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Comparison of Effectiveness Between Conventional Scouring & Bio-Scouring On Cotton Fabrics

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Abstract-This study attempted to evaluate the eco-friendly bio-scouring and the conventional chemical (mainly NaOH) scouring processes of cotton & comparison between the effectiveness of both types of scouring process on cotton fibres and fabrics in the Textile industries. Less developed countries, like Bangladesh, do not set strict rules and regulations to discharge waste water from textile mills after wet processing fibres, yarns or fabrics which contains large amount of harsh and hazardous chemicals. As a result, environmental pollutions (like water, air pollution) are becoming the worst problem over the country. Common peoples are suffering from water-borne diseases, lack of drinkable water. Animals and plants lives are also destroyed gradually. Here, Effluent Treatment Plant (ETP) may be the good solution: which is used to purify waste-water from Hazardous chemicals. But, since textile processing needs lot of water (to produce one kg of textile fabrication approximately 200 liters of water is used) they had to pay lot of money which cuts their profit. In this intricacy, bio-scouring process may be a good substitute for chemical scouring which reduces ETP cost. But we can not ensure it as an only substitute since it does not give desired result in some cases. Still conventional scouring of cotton is the most widespread process for removing the fibres impurities to make the fibre absorbent for textile wet processing in commercial world. Though both have some restriction in the textile sector, they can be properly utilized by evaluating their respective advantages and disadvantages. This study provides a set of experimental results, discussion and comparison between the two processes.

Key words: Absorbency test, Bioscouring, Bleaching, Conventional Scouring, Cotton structure, Dyeing, Methodology, Scouring mechanism.

1 INTRODUCTION

Raw fibres, yarns or fabrics have various kinds of impurities like motes, seed coat fragments, pesticides, dirt, chemical residues, metallic salts of various kinds, and immature fibres. External impurities are removed in the blow room processing while internal impurities of cotton fibres removed by scouring processes. Cotton fibre is constituted with different layers in its body. A schematic representation of cotton fibre structure is shown below:

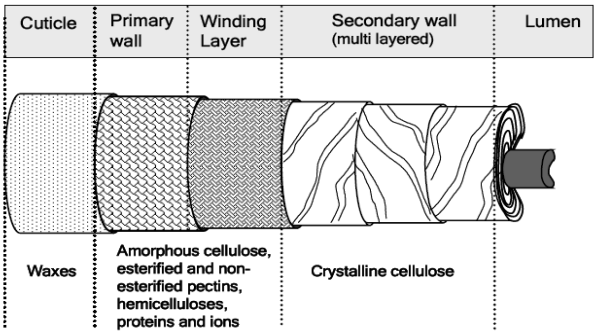


Fig: A schematic representation of mature cotton fibre showing its various layers.

Different constituent of cotton fibres are cellulose (90%-94%), waxes (0.6%-1.3%), pectic substances (0.9%-1.2%), protein (0.6%-1.3%), ash (upto 1.2%), organic acids (upto 0.8%) and others (1.2%). The main target of scouring is to remove waxes, pectins, hemi-celluloses and minerals from the raw cotton fibres during the early stage of textile wet processing to make the fibres highly absorbent, which is necessary for the subsequent processes such as mercerizing, bleaching, dyeing, printing and finishing. For this purpose, Caustic soda (NaOH) treatment is used in conventional scouring, whereas, Enzymes (Cutinases, Pectinases etc.) treatment is applied in bioscouring process.

Though Different scouring materials are used in the textile industry like NaCO3, $Ca(OH)_2$ etc., alkaline (NaOH-sodium hydroxide) is used mostly for the scouring. Conventional chemical scouring is done in hot (90^0C-100^0C) NaOH solution for 45-60 minutes. The conditions depend on the quality of scoured fabric required. Moreover, different agents are used such as reducing agents, detergent, sequestering agent (also called chelating agents or sequestrant), and wetting agent. Sequestering agent reduces the water hardness, reducing agent prevent oxidation of cellulose by air oxygen at high pH, detergent acts as emulsifier to assist in removing waxy substances and wetting agent reduces the surface tension of water helps fibres to swell.

However, use of enzymes in textile wet processing has added a new line research and likely eco-friendly substance to give a good solution to the problem of highly toxic chemicals causing environmental pollution. Enzymes, generally, act in low temperature with excellent efficacy. It saves high cost of energy consumption compared to conventional process. Moreover, it reduces Biological/Biochemical Oxygen Demand (BOD) and Chemical Oxygen Dmand (COD), and other waste water effluent load thus reduces ETP operational cost.

The fabrics treated with harsh chemicals are also unsafe for human health (may affect on human skin) but bioscoured fabrics are completely safe.

2 PROCEDURE

2.1 Methodology

Though this study is based on the effectiveness scouring comparison, performances should also be judged after subsequent processes so that their Overall Efficacy can be measured. For this purpose, effectiveness and performance are tested evaluated after different steps, even after dyeing and finishing. During experintation following steps are followed for each process:

Alkaline/ Bio-scouring
↓
Scouring & bleaching (4 sets each)
↓
Drop test
↓
Column test
↓
Weight loss
↓
Dyeing with different shades
↓
Fastness test (wash, perspiration, acid, alkali, rub fastness)
↓
Fault analysis
↓
Cost analysis
↓
Quality analysis
↓
Effect on environment (BOD, COD, DO etc)
↓
Overall advantages & disadvantages analysis
↓
Comparison of effectiveness

2.2 Mechanism:

2.2.1 Conventional scouring

In the conventional scouring, dilute sodium hydroxide (NaOH) solution is used which swells the cotton fibres and opens up the cell of the fibres to access H_2O_2 (Hydrogen peroxide) in the next process bleaching (NaOH also cleans outer chemicals residue and impurities by dissolution). Some of the waxy substances melt in the high temperature and other parts make water soluble compounds with NaOH. Non-cellulosic substances like pectins, proteins and hemi-celluloses, are also converted into water soluble compounds. Caustic soda (NaOH) neutralizes the fibres which contain some acidic compounds in it such as amino acids, pectic acids etc. Since some of the NaOH is absorbed by fibres, the intra and intermolecular hydrogen bonds becomes stronger in the cellulosic fibres.

2.2.1 Conventional Scouring

In the recent years, enzymes (Biocatalysts) are becoming important materials in the wet processing of textile's pretreatment and finishing for their desirable results and promising process to cover the requirement expected. Biocatalysts act in comparatively low temperature, atmospheric pressure, wide range of PH. Different biocatalysts are experimented for textile scouring, where pectinase and cutinase based enzymes are proved to be better in use. Enzymes remove the pectin from the outermost layer of the fibres which acts as glue to bind wax to fibres. After removal of pectin, fibre wettability increases and removing of wax becomes easier. Since Ca-compounds slow down the removal of pectin and fatty acids, sequestering agent is used. After treating with enzyme, fabrics should be washed in boiled water to melt and remove wax.

2.3 Scouring Process

2.3.1 Conventional Scouring Process

For conventional scouring, 2-4 g/l NaOH (different concentration for different sample) is used. Since water used in the wet processing may have hard-water compounds, 1-3 g/l sequestering agent can be used. Moreover, 1-2 g/l wetting agent, 1-3 g/l detergent and, sometimes, 0.5-1 g/l soda ash can be used. Preocess curve for this scouring is shown below:

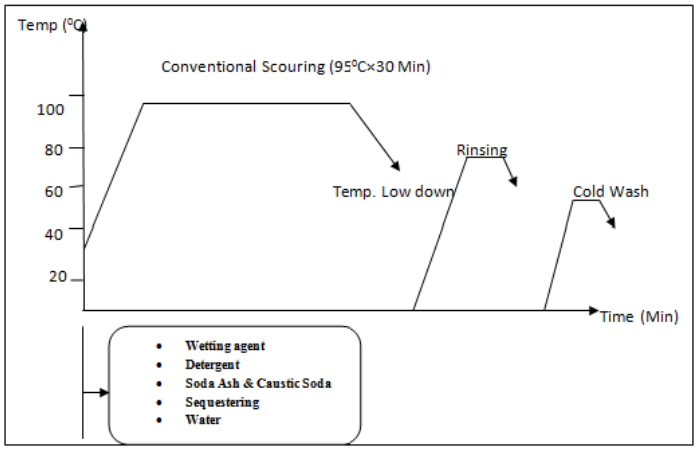
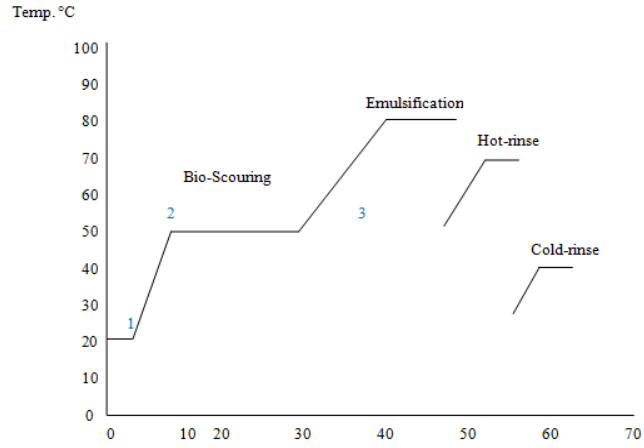


Figure: Conventional Scouring curve for cotton fabric

2.3.1 Bioscouring Process

For bioscouring, 0.4-2 OWF (On the Weight of Fabric) Enzyme (in my research, I used pectinase type enzyme) can be used. PH buffer, to set scouring-bath at a favorable PH for enzyme to act. The PH of the scouring-bath may varies from 6 to 9, according to the type of enzyme used in the process. Moreover, 0.5-1 g/l wetting agent, 0.5-2 g/l sequestrant, and 0.5-1.5 g/l emulsifier can be used. A process curve for bioscouring is shown in the following:



Here,

1. *Water,wetting agent, PH buffer and fabric;*
2. *Enzyme (pectinase);*
3. *Emulsifier.*

Figure: Bioscouring processing curve

2.4 Other Procedures

During research, I have followed tradional processes for bleaching, dyeing in different shades with different types of dyestuffs and printing, and other procedures.

3 Results

3.1 Weight loss

Weight loss of the scoured fabrics, fibres or yarns is an important factor of the textile manufacturers, because, it is related to profit and finished fabrics quality, durability, comfortability and other properties. Therefore, weight loss is determined after scouring this is shown below:

SAMPLE NAME	WEIGHT LOSS (%)	
	SINGLE JERSEY	DOUBLE JERSEY
Conventional Scoured-1	6.87	7.27
Conventional Scoured-2	6.56	7.54
Conventional Scoured-3	7.93	8.22
Conventional Scoured-4	5.64	6.45
Bioscoured-1	1.48	1.70
Bioscoured-2	1.28	1.53
Bioscoured-3	1.35	2.30
Bioscoured-4	2.14	2.53

Table: Weight Loss In Conventional and Bioscoured Fabrics

3.2 Absorbency Test

Since main purpose of scouring is to improve the absorbency of the textile materials, absorbency of the scoured materials should be evaluated. Different methods exist for evaluation of absorbency of scoured materials.

3.2.1 Drop Test

In this test, time taken to absorb a colored drop on the fabric is measured which color drop comes from a solution of 0.1% direct red (Congo red). I have seen, in my experiment, that both types of scoured fabrics give nearly same time for absorption which is less than one second.

3.2.2 Column Test

A 18cm×5cm scoured fabric sample is allowed to immerse in a beaker of 0.1% Congo red solution and after 5 minutes dipped length is measured. A standard dipped length lies between 30mm and 50mm.

Sample Name	Length Of Immersed Fabric (mm)	
	Single Jersey	Double Jersey
Conventional Scoured-1	34	28
Conventional Scoured-2	35	32
Conventional Scoured-3	42	35
Conventional Scoured-4	38	30
Bioscoured-1	34	30
Bioscoured-2	37	34
Bioscoured-3	35	32
Bioscoured-4	37	33

Table: Length of immersed fabric (mm) in column test

3.3 Reflectance of Bleached Fabrics

Bleaching qualities and standards depend on scoured fabric's performances. So, scoured fabric is bleached with H_2O_2, a widely used traditional process and evaluated its performanes. Bleaching is mainly measured by the reflectance of the bleached fabrics. Here, a result of bleached fabrics is shown in the table:

Sample Name	Reflectance (%)	
	Single Jersey	Double Jersey
Conventional Scoured-1	78	82
Conventional Scoured-2	80	79
Conventional Scoured-3	82	86
Conventional Scoured-4	84	85
Bioscoured-1	80	82
Bioscoured-2	80	83
Bioscoured-3	82	86
Bioscoured-4	84	84

Table: Reflectance of bleached fabric followed by conventional & bioscouring.

3.4 Color fastness of the dyed Fabrics

Color fastness can be defined as the resisteance of color of the dyed or printed fabrics to fade or bleed in case of various types of influences like as water, rubbing, washing, perspiration, acids, alkalis etc. In my research, I have determined fastness of the reactive dyestuff dyed fabrics to washing, rubbing,

perspiration, acid and alkali. Results are shown below:

Fastness	Dyeing followed conventional scouring & bleaching	Dyeing followed by bioscouring only
Washing	4	3-4
Rubbing	4-5	4
Acid	4	4
Alkali	5	4-5
Perspiration	4-5	5

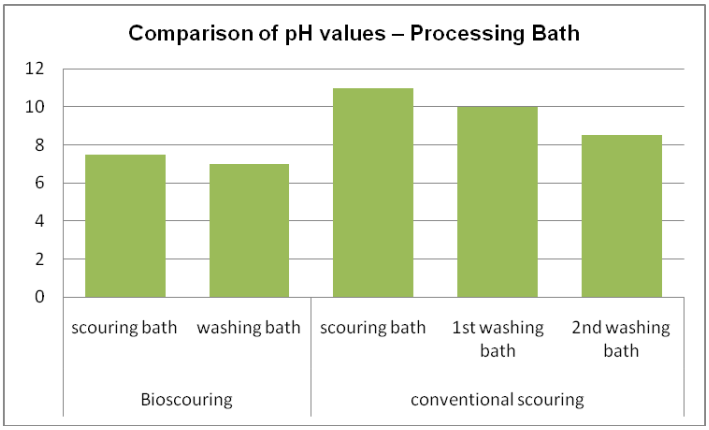
Table: Color fastness of Conventional and Bioscoured Fabrics after dyeing

4 EFFLUENT COMPARISONS

The comparison of effectiveness between conventional and bioscouring is done in different perspectives. These are discussed bellow:

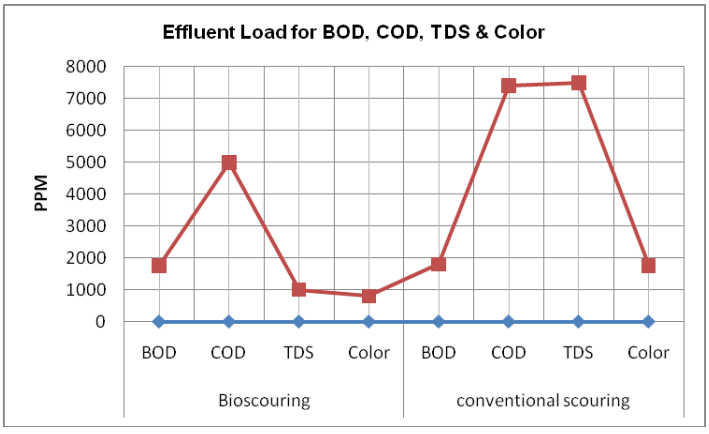
4.1 Effluent Treatment Plant load

4.1.1 P^H of processing bath:



Curve: Comparison of pH values – Processing Bath.

4.1.2 Effluent Load for BOD, COD, TDS & Color:



Curve: Comparison of pH BOD, COD, TDS and Color.

5 OVERALL COMPARISONS

Though comparison is the main topic of my research, my main target was to find out the useability and replaceability of bioscouring process over conventional scouring processes. Thus I have tried to distinguish the advantages and the positive sides of bioscouring. The prospect of bioscouring can be assumed from the discussion below:

- **Fabic strength:** Harsher chemicals used in conventionnal scouring cause in strength loss of the fibres or fabric. On the other hand, bioscouring causes signifycantly less strength loss. It is because of bioscouring agent attacks primary cell wall of the fibres which is required for dye absorption but conventional scouring agent attacks both primary and secondary cell wall and causes higher strength damage.
- **Whiteness:** Conventional scouring produces more whiter fabic than bioscouring produces. Thus conventional scouring is more effective in manufacturing white-colord shades fabric. But to produce dark-colored shades fabrics bioscouring gives same result. If bleaching is followed by bioscouring, then white fabric can be produced.
- **Weight loss:** Due to attacking also the secondary cell wall and high removal of pectin, though removal of pectin is not important for improving hydrophilicity or absorbency, fabrics weight loss (about 3-10%) is higher. For these losed fabrics, manufacturer has to pay extra cost.
- **Dye loss:** Higher revomal of pectin causes higher space in the fibres for dyestuff penetration, reaction and fixation. Thus conventional scoured fabrics dyeing needs higher amount of dyestuffs than dyeing of bioscoured fabrics need.
- **Energy and time required:** Bioscouring needs not as high temperature as conventioanal scouring needs. Bioscouring is done below 70^0C but conventional caustic scouring is done around 90^0C-105°C temperature and to provide this higher temperature, higher heat production is needed. Thus high heat energy production increases cost in scouring. Moreover, after conventional scouring, two step washing is required for neutralizing high alkalinity. Which also increases additional time and cost.
- **Effluent concern:** A lot of harsh chemicals are used in conventional scouring process which is very much responsible to increase the amount of BOD, COD, DO (Dissolved Oxygen) and TDS (Total Dissolved Solids) in the effluent water and increase the unwanted pressure on environment. Caustic scouring is responsible for the lion parts of the total effluent of a factory. 10-20% of the total pollution load generated during entire textile processing operation.
- **Color fastness:** Color fastness of the dyed fabrics after bioscouring and conventional has nearly same though it varies from types of dyestuff, dyeing process, depth of shade, finishing process and other factors.
- **Risk in handling:** The handling of harsh chemicals

increases the possibilities of accident. It may affect on workers health. Moreover, some health-hazard chemicals may stay in the fabrics even after finishing processes which can affect on human health.

6 Conclusions

Though the conventional scouring process is extremely using now-a-days, it has great bad effect on environment. Therefore, many of the developed countries are avoiding the conventional scouring process replacing enzymatic, ecofriendly, scouring processes. Since bioscouring is an eco-friendly scouring process it has great future. The new enzymatic procedure is corresponding with a significant role in minimising the demand of energy, water, chemicals, time and therefore costs. After bioscouring, fabric can be dyed directly without bleaching, which also reduces additional cost in this step. But in this process, light-colored shades can not be produced or very difficult match. Whereas, in conventional scouring and bleaching, it is easier to produce light-colored shades dyed fabrics. Though both processes have some merits and demerits, eco-friendly and cheaper bioscouring process, though it some complexities in operation, has a good prospect to be substituted of conventional scouring in next world textile wet processing.

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Biography

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