AN ECO FRIENDLY TEXTILE TECHNIQUE: POLLUTION REDUCTION AND WATER SAVING BY REUSING MERCERIZATION EFFLUENT

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Abstract: It is well known that a large quantity of water is required for wet processing Textiles, such as pretreatment, dyeing, washing, denim and garment industries. After appropriate treatment of effluent the reuse of treated effluent leads to zero-waste discharge in Textile industries. Reuse of mercerization effluent can be a good solution for implementation of zero-waste concept in Textiles. In this work the effluent obtained after mercerization collected from woven dyeing unit of Zaber & Zubair Fabrics Ltd., Tongi, Gazipur, Bangladesh. Excess NaOH was recovered by distillation process as well as the distilled water was collected in a receiver. After that, distilled water was reused for dyeing knit fabric with reactive dye. After dyeing, rubbing fastness of dyed fabric was checked at Quality Control Lab of National Institute of Textile Engineering & Research (NITER), Savar, Dhaka, Bangladesh. We obtained very close values of rubbing fastness under both the dry and wet conditions indicative of novel possibility of reuse of mercerized effluent after recovery of NaOH. There are double benefits in this process, one is recovery of NaOH and the other one is reuse of water.

Keywords: Reuse, Mercerization, Recovery, Dyeing , Zero waste.

1. Introduction

1.1 General Interpretation

Water is essential to sustain life on the biosphere. However; with the increasing population and industrial growth, its resources are becoming limited and/or contaminated [1]. Due to growing demand globally more than a billion people lack access to sufficient water of good quality. Studies reported that one third of the world's population will experience severe water scarcity within the next 20 years [1]. Water reuse continues to rise as demand for fresh water supplies increases worldwide. By recycling and reusing treated wastewater, communities and industries can save on the costs of clean water, ensure adequate supplies and help to preserve a diminishing natural resource.

A zero waste or discharge concept, in principle, should reduce the pollution completely. Textile effluents are being directly discharged into the surrounding channel in many cases, agricultural fields, irrigation channels, surface water and these finally enter into Burigonga, Turag, Shitalakkhya and Balu rivers surrounding Dhaka City.

1.2 Mercerization

Mercerization is a process in which fabric (typically cotton made) is treated with a caustic soda (NaOH) solution to improve properties such as fiber strength, shrinkage resistance, luster, and dye affinity. The caustic soda actually rearranges the cellulose molecules in the fiber to produce these changes.

Literature reports described reuse of dyeing effluents of various dyestuffs on different fabrics. For example, Vandevivere et al. [2] , Lamas et al. [3] and Erdumlu et al. [4] reported reuses of textile dyeing and finishing wastewaters. But reuse of mercerization effluent was not found as per our literature survey. This paper includes reuse of mercerization effluent in dyeing as well as recovery of excess sodium hydroxide from mercerization effluent.

In this work, the effluent obtained after mercerization collected from woven dyeing unit of Zaber & Zubair Fabrics Ltd., Tongi, Gazipur, Bangladesh and it was distilled to collect distilled effluent with recovery of caustic soda. After that distilled water was reused for dyeing knit fabric with reactive dye. Another piece of the same knit fabric was also dyed by same reactive dye using normal tap water following the same dyeing procedure to compare with dyed fabric where the distilled water was used. Finally quality was checked at the Quality Control Lab of National Institute of Textile Engineering & Research (NITER), Savar, Dhaka, Bangladesh.

2. Material and Methods

2.1. Mercerization Effluent and Equipment

The mercerization effluent used in this work was collected in fresh plastic bottle from a textile industry "Zaber & Zubair Fabrics Ltd." located at Pagar, Tongi, Gazipur, Bangladesh. The authority of Zaber & Zubair Fabrics Ltd. used aqueous NaOH solution (270-300 g/L) for mercerization at room temperature. The pH was measured by pocket sized pH meter.

Specifications of the pH meter: Pocket-Sized pH meter, Model: HI 96107, Manufacturing Company: Hanna Instruments, Country of Origin: Italy.

2.2 Distillation of Mercerization Effluent

The experimental set up included a condenser with two flasks, one flak was used for distillation and another one was used for receiving the distilled water came through the condenser. Both the flasks were clamped by stand and two rubber tubes were used for water in let and outlet. The condenser and flasks were connected by glass tubes with corks. The mercerization effluent was heated in a 250 mL flask by gas burner for distillation. The duration of distillation was 1-2 hour.

2.3 Dyeing Procedure

After getting distilled water from mercerized effluent it was used it in manual cotton knit fabric dyeing with reactive dye (Kiractive, Red ME3BL, Hot brand).

Dyeing Recipe:
Liquor ratio : 1:40, Dyes: 3%, Salt : 70 g/L, Soda: 20 g/L, Wetting Agent: 1 g/L, Sequestering Agent : 1 g/L, Leveling Agent : 1 g/L, Temperature: 80 °C and Time : 50 min.

Neutralization Recipe:
Acetic Acid: 1 g/L, Temperature: 60 °C and Time: 10 min.

Soaping Recipe:
Detergent: 1 g/L, Temperature: 90 °C and Time: 10 min.
After dyeing the dyed fabric was dried in a dryer (Digioven, MAG) in the dyeing lab.

2.4 Quality Test of Dyed Fabric

The dyed fabrics were tested at National Institute of Textile Engineering & Research (NITER), a public-private partnership education and training institute, located at Savar, Dhaka, Bangladesh. We measured the rubbing fastness under both the dry and wet conditions. We used an Auto Rubbing Tester or Crock Meter (James H. Heal, UK) to measure the rubbing fastness of dyed fabrics.
We used a grey scale to test the rubbing fastness of our dyed fabric. Grey scale is the tool by which the fastness of a dyed fabric can be evaluated in a numerical value. This Grey Scale is for assessing the degree of staining caused by a dyed fabric in color fastness tests. The scale consists of nine pairs of gray color chips each representing a visual difference and contrast. The fastness rating goes step-wise from: note 5 = no visual change (best rating) to note 1 = a large visual change (worst rating). The grey scale has the 9 possible values: 5, 4-5, 4, 3-4, 3, 2-3, 2, 1-2 and 1.

3. Results and Discussion

Efficiency of this work was checked by decreasing pH, recovery of NaOH and quality of dyed fabric.

3.1. Characteristics of Mercerized Water

The key characteristic of mercerized water is pH which was not highly variable and was comparable shown in Table 1.

TABLE 1: THE CHANGE OF THE pH VALUE BY THE DISTILLATION PROCESS OF MERCERIZATION EFFLUENT

Characteristics	Value		Percentage of change
	Before distillation	After distillation	
pH of industrial mercerized water	13.1	12.5	4.58% decreased
pH of lab made mercerized water	12.4	11.8	4.84% decreased

After distillation process it was shown that the key characteristic pH was decreased slightly which was useful to reuse the water in conventional dyeing process.

3.2 Recovery of Caustic soda

The recovery of NaOH is one of the major achievement of this work. In textile sector a huge amount of NaOH is used, in this sense it is necessary to know that how to minimize the use of NaOH or how to recover the used NaOH. In this work we recovered 78% caustic soda. Main environmental benefits are reduction of alkaline load of wastewater and minimization of acid requirement for wastewater neutralization. It also minimizes the process manufacturing cost by minimizing the usage of NaOH.

3.3 Quality of Dyed fabric

The quality of rubbing fastness, one of the most important quality parameter of a dyed fabric,depends on buyer requirements. The rubbing fastness result of dyed fabric with distilled mercerized water was not so differ from normal results.

TABLE 2: STANDARD RUBBING FASTNESS AT VARIOUS CONDITIONS.

Shades	Rating	
	At Dry	At Wet
Dark shade	3-4	2-2/3
Medium shade	4	3
Light shade	4-5	3/4 - 4

TABLE 3: OBTAINED RUBBING FASTNESS IN THIS WORK.

Shade	Rating	
	At Dry	At Wet
Red (dyeing with normal tap water in our lab)	4/5	3/4
Red (dyeing with distilled mercerized water)	3	2/3

It was shown that our experimental values of rubbing fastness (Table 4) were close to normal conditions (Table 3). More over our obtained rubbing fastness values were similar to requirement of a famous buyer of Textile Products, H & M [5]. On the other hand DIN EN ISO 105-X12 requirement was very similar to our obtained results [6].

Fig. 1. Dyed fabric with distilled mercerization effluent.

Fig. 2. Dyed fabric with normal tap

l. [7] reported very similar rubbing fastness values for cationized cotton fabrics printed by using C.I. Acid Blue 113 under exhaustion method. They reported several rubbing fastness values such as, 2-3, 3-4, 4 and 4-5 at both the dry and wet conditions. These values are similar to our values. We obtained 2/3, 3, 3/4 and 4/5 at dry and wet conditions. Molla et al. [7] also interpreted that, cotton is one of the most important fibers in the textile industry among other fibres and its coloration can be achieved, by dyeing, printing in aqueous solution, or with pigments using a printing paste. Printed cellulosic fabrics are considered for more than 70% of all printed substrates and pigment printing is a major method [8, 9]. They also concluded that anionic dyes other than reactive dyes (such as acid and direct dyes) for cotton printing are not generally used, because of the repulsion between the negative surface and charge of cellulosic part and the solubilising sulphonic groups in the dye stuff. The above problems can be overcome by modifying the surface of the cotton fiber to carry positive charge that lead to ionic bond formation with the anionic dyes used [10, 11].

Khalifa et al. [12] reported new azo heterocyclic disperse dyes with thiophene moiety for dyeing polyester fibers. They analyzed dyeing performance from aqueous dispersions by color fastness evaluation. They reported rubbing fastness, 2-3, 3-4, 4 and 5 in both the dry and wet conditions. These values are similar to our results in this work. Authors reported that the fastness to rubbing (dry and wet) may be attributed to inadequate diffusion of dye molecule into the fibers.

In another previous report, El-Halwagy et al. [13] concluded that pollution can be reduced in cotton printing with reactive dyeing. We also explained that pollution load can be reduced by recovery of sodium hydroxide as well as using the same wastewater in dying of knit cotton fabric by reactive dye.

4. Conclusion

Reclaimed water is a treated effluent that is considered to be of appropriate quality for an intended water reuse application. Water reclamation and reuse can enable communities to strategically link the distribution and use of locally available water resources with specific water quality and quantity goals, particularly in areas where there are concerns about water supply sustainability. This paper includes most effective methods to recover excess caustic soda and reuse of distilled mercerization effluent. We recovered caustic soda (78%) and reused distilled mercerization effluent to dye cotton knit fabric by reactive dye using conventional manual method. The quality of dyed fabric was checked by testing rubbing fastness in National Institute of Textile Engineering & Research (NITER), Bangladesh. Further studies should be carried out to find out suitable industrial process for recovery of sodium hydroxide and reuse of mercerization effluent in Textiles.

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