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Recycle and Reuse of Textile Waste Liquor from Scouring and Bleaching of Cotton

Zinia Yasmin, Md. Moynul Hassan Shibly, Md. Sazol Ahmmed & Sushama Saha Swati
Primeasia University

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Strictly as per the compliance and regulations of:

Recycle and Reuse of Textile Waste Liquor from Scouring and Bleaching of Cotton

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I. Introduction

Industrialization has brought ease, comfort, luxury, and prosperity to our modern life. Wet processing industry uses vast amounts of water, energy, and chemicals. At the same time, it has also created problems for us. Two issues of concern today are environmental pollution by the industrial waste generated during manufacturing activities, and the other is the endangerment of the health and safety of the user of the industrial products. There are two approaches, to combat the menace of environmental pollution by liquid waste from the dye house/print works. One is the operation of Effluent Treatment Plant to control the pollution and the other is to prevent the pollution. The U.S. Environmental Protection Agency defines pollution prevention (also referred to as source reduction) as the use of materials, processes, or practices that reduce or eliminates the generation of pollutants or wastes at the source. Pollution prevention minimizes water pollution, land, and air. It is a source reduction and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw material, energy, water or other natural sources or protecting resources through conservation. Reducing the volume of effluent released through the prevention of pollution can be accomplished by conservation and more efficient use of resources. Pollution prevention is accomplished through many ways such as:

- Good housekeeping and maintenance.
- Substitution of chemicals.
- Process modification and technology through the selection of clean/green technology.
- Recycle, Reuse and Recovery.
- Modification of machinery, equipment optimization of processes, dyes, chemicals, and water [8].

Moreover, Pollution prevention is more than just another way of reducing pollution. Pollution prevention is a philosophy. Such a philosophy does not accept "that is how we always did it" as a rationale for maintaining a policy or practice [3].

Pollution prevention may result in several benefits for the textile processor, these includes:

- Loss Reduction.
- Decreased Waste Collection.
- Decreased Handling and Disposal Cost.
- Reduction of Chemical, Water and Energy Consumption, thereby resulting in savings, sometimes even increased production.
- Improve Compliance with Regulations.
- Improve Employee morale and Participation.

Textile pre-treatment involves desizing, scouring and bleaching process. Desizing is a process of removal of starch from the woven fabric. Scouring removes the natural (oil, wax, gum, fat etc) impurities. Bleaching destructs the natural color from the textile material. Each process drains a plethora of chemicals along with water, in the effluent stream. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. It pollutes land and makes them useless and barren in the long run [2, 3]. Table 1.1 - Water usage and pollution loads in cotton pretreatment processes [7]

Pre-treatment Process	Water Usage (l/kg)	Water Usage (%)	Approx BOD (mg/l)	BOD (%)	Pollution Load (%)
Desizing	20	5	4500	22	>50
Scouring	4	1	11000	54	10-25
Bleaching	180	46	1000	5	3

The main work of this research is to recycle and reuse the water and chemicals of the textile pre-treatment process. Recycle means utilization of previously used process liquor one or more times/ purpose whereas reuse can be defined as the utilization of used process liquor for another purpose.

Author α σ ρ Ѡ: Department of Textile Engineering, Primeasia University, Bangladesh. e-mails: yasminzinia@gmail.com, shibly25@gmail.com, s.sahaswati@gmail.com, sojol.ipe11@gmail.com

II. Literature Review

a) Cotton

Cotton is nature's most abundant polymer. It is an organic cellulosic compound which is a kind of polysaccharide. Cotton is the backbone of the world's textile trade. In the world cotton fiber has many qualities and countless end uses. Cotton mill consumption estimated around 24.3 million tones which are 45% of total world fiber productionin 2015 [1]. It is a soft fiber of genus *Gossypium*. The cotton plant belongs to the natural order of the MALVACEAE. The cellulose polymers in cotton fiber have high degree of polymerization. The DP (Degree of polymerization) of cellulose molecule is high. It ranges as 10000 [1, 2].

b) Fibre Morphology

Cotton is the important fiber in today's textile industry. The major use of cottonis to make the garments for over 5000 years before, so knowledge of the structural features of these cellulose substrates is essential for analyzing the effects of physical and chemical properties. Cotton fibers have a fibrillar structure. Their morphology, illustrated schematically in below figure, exhibits four main features: cuticle, primary wall, secondary wall, and lumen.

Cotton consists of cellulosic and non-cellulosic material; the primary wall has a network of cellulose fibrils covered with the outer most layer cuticle, covered waxes, and proteins. It serves as a smooth, water-resistant coating, which protects the fiber. The outer cell wall is relatively hydrophobic.

The wax renders the fiber impermeable to water and aqueous solutions unless a wetting agent is present. Cuticle layer surrounded by a primary wall, built of cellulose, pectin, waxes and protein material. The inner part of the cotton fiber comprises of the secondary part, subdivided into several layers of parallel cellulose fibrils and the lumen. The secondary wall consists of several layers and the spiral angle of the fibrils varies from one layer to the next, from about 20° to 35°. The lumen, the cavity that may remain after the protoplasm in the cell interior has proteins, coloring matter and minerals deposited on its walls. The smallest unit of the fibrils consists of densely packed bundles of cellulose chains [6, 9].

The hydroxyl groups OH^-protruding from the sides of the molecule chain link neighboring chains together by the hydrogen bond and form ribbon-like micro-fibrils which arranges into larger building blocks of the fiber [2].

It is very laborious to give a precise value for the degree of polymerization (n) of cotton. The DP of cellulose varies with itsorigin and is expressed as an average value, since a distribution found in most samples. The degree of polymerization of cellulose molecule may be as high as 10000 [4].

III. Methodology

a) Process Flow Chart

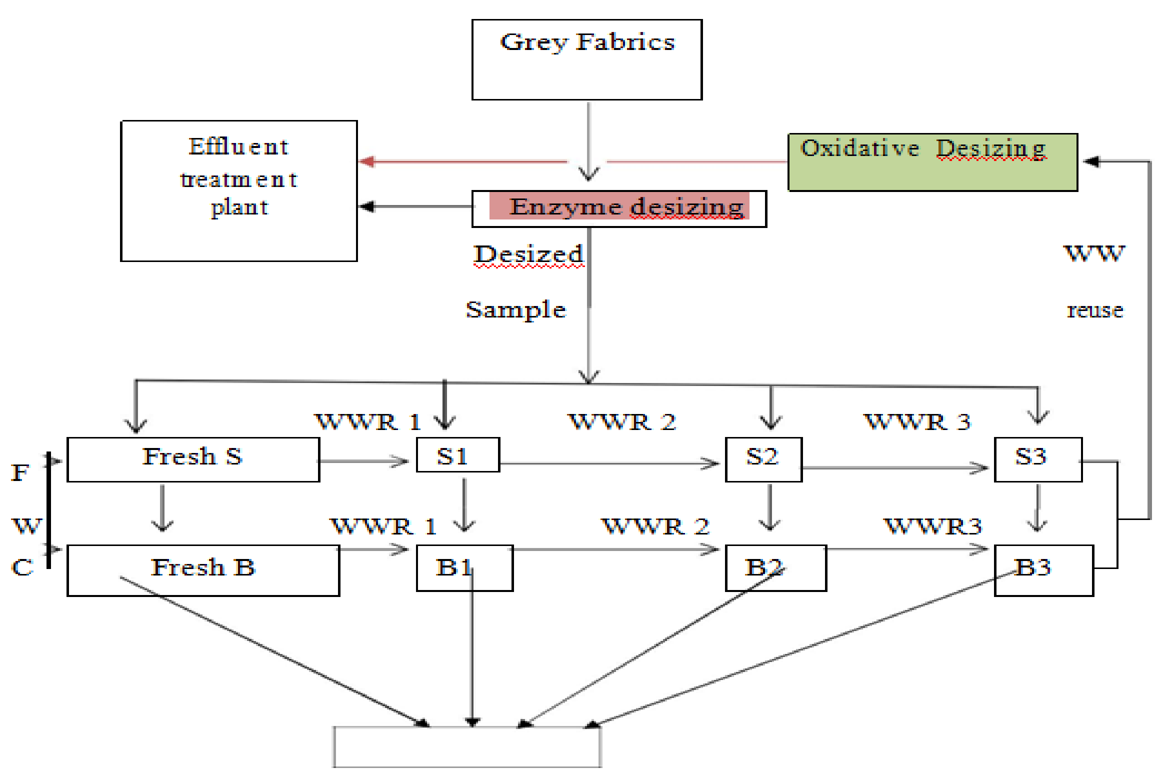

Fig. 3.1: Schematic Flow Diagram of the Recycle and Reuse Process

b) Process Curve for Desizing

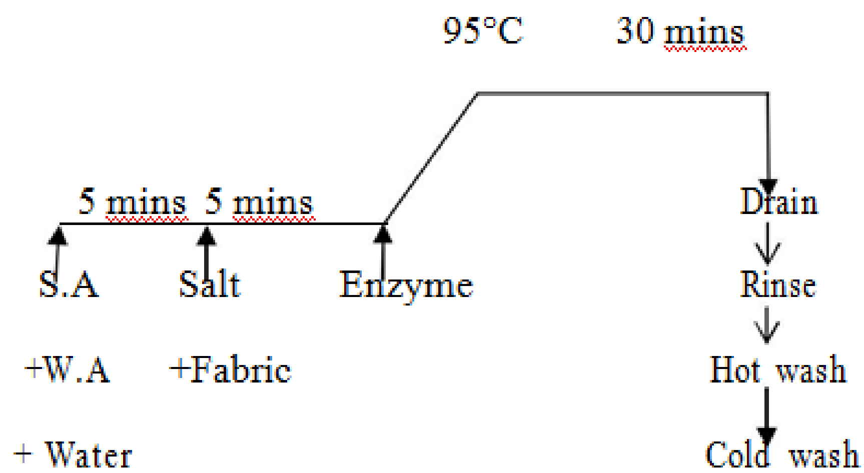

Fig. 3.2: Process for Curve Desizing

c) Process Curve for Scouring

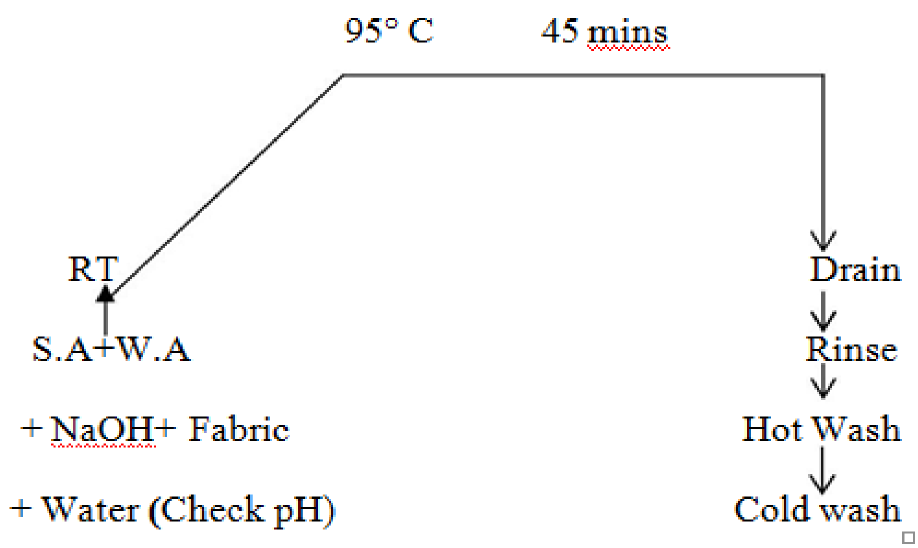

Fig. 3.3: Process Curve of Scouring

d) Process Curve for Bleaching

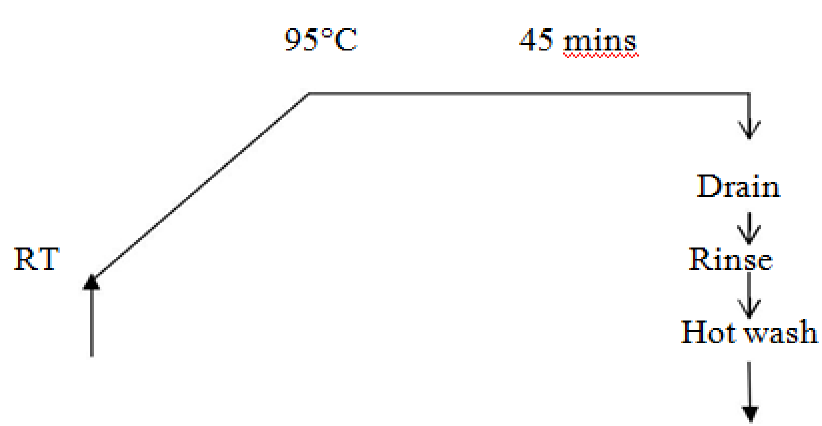

Fig. 3.4: Process Curve of Bleaching

IV. Testing & Analysis

a) Tegewa Test

Iodine drop test (Tegewa test) employed to check the desizing efficiency. The principle of this testis the violet coloration of starch with iodine. Hence, the presence of starch remaining on fabric deciphered. The desized fabric immersed in a beaker consists of a solution of potassium iodide and iodine for 1 min. After one minute the sample rinsed thoroughly under water, dabbed with filter paper and compared with the Tegewa scale or violet scale, having rating 1 to 9. The scale denotes 1 is no removal of size material and rating of 9 indicate complete removal of size material from the fabric. The acceptable rating is 6-7.

b) Drop Test

The absorbency test followed by using AATCC Test Method 79-2000, where a drop of water is acquiesced to fall from a settled height onto the firm surface of a sample specimen. The time required for the reflection of the water drop to disappear, measured and recorded as wetting time. It took five seconds or less to represent the adequate absorbency.

c) Column Height

For column height, 18X5 cm^2 sample was prepared. This sample hung from support by immersing the 1 cm portion of the fabric.

The sample was dried and observed the wicking height performance. The wicking length is 30-50 mm and the above range indicates excellent scouring. 30 mm denotes acceptable and 40-45 mm is good to very good scouring.

d) Presence of Alkali in the Scouring Bath

In this test, the accurately measured volume of the sample titrated against a standard sulphuric acid solution with a phenolphthalein indicator. The alkalinity measured is regarding of $CaCO_3$ (mg/l)

Where,

Alkalinity, mg $CaCO_3$/ l = (A)(N)(50,000)/ml sample:

A: Milliliter of the standard acid used,

N: Normality of the standard acid.

e) Presence of alkali in the bleach bath containing peroxide

This test carried as per AATCC Test Method 98-2007. A weighed specimen of the bleach bath is titrated with a standardized solution of sulphuric acid using Phenol Red indicator or to the pH range 6.8–8.4 on a pH meter. The total alkali expressed as % NaOH, is calculated based on the weight of the bath.

% Total alkali, as NaOH.

% = (ml)(N)(0.040)(100)/W Where,

ml: The number of milliliters of the sulphuric acid solution required,

N: The normality of the sulphuric acid solution,

0.040: The milliliters equivalent weight of sodium hydroxide,

W: Mass of the specimen.

V. Result

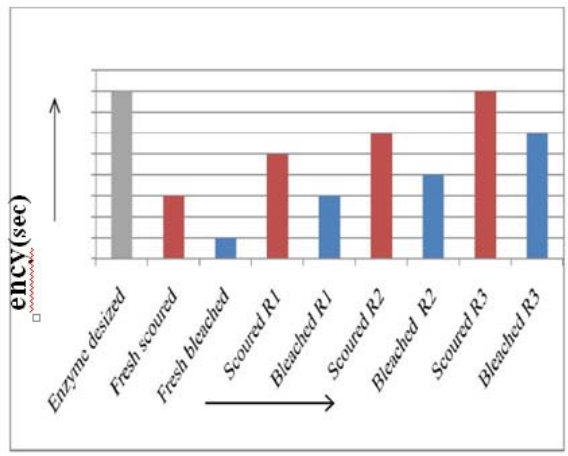

Fig. 5.1: Absorbency Test Result

From fig 5.2 it was seen that the 1st and 2nd recycle scoured sample gave better result compared to 3rd sample which was in acceptable range (above 30mm). Column height gradually falls due to decrease of alkali content in the recycled bath.

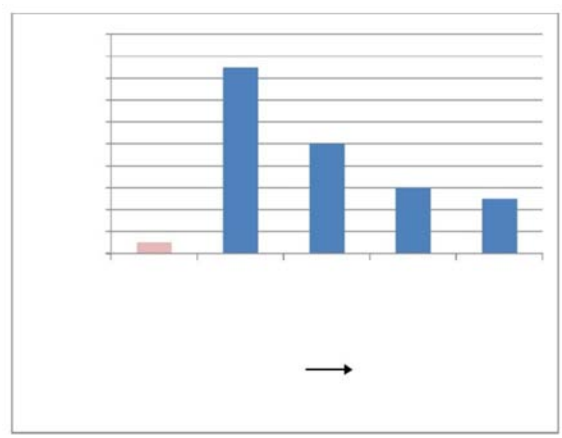

Fig. 5.2: Column Height of Different Scoured Samples

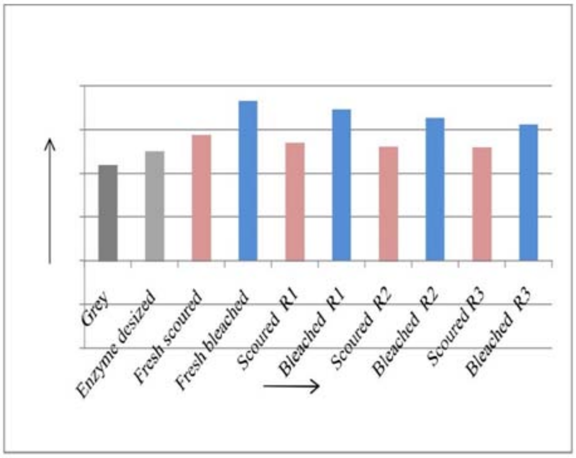

Fig. 5.3: Weight Loss Percentage of Different Processed Sample

From fig 5.3 it was found that weight loss% were lower in every step of scouring processing with recycled liquors. The reduction in weight loss indicates the reduction of alkali in recycling bath. As the more recycled, less scouring action occurs so the 3rd recycling bath shows minimum weight loss.

In case of bleaching also similar trend was observed in respect of weight loss. The loss in peroxide strength resulted in the decrease in weight loss.

VI. Conclusion

The proposed sustainable pre-treatment process was highly efficient in conserving water, energy and process chemicals. When the scouring and bleaching baths recycled, excess utilization of alkali and hydrogen peroxide in both process seen. The fabric properties after recycling was found good up to 2 times. Samples treated in the mixed bath, also showed good scouring and bleaching effect among them, the bath ratio was S:B 30:70 provided a better result. By understanding the potential of the waste stream, it can generate a new way to reduce discharged wastage water and chemicals. This work will reduce the effluent and minimize the load on the effluent treatment plant.

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