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Economical and Sustainable Practices towards Knit-Dyeing Plant Utilizing Enzymes

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ABSTRACT

The introduction of enzymes in the treatment of textiles has made a significant contribution to the textile sector. The traditional pretreatment scouring process has many drawbacks, conciliated by handling with enzymes. Since most factories still use traditional pretreatment to obviate natural impurities from cotton knit fabric, they experience a lot of water, electricity, stream, and time consumption, and more significant fibre loss. Also, the conventional pretreatment method and dyeing of grey fabrics lead to significant wastewater, a detrimental impact on the environment. The main focus of the paper is sustainable practices towards textile processes. In this research, cotton knit fabrics were scoured by SCOUR-ZYME (bio-scouring enzyme) and caustic soda. Physicochemical parameters of the wastewater derived from caustic scouring and enzymatic scouring had been examined. Remazol brand reactive dyes were used for caustic soda scoured fabric and Avitera brand reactive dyes used for bio-scoured fabric. The wastewater generated from both dyeing process were investigated. Some selected physical characteristics including absorbency test, percentage of weight loss, whiteness index, moisture regain, moisture content, bursting strength, carboxylic content, pilling test, colour strength, colour fastness to wash, rubbing and perspiration, were also analyzed for scoured, bleached and dyed materials. Bio-scouring method improved the absorption of the material without any substantial loss of strength and helped to properly dye and finish the cloth. Substantial lower consumption of electricity, water, streams, chemicals, and time and, consequently, cost, environmental pressures were reduced in the enzyme method. Physicochemical parameters test results indicated more significant ecological improvement than the traditional approach for using enzymes and low-impact reactive dyes. The value of colour strength for Avitera coloured specimens was higher than Remazol coloured specimens due to enhanced colour absorption. What is more, the physical characteristics also demonstrated better outcomes in the use of enzymatic scouring method. Therefore, enzymatic scouring and dyeing with Avitera brand reactive dyes in the knit-dyeing plant can be used as an environmentally-friendly compared to caustic scouring and dyeing with Remazol brand reactive dyes.

Key words: Cost-effective, Environmentally friendly, Enzyme scouring, Sustainable practices, Wastewater.

1. INTRODUCTION

One of the biggest industries in the world is the textile industry. The textile industry creates job opportunities which are without a higher level of knowledge and which are a vital factor in providing jobs in poverty-stricken countries such as Bangladesh, India, Pakistan, Sri Lanka, and Vietnam, and thus playing a crucial role in the growth of their GDP [1]. This industry serves several sectors with as varied operational activities as its products.

Greige cotton fibres made up approximately 95% pure cellulose, balanced by non-cellulosic impurities of protein, oil, wax, pectin, carbohydrates, and inorganic materials [2-3]. For all subsequent finishing processes, namely dyeing, printing, and finishing, various treatments must be performed to remove natural non-cellulosic materials during the preparation of cellulosic materials [4]. Pretreatment of textile materials is essential; without pretreatment, the cotton colouring is almost impossible to achieve the desired result [5]. During all phases of processing fibres, fabrics and garments, the textile industry produces a wide range of contaminants that has a detrimental effect on the environment.

In the dispensation of cotton and cotton mixed content, scouring is an essential pretreatment process. The primary aim of the scouring is to obviate non-cellulosic cotton fibre additives and make the fibre absorbent. The traditional scouring process on cotton knitted fabric is carried out with temperatures of 95°C with the sodium hydroxide in a higher alkaline medium [6-9]. Caustic scouring includes many synthetic chemical compounds that are poisonous and hazardous to human skin and the environment.

In conventional scouring method, several toxic chemical compounds are used, which increases the BOD, COD and TDS amount in the wastewater and raise the undesirable environmental pressure. It generates a. over half the total BOD b. just less than half of COD and c. one-tenth of the overall level of pollution produced throughout the production process [10-11].

Since caustic soda works on swelling method and targets the secondary cell wall of cotton, which is almost pure cellulose; as a result, caustic soda destroys the cotton fibres and its strength during the conventional scouring processes. Also, it encourages the dye molecules not to be fixed on the fibre's surface according to our needs, and it accounts for a substantial quantity of dye loss. In reality, weight loss is roughly more than a tenth, potentially resulting in unnecessary weight loss.

Caustic scouring is conducted at 95 °C. In order to maintain this temperature, a lot more energy is needed in which field we are combating and more time is required, and it decreases production efficiency. Furthermore, the health of employees is severely impaired by the processing of these harmful chemicals in conventional caustic soda scouring.

In the textile industry, the main environmental issue concerns the volume of water and the chemical load it bears. The dyeing sector in textile is extremely water-intensive. Water is used during the entire production process to clean the raw material and for many different steps. It was found that nearly two-fifths of water is used during the bleaching process, and a fifth of water is used in dyeing. Also, less than a tenth of water is used in the printing process, while nearly a fifth of water is being used in printing, and only a quarter of water is used in other purposes [12-13]. The production of 1 kilogram of textile goods involves around 200 litres of water [14]. The caustic soda scouring consists of a number of overflows to subdue the scouring baths for subsequent operations that raise the need for water volume and high pH levels. It is a very concerning matter, as we only use a large volume of water, such as about 45,000 litres of water is used per 1000 kilograms of products for the scouring process [15]. Conventional caustic scouring requires a considerable amount of expense in the ETP to refine the wastewater, which is the principal cause of industries not getting the efficient management of wastes [16]. Moreover, in these processes, we can see that large quantities of contaminated water are released. The truth is that the water released after textile processing is well above the norms and comprises a significant quantity of harsh chemical substances that are hazardous to the environment.

There are reports that over 10,000 diverse colorants are industrially used. Each year, more than 7 tons of synthetic dyes are manufactured worldwide [17-18]. In Bangladesh, this sector is experiencing a great deal of decrial over the past few years for rising pollution because most dyeing industries have been established on the river in Bangladesh, leading to water environmental degradation. It is predicted that traditional dyeing activities in 2021 generate approximately 348 million cubic meters of wastewater [19].

Generally, dyes and pigments are being widely used in the dyeing industry. As a lot of chemical compounds are added in the dyeing process, around a fifth of the dyes due in the dye bath and are released along with other residual chemical substances as exhausted dye bath residue. The exhausted dye bath residues also consist of large amounts of coloured content and add colour to the receiving water bodies. Their release into rivers is detrimental to aquatic life due to the high concentrations of organic matter in wastewater and greater durability of modern synthetic dyes. As some of the dyes are made up of complex molecular forms, this helps them remain more stable and unlikely to decompose [20-27].

The greatest obstacle for the clothing industry today is improving manufacturing methods so that they are environmentally sustainable at a reasonable cost, utilizing safer dyes and chemical compounds and cutting the amount of effluent treatment cost. It has become a crucial requirement for the factory managers to figure out a substitute for the conventional caustic soda scouring process for some of its inevitable drawbacks.

On the contrary, the introduction of enzymes in the treatment of textiles has made a significant contribution to the textile sector. These enzymes can be used efficiently for scouring instead of traditional caustic soda scouring. This enables the development of eco-friendly fibre processing techniques and applications to enhance the end product attribute. The critical factor behind the use of enzymes in the finishing of textile products is the use of energy resources and the greater understanding of environmental issues relating to the use and discharge of hazardous substances into low-lying lands, rivers, and other water bodies during the chemical treatment of textiles. Bio-scouring enables an effective scouring of the fabric without adversely impacting the fabric or our surroundings [28].

Besides, low-impact dyes indicate a lesser environmental effect. This implies a lower amount of water is needed for rinsing and fewer dye drains within the water; thus, the dyes have a lower influence on the environment. Also, low-impact dyes neither consist of heavy metals, namely, Cr^{3+}, Zn^{2+}, and Cu^{2+} nor do they need poisonous chemical mordants to affix them to the fibres [29].

To save our world is a hot potato in our society at the moment. In view of the possibility of industrial waste streams, governments and communities are getting aware of environmental-related issues. Garment industries are confronting several difficulties from ecological issues and environmental regulation, incorporating higher water prices, ETP and disposal prices, more astringent legislations, and the implementation of ISO 14001, in particular [30-31]. Dyeing plants contaminate the water bodies will confront the danger of closing down, which has just begun in Bangladesh.

In Bangladesh, Cotton fibres are being dyed with traditional reactive dyes (Remazol brand), and caustic soda scouring process is being widely used compared to enzymatic scouring process because of the accessibility of resources. That is why nobody is worrying about the effect on the ecosystem.

This work is a little attempted to reduce the reasons mentioned earlier of pollution in our country and the entire planet. This article examines a study of the environmental contamination from traditional caustic soda pretreatment to dyeing and cotton knit materials treated utilizing enzyme and low-impact reactive dyes. Comparative research was carried out on specific selected physical characteristics of both types of finished products.

1.1 Aim and Objectives of the Study

- To perform the traditional caustic pretreatment as well as enzymatic scouring for cotton knit fabric.
- To execute traditional dyeing with Remazol brand reactive dyes of caustic scoured fabric and low-impact dyeing with Avitera brand reactive dyes of enzymatic scoured fabric.
- To assess the physicochemical parameters of industrial wastewater produced by the processes mentioned earlier.
- To examine differences in the physical characteristics and cost analysis of both treated fabrics.
- To analyze and compare the effect of colour strength of both types of scoured fabric using Avitera brand reactive dyes and Remazol brand reactive dyes.

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2. MATERIALS AND METHODS

The utilized materials are-

- Types of fabrics: 100% S/J (single jersey) Cotton
- Count: 30^s
- GSM: 160

2.1 Chemicals

The Four H Dyeing & Printing Ltd supplied SCOUR-ZYME (a commercial grade enzyme) for the enzymatic scouring process. Sodium hydroxide and soda ash were used for the caustic scouring process. Chemical auxiliaries, such as SHUNTEX XPA (sequestering agent), PERSOCLAN STN (wetting agent), FEROL-ZOM (detergent), RUBINE OS (anti creasing agent), ANTIFOAMING JET (anti-foaming agent), and citric acid were provided by Four H Dyeing & Printing Ltd.

2.2 Conventional Method of Scouring

1 gram per litre of caustic soda and 2 gram per litre of Na_2CO_3 is used for traditional caustic scouring. Since wet processing water can have hard water compounds, i.e. 30 ppm hardness was discovered; for this reason, 0.20 gram per litre SHUNTEX XPA was used. In addition, the scouring of caustic soda was performed with a 1:8 ratio of liquor, 1 gram per litre of PERSOCLAN STN, 2 gram per litre of FEROL-ZOM, 1 gram per litre of RUBINE STN, 1.50 gram per litre citric acid and 0.05 gram per litre of ANTIFOAMING JET at 95°C for the period of one hour.

2.3 Method of Bio-Scouring

0.80% of SCOUR-ZYME has been used for enzymatic scouring. Citric acid was used for the enzyme so that enzyme can work at a suitable pH. The pH of the bathtub was 6.5. Furthermore, 1 gram per litre of PERSOCLAN STN, 0.05 gram per litre of ANTIFOAMING JET, 1 gram per litre of FEROL-ZOM, and 1:8 of liquor ratio have been used at 55 ° C for a half-hour. The following demonstrates a process graph for enzymatic scouring.

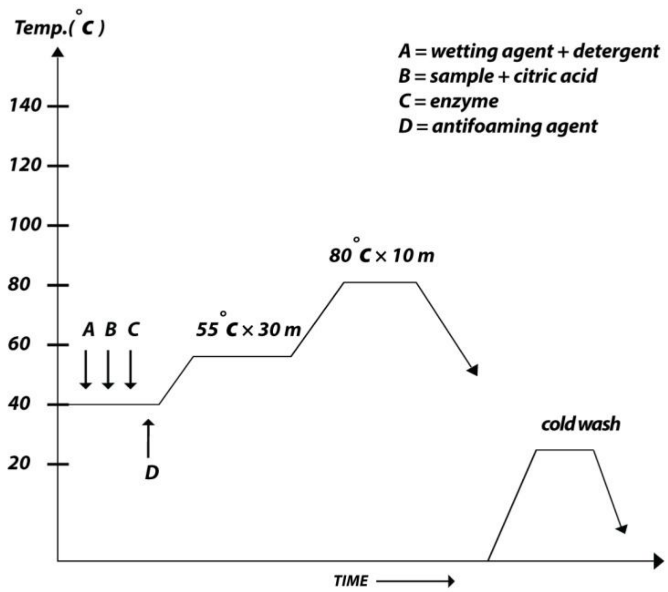

Figure 1: Pictorial Illustration of the Bio-Scouring Curve.

2.4 S/J Cotton Knit Fabric Dyeing With Avitera Brand Reactive Dyes

For 1% shade, dyestuff 1%, Glauber salt 30 gram per litre, Soda ash 8 gram per litre,1.50 gram per litre of levelling agent, temp. 60°C, time 60 minutes, liquor ratio 1:8 were used. Similarly, for 2% shade, dyestuff 2%, Glauber salt 50 gram per litre, Soda ash 12.5 gram per litre, 1.50 gram per litre of levelling agent, temp. 60°C, time 60 minutes, liquor ratio 1:8 were used.

2.5 S/J Cotton Knit Fabric Dyeing With Remazol Brand Reactive Dyes:

For 1% shade, dyestuff 1%, Glauber salt 30 gram per litre, Soda ash 8 gram per litre, 1.50 gram per litre of levelling agent, 0.60 gram per litre of sequestering agent, 1.50 gram per litre of citric acid, 1.5 gram per litre of wetting agent, temp. 60°C, time 1 hr, M: L 1:8 were used. Likewise, for 2% shade, dyestuff 2%, Glauber salt 50 gram per litre, Soda ash 12.5 gram per litre, 1.50 gram per litre of levelling agent, and 0.60 grams per litre of sequestering agent, 1.50 gram per litre of citric acid,1.5 gram per litre of wetting agent, temp. 60°C, time 1 hr, liquor ratio 1:8 were used.

2.6 H_2O_2 Bleaching

At 95 ° C, the scoured cloth was bleached using H2O2 50%(2 g / L), peroxide stabilizer (0.30 g / L) and NaOH (1 g / L) for the period of 1 hour. After treatment, the cotton specimens were withdrawn and washed through and through with water and neutralized with green acid and peroxide killer.

2.7 Bio-polishing

Bio-polishing is a finishing treatment that improves the fabric's attribute by minimizing the affinity of the pilling of knit fabrics. After completing the scouring and bleaching

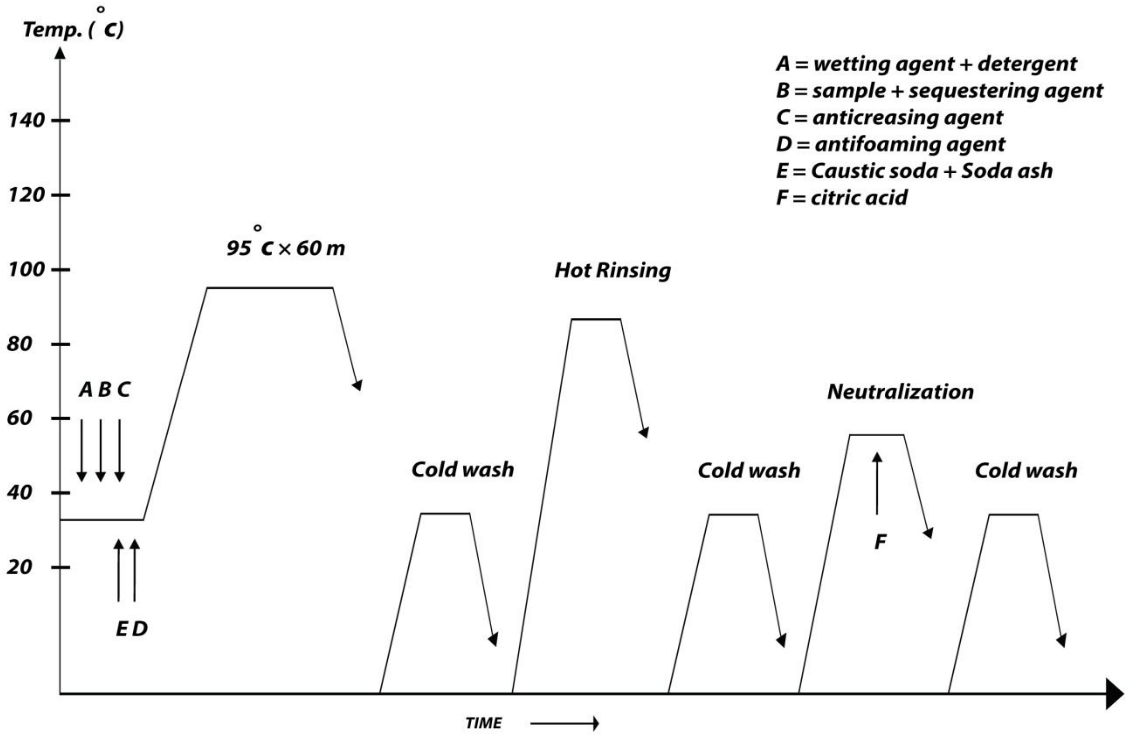

Figure 2: Pictorial Illustration of the Caustic Scouring Curve.

process, the fabric was bio polished with the help of CELLUSOFT COMBI 3000L (bio-polishing enzyme). 0.30% stock solution of the bio-polishing enzyme, acetic acid, sequestering agent, wetting agent used to do this process in the presence of pH-5.5 at 55°C & 40 minutes. Moreover, at 80°C, normal hot was given to destroy the enzyme's existence on the fabric surface.

2.8 Assessment of Absorbency Test

A. Drop Test

Water is taken in the pipette, and the water drops are fall on the scoured cloth and observe the absorption of the water droplet.

B. Spot Test

In pipette, a 1% solution of reactive blue dye is taken and places the drops of solution in different parts of the fabric. Next, notice the shape of the absorption place of the fabric.

C. Wicking test

During a glass beaker, the cotton content strip (18 cm × 5 cm) was suspended higher than the H2O line; the end of such a horizontal plane contacts the surface of the water. Capillary force discovered natural wicking. The peaks of the fluid height range were recorded for 5, 10, and 15 minutes.

D. Sinking test

Absorption can be used in a number of ways, the most common being the sinking time check. Test specimens measuring 1 cm × 1 cm were cut randomly and mounted on the surface of the water. The sample was slowly wetted, and the air trapped was extracted. It was noted that the time is taken for the sample to go within the water from the floating state and sunk in absolutely.

2.9 Percentage of Loss of Weight

The weight loss of the materials was determined by distinguishing between the pre-and post-treatment. Once the treatment was completed, the material was dried and weighed.

$$\text{Wt.\%} = \frac{A - B}{A} \times 100 \tag{1}$$

Where, A and B is the weights of fabrics before and after scouring.

2.10 Assessment of Whiteness Index

The whiteness index of the scoured and bleached specimens was analyzed by the reflectance value of the spectrophotometer (Data color 650TM).

2.11 Assessment of Moisture Regain and Moisture Content Test

The quantity of water present in a textile sample shall be determined either by its regain or by its moisture content. Method ASTM D2495-07 is used to perform the test. The specimens were taken and weighed before being oven-dried at 105 °C until a constant weight is maintained. The difference between the initial pre-drying mass and the oven-drying mass is measured as a percentage.

$$\text{Moisture Regain, R} = \frac{W}{D} \times 100 \tag{2}$$

$$\text{Moisture Content, C} = \frac{100R}{R + 100} \times 100 \tag{3}$$

Where, D is the oven dry wt. of the materials and W is the wt. of water in the fabrics.

2.12 Assessment of Color Strength

By using a Data color 650™ spectrophotometer, reflectance norms for all colored samples were determined in a visible range with a wavelength of 650 nm. The color strength has been determined by using Kubelka-Munk formula:

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \quad (4)$$

Where, K is the absorbance, R is the reflectance and S is the scattering.

2.13 Assessment of Bursting Strength Test

The pneumatic method (ISO 13938-2: 1999) was used to assess the samples' bursting strength.

2.14 Assessment of Carboxyl Content

The content of carboxyl groups treated fibers was calculated in accordance with ASTM D1926-00. For the period of 18 hours, Cotton was processed with 2×10^{-4} M $C_{16}H_{18}ClN_3S$ solution at pH 8. The dwindling in the concentration of $C_{16}H_{18}ClN_3S$ in the bath was then determined using a visible UV spectrophotometer and corresponded to carboxyl content as mill moles of the carboxyl group per 100 g of cellulose.

2.15 Assessment of Color Fastness to Rubbing

ISO 105-X12: 1993 method is used to conduct the fabric test. Using crock meter, 20cm×5cm of sample size, 5cm×5cm of bleached fabric, and given rotation of 10 cycles for 10 seconds to carry out the test.

2.16 Assessment of Color Fastness to Washing

ISO 105-C06 B2S procedure is used to conduct the fabric test. 1g/L of $BNaO_3 \cdot 4H_2O$, 4g/L of ECE phosphate detergent were used. Also, 10cm × 4cm of sample size, 10cm × 4cm of multifibre size, and 25 number of steel ball were used at 50°C for 30 minutes to perform the test.

2.17 Assessment of Color Fastness to Perspiration

ISO 105-E04:2013 procedure is used to conduct the fabric test. 0.5g/L of $C_6H_9N_3O_2 \cdot HCl \cdot H_2O$, 2.2g/L of Sodium dihydrogen orthophosphate dihydrate, 5g/L of NaCl were used for the acidic solution. Moreover, 10cm × 4cm of sample size and 10cm × 4cm of multifibre size were used at 37°C for 4 hours to conduct the test. 5.5 of the pH value were maintained in this test.

Furthermore, 0.5g/L of $C_6H_9N_3O_2 \cdot HCl \cdot H_2O$, 2.5g/L of disodium hydrogen phosphate dihydrate, 5g/L of NaCl were used for the alkaline solution. Moreover, 10cm × 4cm of sample size and 10cm × 4cm of multifibre size were used at 37°C for 4 hours to operate the test. 8.0 of the pH value were maintained in this test.

2.18 Assessment of Pilling Test

ISO 12945-2:2000 method is used to perform the fabric test. For the test, cut a sample of 140mm dia from the specimen fabric. For 500 cycles, the specimens were examined to multi-directional friction. After the finished cycle, the samples were taken under adequate lighting and in comparison to standard photographs, and the grading was carried out.

2.19 Physicochemical Parameters Test

A. pH, Dissolved Oxygen and Electrical Conductivity

Wastewater from various stages is collected in the beaker, the port of DO, and the ports of pH were set to multimeter for pH, DO and EC determination. Afterwards, the port was immersed in the effluent water and held for a few seconds until the result was seen on the screen. The values of DO (ppm), pH and EC (mS / cm) were measured directly from the multimeter.

B. Biochemical Oxygen Demand

BOD was defined in accordance with *Method APHA 5210 B.* The underlying concept is the calculation of the DO absorption of the specimen and blank initially and after incubation for three days at 27°C. In order to get the correct BOD measurements, the incubation time and temperature were as follows: 5 days and 20°C, respectively. In the first position, pure distilled water saturated with oxygen was taken from BOD Oxitope. 5 ml of the contaminated water+25ml of fresh water were taken from another BOD Oxitope. The two Oxitopes were then held at 20°C for five days in the BOD incubator. After five days, the dissolved oxygen of the pure water and the diluted impurity of the water were measured to obtain BOD values.

C. **Chemical Oxygen Demand**

COD was measured in accordance with *Method APHA 5220 B.*

3. RESULTS AND DISCUSSION

3.1 Weight Loss Result

Table 1: Test Results of Weight Loss (%)

Sample No	Before weight (gm)	After weight (gm)	Weight loss %
Sample-1 (conventional)	10	9.77	2.3
Sample-2 (bio-scouring)	10	9.90	0.96

Observation: From the analysis, we can see that the percentage of weight loss is greater in the traditional caustic soda process than in the enzymatic process. This is because partial amount of cellulose is removed with impurities, namely wax, protein, pectin, oil etc. in the traditional process.

3.2 Absorbency Test Result

A. Wicking test

Table 2: Test Results of Wicking Test

Sample No	Length Of Immersed Fabric (mm)	Standard Dipped Length (mm)
Sample-1 (conventional)	92	30-50
	95	
	101	
Sample-2 (bio-scouring)	64	
	76	
	96	

Observation: From the above table, the results reveal that enzymatic scoured specimens are in optimal absorbing range compared with traditional caustic soda scoured specimens. This result demonstrates distinct differences between caustic soda scouring and enzymatic scouring.

B. Spot Test

Table 3: Test Results of Spot Test

Bio-scouring Sample	Caustic scouring sample
	
Good scouring	Uniform scouring

Observation: We can see from the findings that the enzymatic scoured material was quite well scoured than the traditional caustic soda scoured material.

C. Drop Test

Table 4: Test Results of Drop Test

Sample No	Time (sec)
Sample-1 (conventional)	1.20
	0.69
	0.24
Sample-2 (bio-scouring)	0.24
	0.53
	0.45

Observation: Compared with the traditional caustic soda scoured specimens, the absorbency of enzymatic scoured specimens is quite satisfactory because enzymatic scoured materials take less time to absorb water drops in comparison to traditional caustic soda scoured materials.

D. Sinking Test

Table 4: Test Results of Sinking Test

Sample No	Time (sec)
Sample-1 (conventional)	2.37
Sample-2 (bio-scouring)	1.82

Observation: The less time is taken by the materials to sink fully into the water, the higher its absorbency. From the analysis, the result reveals that compared with the traditional caustic soda scoured materials, time taken by the enzymatic scoured materials is lower.

3.3 Whiteness Index Result:

Table 4: Test Results of Whiteness Index

Sample No	Whiteness index
Sample-1 (conventional)	36.84
Sample-2 (bio-scouring)	16.05
Sample-3 (Alkaline Bleach)	67.8
Sample-4 (Enzymatic Bleach)	61.3

Observation: The outcome of the study shows that compared to the traditional caustic soda scoured materials, the whiteness value of the enzymatic scoured materials is lower. Its appearance is yellowish because inadequate elimination of seed-coat fragments and mote properly in the scouring phases. These are obviated during the bleaching process, and the whiteness is enhanced by approximately 45.

3.3 Moisture Regain and Moisture Content Test Result

Table 5: Test Results of Moisture Regain and Moisture Content Test

Sample No	Moisture Regain (%)	Moisture Content (%)
Sample-1 (conventional)	6.27	5.90
Sample-2 (bio-scouring)	6.83	6.39

Observation: There are 6.83% of moisture regain for sample no 2 while the figure for sample no 1 stood at only 6.27%. As the percentage of moisture regain depend on effective scouring; as a result, sample no 2 shows higher value compared to sample no 1. Similarly, moisture content for bio-scoured fabric reveals higher value.

3.4 Bursting Strength Test

Table 6: Test Results of Pneumatic Bursting Strength Test

Sample No	Distension (mm)	kPa
Sample-1 (conventional)	15.79	255.15
Sample-2 (bio-scouring)	16.16	282.43
Grey Fabric	16.41	292.54

Observation: The strength of the enzymatic scoured specimen shows greater value than traditional caustic soda scoured specimen. Enzyme scouring allows the elimination of the cuticle portion by partial hydrolysis. This is why, after enzymatic treatment, cotton has an intact structure with a lower strength.

3.5 Carboxylic Content Result

Table 7: Test Results of Carboxylic Content

Sample No	meq/100 gm. Of cellulose
Sample-1 (conventional scoured and bleached)	1.67
Sample-2 (enzymatic scoured and bleached)	1.45

Observation: Higher carboxyl content means higher oxycellulose formation, and gives information on degradation to cotton fibers related to scouring and bleaching phases. The analysis reveals that the cotton fibers handled with the traditional method have greater carboxyl content than the enzymatic method. Since traditional caustic soda scouring are conducted at high temperature, the greater portion of hydroxyl groups (-CHOH) in the cellulose is oxidized to aldehyde (-CHO) groups and even to carboxyl groups (-COOH). In comparison with the enzymatic method, caustic scouring indicates more chemical disruption to cellulose fibers.

3.6 Pilling Test Result

Table 8: Test Results of Pilling Test

Sample No	Results
Sample-1 (conventional scouring with bio-polish)	4/5
Sample-2 (bio-scouring with bio-polish)	4/5
Sample-3 (Grey fabric)	4

Observation: Both sample 1 and sample 2 shows the same rating after the bio-polishing treatment. This is because both samples have been treated with the bio-polishing enzyme. That means partial pills are formed on the fabric surface.

3.7 Impact on Color Strength Result

Table 8: Test Results of Color Strength for Various Shade%

Sample No.	Shade %	Reflectance %	K/S value
Caustic scoured fabric dyeing with Remazol brand	1	75.12	36.57
	2	75.16	36.59
Enzymatic scoured fabric dyeing with Avitera Brand	1	79.31	38.66
	2	76.81	37.41

Observation: In terms of 1% and 2% shade the value of K/S reflects that Avitera brand reactive dyes have a significant effect on dye uptake for sample no 1 as opposed to sample no 2. Since low impact environmentally friendly dyes and chemical compounds have been used in pretreatment and dyeing process, sample no 1 shows greater value.

3.8 Rubbing Fastness Test Result

Table 9: Assessment Color Fastness to Rubbing

Sample No	Shade %	Type	Rating Bleached cotton
Sample-1 (bio-scouring fabric)	1.0%	Dry	4/ 5
		Wet	3/4
	2.0%	Dry	4/5
		Wet	4
Sample-2 (conventional scouring)	1.0%	Dry	4/ 5
		Wet	3/4
	2.0%	Dry	4/5
		Wet	3/4

Observation: In comparison to caustic treated fabric with Remazol brand reactive dyed specimens, enzyme-treated fabric with Avitera brand dyed materials deliver greater values for 1% and 2% shades. It can be clarified in this way that Avitera brand dye has more flexibility for connecting to cellulose fibers, which ensures that the properties of color fastness are also greater in rating.

3.9 Color Fastness to Perspiration Result

Table 10: Assessment of Color Fastness to Perspiration

Sample	Shade%	Type	Grey scale Rating
Bio-scoured fabrics	1.0%	Alkali	4
		Acid	4/5
	2.0%	Alkali	4/5
		Acid	4/5
Conventional scoured fabrics	1.0%	Alkali	4
		Acid	4/5
	2.0%	Alkali	4
		Acid	4/5

Observation: As opposed to the enzyme-treated fabric with Avitera brand reactive dye, Caustic treated fabric with Remazol brand reactive dye is taken lower rating because Avitera 's reactive dye has more sensitivity to bind to cotton fabric.

3.10 Water Consumption

Since a wide range of chemical compounds were used to complete the cycle in conventional scouring; hence, a large amount of water was required for rinsing. On the contrary,

Table 11: The Volume of Water Needed for the Processing of 10 Kg of Cloth at a Liquor Ratio of 1:8

Method	Liters
Conventional Scouring (appx)	428
Enzymatic Scouring (appx)	134

we employ the enzyme rather than chemical substances in the scouring method; thus, less water was needed in this method. The quantity of water to be saved is approximately 29 liters per kilogram treated. With a division making 25 Metric tons of scouring daily, the volume of water to be recovered is 725,000 liters each day. On a yearly basis, there are 264625.000 liters of water.

3.11 Time Consumption

Table 12: Assessment of Time Consumption

Method	Time
Conventional Scouring (appx)	2 hr. 50 min
Enzymatic Scouring (appx)	1 hr. 10 min

Observation: Caustic soda scouring takes a huge time compared to the enzymatic scouring method to complete the entire scouring method. Hence, it obviously saves a massive amount of time if we consider the enzymatic scouring method rather than the conventional scouring method.

3.12 Electricity and Stream Consumption

Table 13: Assessment of Electricity And Stream Consumption

Method	kWh	kg/kg of fabric
Conventional Scouring	22.34	1.8
Enzymatic Scouring	9.20	0.7

Observation: A huge amount of time was needed to execute the caustic method; as a result, the caustic scouring method consumed more electricity than the enzymatic scouring method. The quantity of electricity to be saved is more than half for bio-scouring. On the other hand, the amount of stream required for caustic scouring is considerably higher compared with enzymatic scouring. So, more than three-fifths stream has been saved in the enzymatic scouring.

3.13 Temperature Saving:

Table 12: Assessment of Temp. Saving

Method	°C
Conventional Scouring	95
Enzymatic Scouring	55

Observation: The difference in temperature is about 40 ° C. Considering 1:8 materials to liquor ratio for one kilogram of cotton treated, 8 liters of water are needed throughout the scouring method.

The quantity of heat energy necessary per kilogram of cotton processed = (95- 55) × 1000 × 4.186 × 8 = 1339520 Joules = 1339.52 kilojoules.

Where, water specific heat capacity 4186 Joule/gram K. To heat 1 gram of water by 1 Kelvin, 4.186 joules of energy are required.

The quantity of heat energy to be recovered is approximately 1339.52 kilojoules per kilogram material processed. With a division making 25 Metric tons of scouring daily, the volume of heat energy to be saved is 1.22 x1010 KJ each year.

3.14 Effluent Generation and Its Treatment Cost

Table 13: Test Result of Wastewater Generation and Its Treatment Cost for 1000 Kilograms Fabrics

Method	Liters	Treatment Cost (BDT)
Conventional Scouring	42800	1098.3764
Enzymatic Scouring	13400	343.8842
Cost for one liter effluent = 0.025663BDT. Or, Cost for one cubic meter effluent = 25.66 BDT.		

Observation: The effluent produced by the traditional process is 42800 liters per 1,000 kg of fabrics, while the enzymatic method is 13400 liters. This results in an effluent load savings of 68.7% in bio-scouring. The cost of treatment of effluent is estimated to be BDT. 1098.3764 in the case of caustic scouring and BDT. 343.8842 in the case of enzymatic scouring, resulting in net savings of 68.7 % in the cost of bio-scouring treatment of effluent.

3.15 Color Fastness to Wash Result

Table 14: Assessment of Color Fastness to Wash

Sample	Shade%	Di acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Bio-scoured fabrics	1.0%	4/5	4	4/5	4/5	4/5	4/5
	2.0%	4/5	4/5	4/5	4/5	5	5
Caustic scoured fabrics	1.0%	4/5	3/4	4/5	4/5	4/5	4/5
	2.0%	4/5	4/5	4	4/5	4/5	4/5

Observation: Color fastness to wash demonstrates the effects in terms of color staining. These findings indicate that the wash materials vary in the caustic soda scoured specimen and the enzymatic scoured specimen depending on the nature of the color's fastness. Conventional scoured samples with Remazol brand reactive dye show a little bit different as opposed to the bio-scoured samples with Avitera's reactive dye.

3.16 Cost Analysis

A. Water Cost

Table 15: Water Cost for 1000 Kilograms Fabrics

Method	Litres	Cost (BDT)
Conventional Scouring	42800	313.724
Enzymatic Scouring	13400	98.222
Cost of water = BDT. 7.33/ 1000 liters		

B. Electricity Cost

Table 16: Assessment of Electricity Cost

Method	kWh	Cost (BDT)
Conventional Scouring	22.34	159.284
Enzymatic Scouring	9.20	65.596
Cost of electricity = BDT. 7.13/ kWh		

C. Stream Cost

Table 17: Assessment of Stream Cost for 1000 Kilograms Fabrics

Method	kg	Cost (BDT)
Conventional Scouring	1800	2304
Enzymatic Scouring	700	896
Cost of stream = BDT. 1.28/ kg		

D. Chemical Cost of enzyme scouring

Table 18: Chemical Cost for Bio-Scoured Fabrics

Chemicals	g/L	Unit Price (BDT)	Qty/ 1000 kg of fabric	Cost/ 1000 kg of fabric (BDT)
SCOUR-ZYME (bio-scouring enzyme)	0.80%	595.80	0.064	38.13
Citric acid	0.20%	88.74	0.016	1.42
PERSOCLAN STN (wetting agent)	1	375.0	8	3000
ANTIFOAMING JET (anti-foaming agent)	0.05	254.71	0.4	101.88
FEROL-ZOM (detergent)	1	465.0	8	3720
			Total	**6861.43**

E. Chemical Cost of caustic scouring

Table 19: Assessment of Chemical Cost for Caustic Scoured Fabrics

Chemicals	g/L	Unit Price (BDT)	Qty/ 1000 kg of fabric	Cost/ 1000 kg of fabric (BDT)
Caustic soda	1	57	8	456
Soda ash	2	25.76	16	412.16
PERSOCLAN STN (wetting agent)	1	375.0	8	3000
ANTIFOAMING JET (anti-foaming agent)	0.05	254.71	0.4	101.88
FEROL-ZOM (detergent)	2	465.0	16	7440
Citric acid	1.50	88.74	12	1064.88
SHUNTEX XPA (sequestering agent)	0.20	110.0	1.6	176
RUBINE OS (anti creasing agent)	1	78.4	8	627.2
			Total Cost	**13278.12**

Observation: Tables 15, 16, 17, 18 and 19 show that in traditional processes, the entire scouring price includes chemicals, steam, water, and electricity falls about BDT. 16055.13, while the cost of bio-scouring is BDT. 7921.25.

3.17 Physicochemical parameters Test Result

Table 20: Test Results of Physicochemical Parameters of Wastewater for Different Scouring Process

Origin of wastewater	Parameters	Results (parts per million)	DOE[1] Standards for waste from industrial units
Alkaline bleach	BOD	1286.86	50
	COD	3927.61	200
Enzymatic bleach	BOD	965.15	50
	COD	2252.01	200
[1]Department of Environment			

Observation: The study's outcome shows that the alkaline bleach sample has a greater ecological impact on the environment than enzymatic bleach. This is because the microorganism present here, i.e., the bio-scoring enzyme, is used as scouring agents. On the other hand, a lot of harsh chemical compounds are used in the alkaline scouring method. That is why BOD and COD values are considerably higher compared to enzymatic bleach.

Table 21: Test Results of Physicochemical Parameters of Wastewater for Different Brand Reactive Dyes

Sample No.	Origin of wastewater	Parameters	Results (parts per million)	DOE Standards for waste from industrial units
Sample No. 1	Caustic soda scoured fabric dyeing with Remazol brand	Biochemical Oxygen Demand	819.62	50
		Chemical Oxygen Demand	1873.81	200
		Dissolved Oxygen	2.57	6
		Electrical Conductivity	28	12
		pH	11.29	6–9
Sample No. 2	Enzymatic scoured fabric dyeing with Avitera brand	Biochemical Oxygen Demand	221.37	50
		Chemical Oxygen Demand	647.31	200
		Dissolved Oxygen	2.16	6
		Electrical Conductivity	5.90	1.2
		pH	11.07	6–9

Observation: After dyeing with low impact Avitera brand reactive dyes, the wastewater value of BOD for enzymatic scoured fabric demonstrates a greater and lesser value, i.e., 221.37 ppm. On the contrary, the traditional caustic soda scoured cloth after processed with Remazol brand reactive dyes the effluent quantity of BOD rises to 819.62 ppm. The COD (ppm) amounts of wastewater after enzymatic scouring and dyeing with Avitera brand reactive dyes and caustic soda scouring and dyeing with Remazol brand reactive dyes are shown in table 20. The finding demonstrates that the COD value of the sample no 3 shows greater value compared with the sample no 4. The quantity of COD is 647.31 ppm for sample no 4, close to the Department of Environment Standards.However, in comparison with the sample no 2, the value of DO, pH, and EC for sample no 1 show substantially higher value. This is because sample no 2 is treated with the enzyme in the pretreatment process. Moreover, the enzymatic scoured fabric is processed with low impact Avitera brand reactive dyes. That is why sample no 2 presents a lower value than sample no 1.

4. CONCLUSION

Although the traditional caustic cotton scouring method is being widely used these days, it is facing a quantity of water, power, stream, and time consumption, and higher fibre damage. Besides, the conventional pretreatment method and dyeing of greige cotton fabrics with Remazol brand reactive dyes produce a significant volume of effluents, which harms our surroundings. Hence, sustainable, cost-effective, and environmentally friendly manufacturing are imperative in order to maintain environmental integrity, preserve energy, environmental assets, and minimize costs and effluents. As long as many dyeing plants are still using conventional caustic cotton pretreatment and Remazol brand reactive dyes, they are consuming a large amount of energy, water, fibre loss, dye loss and colour strength as well as are contributing towards environmental degradation. By executing empirical analysis, we arrived at the conclusion that the use of bio-scouring against traditional caustic cotton scouring facilitates the movement towards the development of environmentally friendly, cost-effective, and sustainable products. Enzyme scouring and Avitera brand reactive dyes for dyeing allow minimal ecological effect as opposed to conventional caustic cotton pretreatment and Remazol brand reactive dyes. Because of the enzymatic scouring minimizes about 25% BOD and 43% COD in comparison to caustic scouring. As opposed to the caustic cotton pretreatment, bio-scouring reduces more than two-thirds of water, nearly three-fifths of time and electricity, just over three-fifths of the stream. In addition, enzyme scouring decreases just under half of the chemical cost, just above three-fifths of stream cost, more than half of electricity cost, just over two-thirds of ETP cost and water cost than traditional pretreatment. Also, bio-scouring loses a tiny fraction of fibre strength compared with the grey fabric. Also, the findings indicate that the use of low impact Avitera brand reactive dyes have more considerable environmental progress than Remazol brand reactive dyeing processes by minimizing wastewater BOD, COD, EC, alkalinity and pH and by increasing the DO value in the dyeing phases. The chosen physical characteristics test reveals better result for enzyme scoured fabrics than caustic scoured cotton knit fabrics. Because of the inadequate financial assistance, the ecological effect of various shade percentage of Avitera brand dyes could not be evaluated. This work represents a small obtainment to better reliable activists which would lead to the implementation of various sustainability questions for textile and apparel manufacturers, producers, distributors, clients and consumers. Thus, to bring consciousness and take them on sustainable activities for the textile mills in order to make the world healthier and greener. Everyone who participates in a textile production process must be respectful to the environment and maintain the image of our clothing in developed countries for the betterment of our nations.

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