The results are shown in Table (1) . The wastewater samples were reused four times for dyeing of bleached cotton fabric using exhaustion methods. The concentrations of the waste water from the last reused dye bath were also estimated using heat colorimetry. The dyed cotton samples after each cycle were then tested for washing , rubbing, and light fastness.

Assessment of the color fastness was done using Japanese standards ; grey scales and blue scale. The results of color fastness are tabulated as in table 3. Statistical analysis was carried out for reduction in concentration , and the color fastness.

The concentration of vat dye was reduced from 0.7 g/l to 0.15 g/l. The concentration of sulfur dye was reduced from 1.0 g/l to 0.2 g/l. Consequently the values of BOD, COD, anions , The cations, TDS, and turbidity of the remaining wastewater were reduced by 50 to 75%. color fastness of the dyed samples were almost good. From table3 it can be said that, pollution load can be reduced by reusing of wastewater. It is possible to dye samples of fabric with the same dye bath to different shades (medium and light shades). The dye bath left is of low color value which can easily be treated, decolorized, or can be renovated (i.e. new dyestuff is added) and reused for many times. Reduction in color concentration is calculated as 79% for vat dye wastewater, where as it is 80% for sulfur dyes. This indicates that significant saving in color has taken place. Water is saved by 70%, energy is also saved by 45%, this is because dyeing is carried out in hot liquor, and no need to heat the dye bath for the next reuse, and this will also save time. The fastness properties of the dyed samples are good, especially the light and the washing fastness.

Table (2) Results of colour fastness of the reused vat and sulfur dye bath

Sample No.	4	7
Specification of wastewater	Vat dye	Sulfur dye
Number of reuse cycles	4	4
Concentration before reuse	0.7 g/L	1 g/L
Concentration after the last reuse	0.15 g/L	0.2 g/L
Washing fastness	Cycle no. good	Medium-good
	1 <sup>st</sup>	4
	2 <sup>nd</sup>	4
	3 <sup>rd</sup>	3-4
	4 <sup>th</sup>	3-4
Rubbing fastness	Cycle no. good	Medium-good
	1 <sup>st</sup>	4
	2 <sup>nd</sup>	3-4
	3 <sup>rd</sup>	3-4
	4 <sup>th</sup>	3-4

Light fastness	Cycle no.	good	good
	1 <sup>st</sup>	6-7	6-7
	2 <sup>nd</sup>	6-7	6
	3 <sup>rd</sup>	6	6
	4 <sup>th</sup>	6	5-6

\*Wash and rubbing fastness (excellent=5, good=4, medium=3, poor =2, bad=1).

\*Light fastness (excellent=8, good to very good=6-7, fair = 4-5, poor 2-3, bad=1).

### Results of the mean values of different parameters for all the wastewater samples

Table (3) Mean values of the results of samples for different parameters

Range	1	2	3	4	Mean values
pH	11.7	11.5	9.8	10.6	11
Electrical conductivity (SCM <sup>-1</sup> )	7170	2433	9962	3871	5859
Total dissolved solids mg/l	5036	1703	6973	2709	4105
Alkalinity( Carbonate mg/l)	1347	1077	1201	348	973
Na flame photometer PPM	4748	3883	4380	3842	4221
Turbidity NTU	-	-	-	1842	1842

The mean values of the results of pH, electrical conductivity, total dissolved solids, alkalinity, sodium concentration, and turbidity were calculated for all the tested samples. The average value of pH is 11, the accepted limits in many countries ranges from pH 6-9, where most of the aquatic organisms function best. Below or above this range a serious effect on an ecosystem by indirectly altering other aspects of water chemistry, consequently when combined with certain metals and chemicals . water becomes more toxic

The values of TDS could be considered as indicators to pollution overload. High concentration of TDS is due to the presence of inorganic dissolved solids which include chlorides, nitrates, sulfates, phosphates of sodium, magnesium, calcium, and iron. High concentrations of TDS can cause water balance problems for organisms and result in lower dissolved oxygen levels (DO).

As Table (3) show, and by comparing the results obtained with the wastewater acceptability standards, where turbidity levels for aquatic life should not exceed 100 NTU, it was found that, the mean value of turbidity is higher than the limits which are internationally allowable.

It is known from literature that, higher level of turbidity can affect several aquatic lives; it can result in low dissolved oxygen levels by preventing photosynthesis, by blocking sun light and raising water temperature, by absorbing more heat from the Sun. (WHO, 1993).

### Results of COD, BOD, cations, and anions

Table (4) Results of COD, BOD, cations, and anions,

Type of waste	COD mg/l	BOD mg/l	Sulfate mg/l	Chloride mg/l	Copper mg/l	Chromium mg/l
Washing	1121	457	45.6	95.7	0.00	0.00
Scouring	1470	426	68.5	342.4	0.00	0.00
Bleaching	1149	354	76.3	250.8	0.00	0.00
Dyeing, (vat)	2124	562	224.9	385.4	0.43	1.23
Dyeing, (reactive)	1850	518	758.7	496.2	0.38	0.39

Results of Chemical and Biological Oxygen Demands (COD and BOD) are relatively high for wastewater from dye bath due to the use of jigger machines where high dosage of dyes and auxiliaries are required to achieve the desired shade, low exhaustion%, and the higher percentage of the hydrolyzed reactive dye. The values of COD and BOD from fabric preparation are also high enough compared to the standard limit values (NEQS limits 80-150 mg/L); this can be attributed to the fact that, most of the contamination in the fabric, such as dust, coloring matters, waxes, fats, sizing materials, etc., are removed here. The high values of these parameters indicate potential depletion of dissolved oxygen in the water body, which could affect the biological activity in water environment.

The highest concentration of anions (sulfates, and chlorides) is reported for reactive dyes and vat dyes waste water, this may be attributed to the addition of salts during the dye manufacture for (salting out), or during dye application as electrolytes for improvement of the dye exhaustion and leveling.

The sulfate ion concentration of waste water from reactive dyes is the only one which exceeds the National Environmental Quality Standards (NEQS) limit which is (600mg/L).

Copper and chromium ions were observed in wastewater from dyeing. When comparing chromium results with the NEQS limits, it is found that, the sample (vat dyed) have got

higher results than (reactive dyed). Chromium is toxic to aquatic animals, and harmful to human above the limits specified, the toxicity is a function of temperature, pH, degree of water hardness, and chromium species. The negative health effect may be “lung cancer, kidney damage, headaches”. Usually chromium has cumulative effect, which tends to accumulate in the food chain of living organisms.

### Results of Ratios of BOD to COD

Table (5) Ratios of BOD to COD

Sample No.	Type of waste	COD mg/L	BOD mg/L	Ratio of BOD/COD
30	Washing	1121	457	0.41
31	Scouring	1470	426	0.29
32	Bleaching	1149	354	0.31
33	Dyeing, (vat)	2124	562	0.26
34	Dyeing, (reactive)	1850	518	0.28

The high values of both COD and BOD as shown in table 6. indicate high organic pollution levels and a great deal of organic materials enter the water, the environmental effect is that microorganisms are required to degrade and break down the organic substances consequently the microorganisms consume large quantities of oxygen in the process. This essentially causes suffocation of aquatic organisms that require oxygen to survive.

### 3.6 Results of waste water mean values in comparison to standards

Table (6) Mean values of waste water samples compared to NEQS and U.S. EPA standards

pollution Parameters	Mean Values	NEQS Limits	U.S. EPA Limits
pH	11	6-9	6-9
Electrical conductivity (Scm <sup>-1</sup> )	5859	1500	1750
Total dissolved solids (mg/L)	4105	3500	2500
Alkalinity(mg carbonate /L)	1043	208	250
Na (mg/L)	4221	147	200
Turbidity (NTU)	1842	100	100
BOD(mg/L)	463	80	30
COD(mg/L)	1542	150	200
Sulfates(mg/L)	235	600	800
Chlorides(mg/L)	314	1000	800

Chromium(mg/L)	0.32	1.0	0.10
Copper (mg/L)	0.16	1.0	0.25
Color (Pt-Co)(mg/L)	1366	150	150

When the mean values of wastewater characteristics as in table7 are compared with the standard limits, the following points are revealed:

1. pH of the samples exceeds the upper limits of both NEQS and EPA standards.
2. The electrical conductivity, the total dissolved solids, the alkalinity, and the sodium ion both exceed the NEQS and EPA limits.
3. BOD, COD in all the reported cases, exceed the NEQS and EPA limits.
4. Sulfates and chlorides are below the NEQS and EPA limits.
5. Chromium and copper ions are below the NEQS limits, although they exceed the EPA limits.
6. Color (mean value) exceeds the NEQS and EPA limits, although certain individual cases are well within or below the limits.

## CONCLUSIONS

1. The wet processing employs much water 180 litre/ Kg of fabric.
2. The environmental impacts of wet processing is due to various processing stages .
3. Some substances are said to be toxic and represent a chronic health risk.
4. The wastewater is usually disposed hot, mostly alkaline which contains high BOD, COD and highly colored.
5. Heavy metals; chromium and copper are observed.
6. Anions, higher turbidity and electrical conductivity are reported.
7. Wastewater from dyeing, have the highest pH, color, COD, BOD, conductivity, anions, cations and of high pollution load electrical
8. The ratios of BOD to COD are almost not within the acceptable standard limits,
9. Decolourization of wastewater is obtained through, precipitation, carbon absorption, reusing or recycling. 10.Wastewater can be reused, or renovated for the same process or others.
10. Wastewater from dyeing (vat and sulfur) can be reused or renovated for dyeing up to four times.
11. The reused dye bath gives good color fastness when it is applied on bleached fabric .
12. The reused wastewater strength was greatly improved, color, COD, BOD and TDS were reduced by 50 -75%, pH is reduced to the standard range(6-9), anions and cations were reduced by 65%.

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### الخلاصة

في هذا البحث أجريت الدراسة على أحد مصانع النسيج بالخرطوم بحري, وهدف البحث تقليل التأثيرات البيئية الناتجة عن مياه صرف عمليات التجهيز المختلفة في المصنع, وإيجاد درجة الاجهاد البيئي وإيجاد درجة المعالجة المطلوبة للتخلص من التلوث أو تقليله ليكون وفقاً لما هو مسموح به عالمياً. أجريت الدراسة على أهم العوامل المرتبطة بعمليات التصنيع المختلفة التي لها دوراً كبيراً في الاجهاد البيئي وتحميله؛ كإزالة النشا، الغلية، التبييض، الصباغة، التجهيز والغسيل. أخذت عينات مختلفة من مياه الصرف الصناعي للمصنع في أوقات مختلفة, وقد أجريت عليها اختبارات عديدة وذلك باستخدام طرق تحليلية وأجهزة مختلفة مثل: مطياف الضوء المرئي وفوق البنفسجي ومطياف الامتصاص الذري, ومطياف اللهب, العكارة، مفاعل COD و BOD وغيرها. أثبت النتائج والدراسة أن الاستخدام المكثف للمواد الكيميائية والأصبغ والمياه تنتج عنها كميات مقدرة من مياه الصرف الملوثة التي تتفاوت في درجة تلوثها ومحتوياتها وتركيزها مثل: الأوكسجين الكيميائي المطلوب, الأوكسجين الحيوي المطلوب، المعادن الثقيلة، الأيونات السالبة، اللون, درجة الأس الهيدروجيني، وغيرها. وقد وجد أن مياه الصرف تحتوي على مواد سامة ومواد غير قابلة للتحلل الحيوي والبكتيري.