



Practices towards Sustainable Textile Processes: Investigation on Environmental Issues at Different Stages of Knitted Fabric Wet Processing

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Abstract

In this study-the ecological parameters of the effluents obtained from scouring and dyeing with reactive dyes of Remazol brand for conventional cotton single jersey knitted fabric as well as bio-scouring and dyeing with low impact reactive dyes of Avitera brand for organic cotton single jersey fabric have been investigated. The ecological parameters include chemical oxygen demand (COD), biological oxygen demand (BOD), total dissolved solids (TDS), Total Suspended Solid (TSS), dissolved oxygen (DO), EC or conductivity, alkalinity and pH. Also some selected physical properties have been investigated for both dyed fabrics such as bursting strength, fabric drapability, color fastness to wash, color fastness to rubbing and color fastness to perspiration. The results of ecological test show greater ecological advances for using organic cotton, bio scouring and low impact reactive dyes than the conventional method and raw materials. In addition, the bleaching process has eliminated by dyeing with deep shade that results less toxic chemicals in effluent. The physical properties also showed better results of using eco-friendly fabric and processes.

Keywords: Organic cotton; Conventional cotton; Low impact reactive dye; Environment friendly; Ecological parameters

Introduction

Rapid growth in the industrial sector is playing a vital role in the economy of Bangladesh. Mainly the growth has been concentrated in garments which are export-oriented industries. To support garments sector a large number of other textile industries have been established and more are growing to be set up shortly. The textile industry actually represents a range of industries with operations and processes as diverse as its products [1].

The development of genetically modified cotton adds environmental problems at different level. Growing the cotton fiber uses 22.5 percent of all the insecticides used globally. For one T-shirt development, growing enough cotton requires 257 gallons of water.

Greige fabrics, after its manufacturing, are subjected to several wet processes such as pretreatment process involving demineralization, scouring, bleaching and mercerization. The pretreated fabric is then dyed using textile dyes and finished by softener padding. The pretreatment and dyeing process results in large volume of effluent that has harmful effect on environment [2-11].

It is estimated that 12-65 L of water is required for processing one meter of cloth. Therefore, it is easily understood that what a large volume of wastewater generates daily from different textile mills [12].

Generally, textile effluent is colored with high pH, temperature, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolve solid (TDS) and total suspended solid (TSS).Color is imparted to textile effluents because of the various dyes and pigments used to color the fabric [13]. The presence of dyes in the wastewaters will cause severe damage to the aquatic biology. This is because dyes have a synthetic origin and a complex molecular structure that makes them more stable and difficult to be biodegraded [14].

On the other hand, Organic cotton represents a return to safe and sustainable practices. It is grown with natural fertilizers and is free from toxic chemicals. Organic farmers rely on crop rotation to replenish and maintain soil fertility. Mechanical cultivation and botanical or biological

means are used to control pests and weeds. A field must be pesticide-free for at least three years to be certified organic, and the cotton must be processed according to international organic standards. Third-party organizations certify that organic cotton farms use only these approved methods and do not spray toxic chemicals on their crops [15].

There is a need wherever possible to dissociate growth from increased consumption of fossils fuels, water, and energy and reduce the use and resulting impact upon natural resources. Output to the environment from production and waste must also be reduced in volume and impact [16].

In Bangladesh, conventional cotton with typical reactive dyeing (Remazol) and caustic pretreatment is popular. Due to low cost and availability of resources no one is concerning about the impact on environment.

To minimize the above-mentioned causes of environmental pollution of our country as well as the whole world this research is a little approach. This paper contains the investigation of the environmental pollution of conventional cotton knit fabric processing from wet pretreatment to dyeing and organic cotton knit fabric processing using enzymatic scouring and low impact reactive dyes. Some selected physical properties of both type of finished fabric have been studied to do a comparative study.

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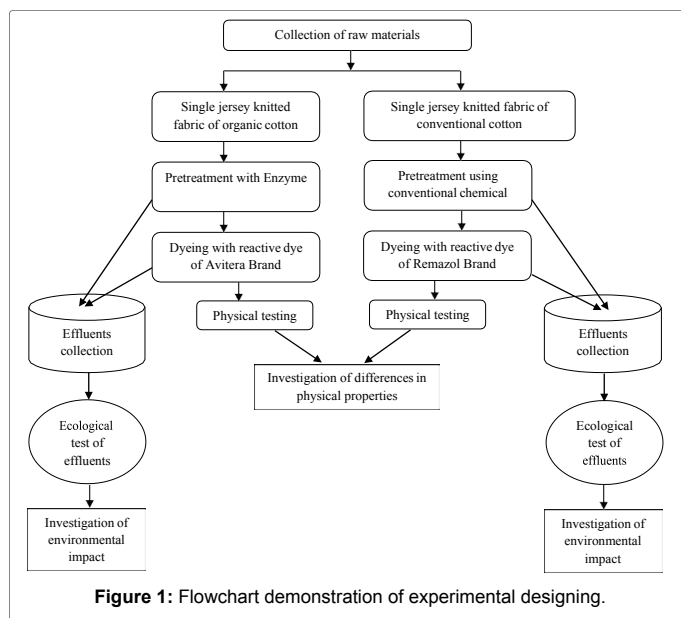
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Aims and Objectives

1. To conduct scouring of conventional cotton knit fabric and bio scouring of organic cotton knit fabric.
2. To conduct conventional Reactive dyeing of cotton knit fabric and Low impact Reactive dyeing of organic cotton knit fabric.
3. To investigate ecological parameters of the effluents collected from above processes.
4. To investigate changes in some selective physical properties of both dyed fabric.

Experimental Design

The Experimental design will be shown in the following flowchart (Figure 1).



Scouring of single jersey knitted fabric of conventional cotton

Recipe: NaOH 5 g/L, Wetting agent 1 g/L, Detergent 2 g/L, Sequestering agent 1.5 g/L, M:L 1:25, Temperature 95°C-100°C, Time 45 min, pH 10.5-11.0 (Figure 3).

Dyeing of single jersey knitted fabric (organic cotton) with reactive dye of Avitera brand

Recipe: Dyestuff 3%, Gluber salt 50 g/L, Soda ash 15 g/L, Temperature 60°C, Time 45 min, pH 10-11, M: L 1: 25 (Figure 4).

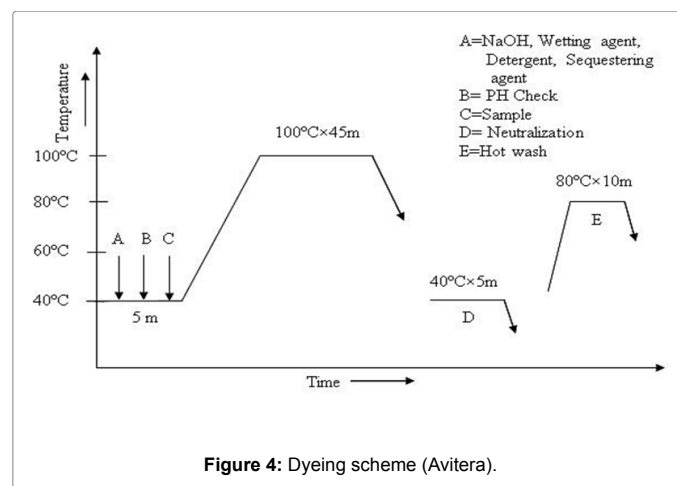
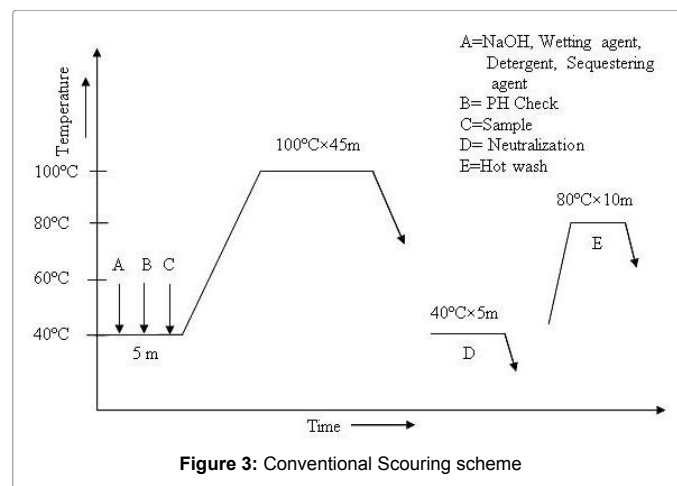
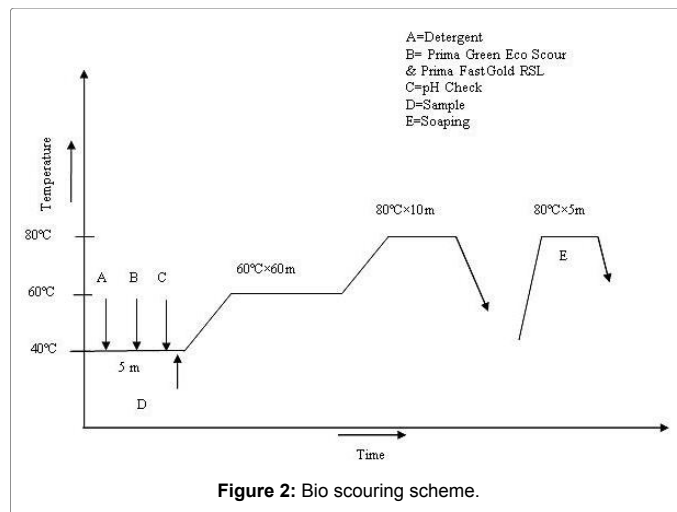
Dyeing of single jersey knitted fabric (Conventional cotton) with Reactive dye of Remazol Brand

Recipe: Dyestuff 3%, Salt 50 g/L, Soda ash 15 g/L, Sequestering agent 1.5 g/L, Wetting agent 1.5 g/L, Leveling agent 1.5 g/L, Temperature, 60°C, Time 45 min, pH 10-11, M:L 1:20 (Figure 5).

Material and Method

Bio scouring of single jersey knitted fabric of organic cotton

Recipe: Prima Green Eco scour 0.20%, Prima Fast Gold RSL 0.50%, Detergent 0.30%, Wetting agent 0.20%, M: L 1:20, Temperature 60°C, Time 60 min, pH 6 (Figure 2).



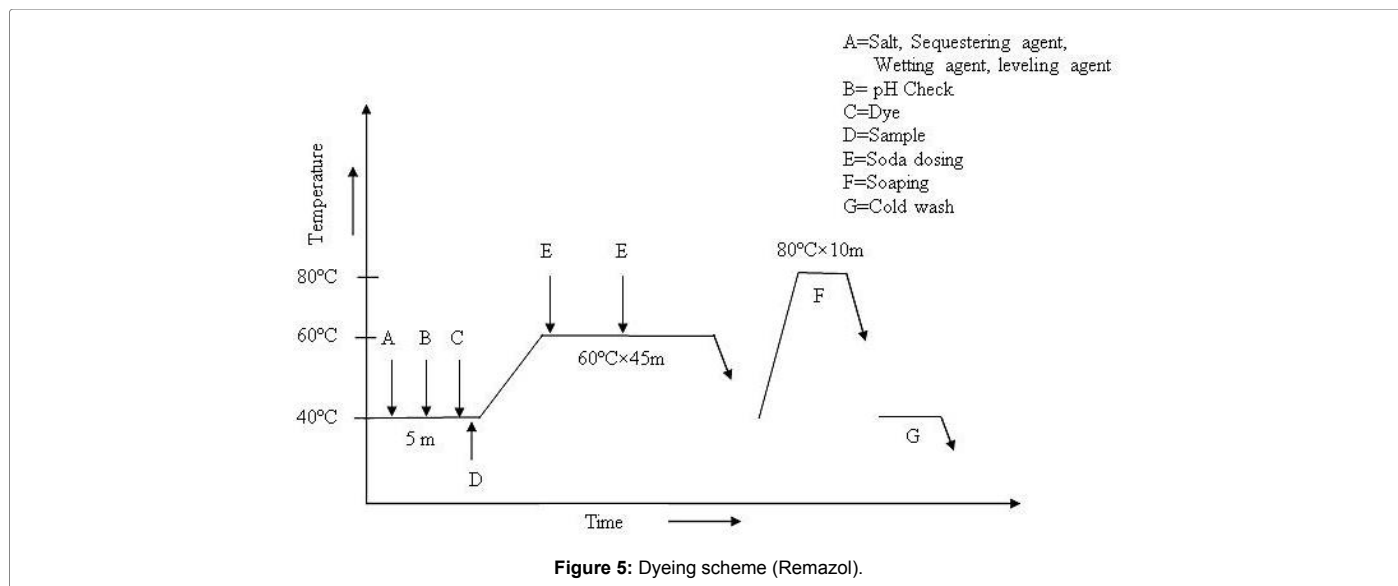


Figure 5: Dyeing scheme (Remazol).

Characterization

After all wet processes of both samples effluents have been collected and sent them for different environment tests.

Ecological parameters test

Biological oxygen demand: BOD is the amount of oxygen used by aerobic bacteria to decompose organic material. This process may take place many days hence to standardize the measurement of BOD following standards are taken: Time (Incubation period) 5 days, temperature: 20°C.

Chemical oxygen demand: Any kind of chemically oxidizable impurities present in effluent is COD. It is the measure of both biologically oxidizable and biologically inert organic matter measured by COD Reactor.

Alkalinity: Alkalinity is measured volumetrically by titration with N/50 (i.e., 0.02 N) H_2SO_4 and is reported in terms of equivalent $CaCO_3$.

Total suspended solid and total dissolved solid: Total solid (TS) refers to the matter that remains as residue upon evaporation and drying at 103-105°C. The total solid includes total suspended solid (TSS) - the portion of the total solid retained by filter and total dissolved solid (TDS) - the portion that passes through the filter.

Dissolved oxygen, pH and electrical conductivity: Oxygen saturation in the environment generally refers to the amount of oxygen dissolved in the soil or bodies of water. pH is a measure of the acidity or basicity of an aqueous solution. The conductivity (or specific conductance) of an electrolyte solution is a measure of its ability to conduct electricity. pH, DO (mg/L) and conductivity (mS/cm) values were found directly from multimeter [17].

Physical properties test

Absorbency test: Absorbency test has done by two methods. Drop test, in a pipette a solution of 0.1% direct red was taken and was dropped on the fabric on the fabric sample from 5 cm above. Then the absorption of the color drop was observed visually and time in second to absorb one drop of solution was taken. Spot test, in a pipette

a solution of 0.1% direct red was taken and droplet of solution was put on the different places of the fabric. Then the shape of the absorbed area on the fabric was observed [18,19].

Color fastness to wash: Color fastness to wash test method *ISO-105-C03* using soda ash (Na_2CO_3) and ISO standard soap in Gyro wash machine (Wash wheel).

Color fastness to perspiration: Color fastness to perspiration test method *ISO-105-E04-1994(E)* using Histidine Monohydrochloride monohydrate ($C_6H_9O_2HClH_2O$) 0.5 g, Sodium Chloride (NaCl) 5 g, Disodium hydrogen orthophosphate dehydrate ($Na_2HPO_4 \cdot 2H_2O$) 2.5 g.

Color fastness to rubbing: Color fastness to rubbing has been tested by *AATCC Test method 8-2007* using crockmeter.

Fabric drapability test: Fabric drapability measurement by test method *ASTM-D-3787* using fabric drape tester.

Bursting strength: Bursting strength test using Universal Strength tester test speed was 305 mm/min, Preload 0.100 lb., Diameter 1.75 inches, Sample size 5"×5".

Results and Discussion

The Test results of ecological parameters and Graphical Representation of ecological test parameters are shown below in the table and the figures (Table 1 and Figure 6).

Discussion

The BOD (mg/L) values of the effluents for organic cotton after bio scouring is a greater extent lower than the conventional cotton caustic scouring. This is because the use of enzyme in place of caustic soda and maintaining a lower temperature around 60°C and the BOD (mg/L) value of the effluents for organic cotton scoured fabric after dyeing with low impact reactive dyes it shows a better and lower value i.e., 200 mg/L which is near about the DOE standard BOD value 50 mg/L. On the other hand the conventional cotton scoured knit fabric after treated with cold brand Remazol reactive dyes the BOD value of the effluents increases to 800 mg/L. The COD (mg/L) values of the effluents for organic cotton after bio scouring and low impact dyeing and conventional cotton after scouring and dyeing are presented in Figure 5. The results show that the COD of the effluents does not show much

Sample No.	Source of Effluents	Effluents content	Test name	Results	DoE Standard
Sample-1 (Conventional Cotton Scouring effluents)	Scouring	Wetting agent, Detergent, Sequestering agent, Caustic soda, Cotton waste	BOD in mg/L	1500	50
			COD in mg/L	2700	200
			DO in mg/L	1.06	6
			EC in mS/cm	32	12
			TDS in mg/L	16120	2100
			TSS in mg/L	258	150
			Alkalinity in mg/L	800	500
			pH	12.69	7
Sample-2 (Organic cotton Bio-scouring effluents)	Enzymatic scouring	Detergent, Wetting agent, Prima green Eco scour enzyme, Prima fast Gold RSL enzyme	BOD in mg/L	1000	50
			COD in mg/L	2200	200
			DO in mg/L	2.76	6
			EC mS/cm	6.27	12
			TDS in mg/L	3130	2100
			TSS in mg/L	151	150
			ALKALINITY in mg/L	700	500
			pH	6.41	7
Sample-3 (Conventional cotton Reactive dyeing effluents)	Dyeing	Reactive dye (Remazol brand), Sodium chloride, Sodium carbonate, Sequestering agent, Wetting agent, Leveling agent	BOD in mg/L	800	50
			COD in mg/L	1989	200
			DO in mg/L	2.23	6
			EC mS/cm	59.1	12
			TDS in mg/L	29500	2100
			TSS in mg/L	585	150
			Alkalinity in mg/L	1200	500
			pH	11.27	7
Sample-4 (Organic Cotton Low impact Reactive dyeing effluents)	Dyeing	Reactive dye (Avitera brand), Sodium chloride, Sodium carbonate	BOD in mg/L	200	50
			COD in mg/L	644	200
			DO in mg/L	2.92	6
			EC mS/cm	57.1	12
			TDS in mg/L	22700	2100
			TSS in mg/L	430	150
			Alkalinity in mg/L	800	500
			pH	11.16	7

Table 1: Test results of ecological parameters.

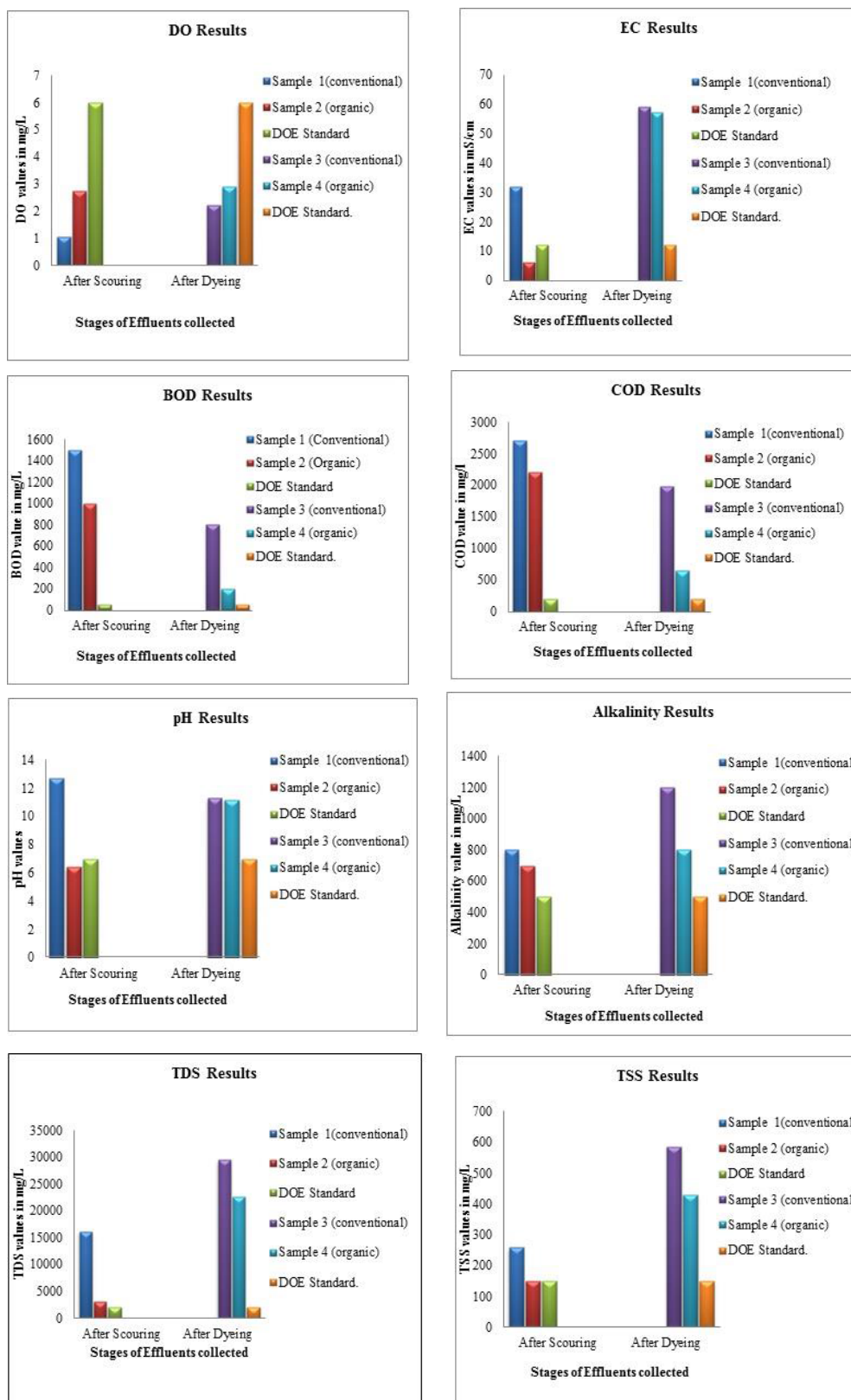


Figure 6: Graphical Representation of ecological test parameters.

difference between the organic cotton bio scouring (2200 mg/L) and conventional cotton scouring (2700 mg/L). Sample 2 is just a bit lower than the sample 1. But the COD value of the effluents of organic cotton knit dyed fabric by low impact reactive dye shows a greater reduction than conventional cotton reactive dye effluents. The COD value is 644 mg/L for organic cotton low impact dye effluents which is adjacent to the DOE standard COD value 200 mg/L. The results show that the DO value in mg/L of the effluents collected after bio scouring of organic cotton shows a greater value 2.76 mg/L in comparison of conventional cotton scouring effluents only 1.06 mg/L. And in case of low impact reactive dyeing it again shows a greater DO value 2.92 mg/L than the conventional cotton knit fabric reactive dyeing. EC of organic sample was well satisfactory as there was no electrolyte in the effluents so its purification was also satisfactory.

On the other hand conventional sample showed less purity as its EC value is so much higher than the normal water. Both the effluents collected from dyeing process i.e. from conventional and organic showed higher value of EC as chemical and auxiliaries used in dyeing worked as electrolyte solution. Organic sample shows lower TSS value as compared with conventional cotton knit fabric. This is because of the application of low impact reactive dye on organic cotton knit fabric. TDS result of sample 2 is well satisfactory as compared with sample 1. This is because enzyme was used for scouring process. Caustic and other inorganic materials were used in conventional scouring so sample 1 shows higher TDS. Both the Effluents collected from dyeing process show higher TDS because of the hydrolysed reactive dyes and a huge

amount of salt and soda content. But TDS of sample 4 shows less TDS value than sample 3 because of the application of low impact reactive dye. pH level of the effluents collected from enzymatic scouring of organic cotton fabric was well satisfactory as it was near to 7. This was because here enzyme i.e. microorganism was used as scouring chemical. On the other hand pH of the effluents of conventional cotton fabric scouring with NaOH was highly alkaline which is not safe to discharge into water. Effluents collected from dyeing process of both sample showed alkaline pH in dyeing stage because the effluents contain gluber salt and soda ash. In sample 1 the alkalinity shows greater value because of using caustic soda during scouring. On the other hand using enzyme reduces the alkalinity of the effluents in sample 2. In dyeing both in sample 3 and sample 4 the effluents contains a great amount of soda ash and gluber salt which increases the alkalinity of the effluents.

Physical test results

Test results of physical parameters are shown in the following table (Table 2).

Discussion: Knitted fabric of organic cotton treated with Enzyme shows excellent scouring effect than the fabric sample of conventional cotton as it took lower time to absorb one drop of color solution. Spot test of the sample shows that scouring effect of the fabric sample of organic cotton is more uniform than the sample of conventional cotton. It has been noticed that weight loss percentage of organic cotton sample is comparatively higher than the conventional cotton sample.



Physical Test Name		Knitted fabric of Organic cotton treated with Enzyme				Knitted fabric of Conventional cotton treated with Caustic soda	
Estimation of scouring effect	Drop test result	Absorption time in second 0.47				Absorption time in second 1.02	
	Results of spot test						
	Fabric weight loss due to scouring	Weight before scouring (gm.)		Weight after scouring (gm.)		Weight loss%	
		Sample of org. cotton 350	Sample of conv. cotton 10	Sample of org. cotton 318	Sample of conv.cotton 294	Sample of org. cotton 9.14%	Sample of conv.cotton 5.16%
Results of Color fastness to Wash	Color change	4/5				4/5	
	Color staining						
	Di-acetate	4/5				4/5	
	Cotton	4/5				4/5	
	Nylon	4/5				4	
	Polyester	4/5				4/5	
	Acrylic	4/5				4/5	
Test result of color fastness to rubbing	Dry	5				4/5	
	Wet	4/5				4	
Test results of color fastness to perspiration	Color change	4/5				4/5	
	Color staining						
	Di-acetate	5				5	
	Cotton	4/5				4	
	Nylon	4/5				4/5	
	Polyester	4/5				4/5	
	Acrylic	4/5				4/5	
Test results for Ball Bursting Strength	Grey	291.560 N				288.290 N	
	Dyed	236.580 N				326.600 N	
Result for fabric Drape test	Drape co-efficient	64.94					
	Drapability	Excellent					

Table 2: Test results of Physical Parameters of both samples.

Slight difference in the color fastness to wash of both the sample was found. However, result of dry rubbing was same for the both samples; slight difference found in wet rubbing. No noticeable difference has found in the result of color fastness to perspiration for both the sample of organic cotton and conventional cotton.

It has noticed that ball bursting strength for fabric of organic cotton was fall due to enzymatic scouring whereas strength of fabric sample of conventional cotton has increased due to scouring using caustic soda.

Result of drape test was well satisfactory for organic cotton sample as it shows a lower value of drape co-efficient that means the fabric is softer and easily drapeable than the sample of conventional cotton.

Conclusion

The selection of organic cotton over conventional cotton ensures the journey towards eco-friendly product development. In the subsequent processes the selection of enzymatic scouring, low impact reactive dyes for dyeing ensure the low environmental impact than conventional cotton fabric processing. The results shows that the use of organic fabric, enzyme and low impact dye has a greater ecological advances as it reduces the BOD, COD, TDS, TSS, Alkalinity and P^H of the effluent and increases the DO value in both scouring and dyeing stages than the conventional cotton, caustic scouring and cold brand reactive dyeing processes. The bleaching process has avoided here by dyeing in deep shade, which also reduces the amount of toxic effluent. The selected physical properties test results also show similar or better result of organic cotton knit fabric with conventional cotton knit fabric except the lower bursting strength. This work has done on only one shade of dye. The effluents of dyeing by different shades of dye can test. Due to the insufficiency of monetary support the toxicity, carcinogen, azo, formaldehyde and other metal content tests of the fabric could not perform. The environmental impact of different shades of low impact reactive dyes could measure. This research is a little approach towards better sustainable practices that would drive the textile and clothing designer, manufacturers, merchandisers, customers and as well as consumers to introduce various sustainable issues in their works. Hence growing awareness and leading them towards sustainable practices in the textile industries for a better and greener world.

Acknowledgements

All ecological parameters have been tested in Environment Lab and the physical properties have been tested in Textile Testing Lab of Dhaka University of Engineering and Technology, Gazipur.

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