

# Investigating the Possibilities of Reusing Textile Wash Water Directly for Pretreatment (Scouring and Bleaching) of Knit Cotton Goods

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**Abstract:** *Textile dyeing and washing industries in Bangladesh are extracting ground water and releasing to the surface water after use, which creates depletion of water resources eventually threatens our existence. The dyeing industries do not need water as pure as for drinking purpose. The object of the project is to use textile wash water for the pretreatment process of textile goods, instead of using fresh water. The different sources of wash water from yarn dyeing factories are used. Absorbency was found satisfactory for almost all the wash water samples. But, Before Dyeing Rinse (BDR) is the most suitable and highly acceptable than all other selected wash water. It was found the best performing in respect of visual assessment, absorbency, weight loss, color difference, shade matching performance and all the fastness tests. Finally the BDR is selected as the best suited wash water for reusing. The scouring, bleaching and dyeing performances of samples scoured-bleached with BDR wash water is tested against Fresh water samples from the same factory. It is envisaged that, the BDR wash water can be directly used for the scouring bleaching purpose of cotton yarn fabric. For a dyeing mill of 25 ton capacity total saving of water would be 70,000 m<sup>3</sup> per year.*

**Keywords:** *waste water, reuse, scouring and bleaching, dyeing, water saving.*

## 1. Introduction

Foreign earning from textile sector rose up to more than 75% in 2005-06 and these industries are providing employment, increasing local incomes, and earning foreign exchange for the country. It is reported that there are around 1500-2000 textile dyeing and washing units at the industrial zone of Bangladesh and few hundreds are in the pipeline. Most of these industries are extracting ground water and releasing it to the surface water directly, mostly without treatment. They are releasing wastes directly into rivers, although the effluents contain pollutants of 10 to 100 times the allowable levels permissible for human health [1]. As a result, the surface water body is now vulnerable, aquatic life is endangered and users are facing serious health problems due to contamination by hazardous chemicals from those industries. Wet processing industry uses water in its various steps. Huge amount of water is consumed in dyeing, washing and printing industries from the very beginning of pretreatment stage to finishing. More than 110 liters of water is used to process 1 kg of cotton fabric with reactive dyes in batch process. The water consumption of an average sized textile mill having capacity only 8 tons/day is about 1.6

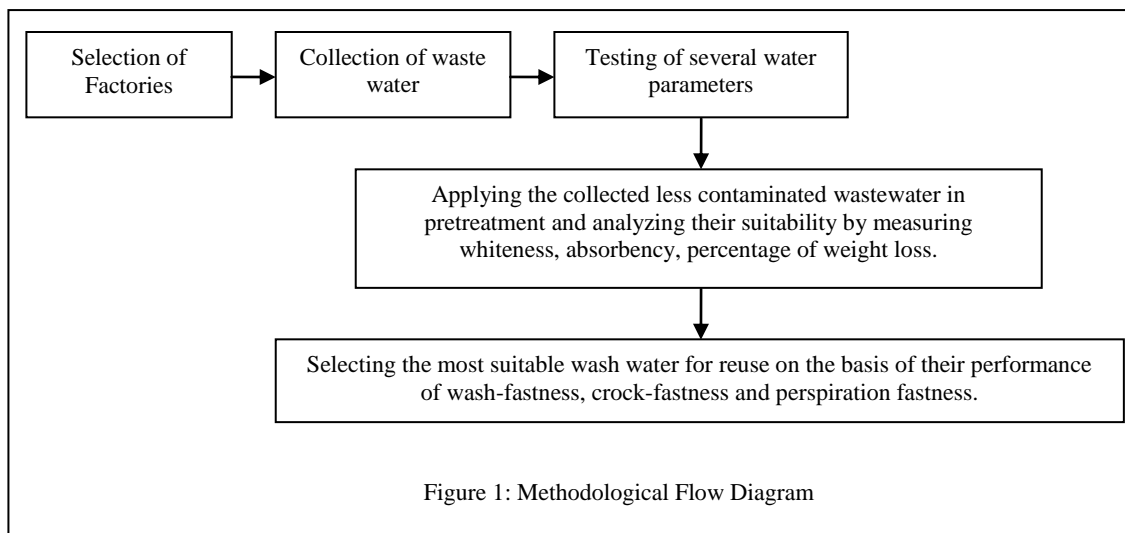
million liters per day [2]. The characteristics of the rinse water are variable in different steps in whole batch process. In some stages, it is nearly clear like fresh water and at the post dyeing stages it is colored.

The continuous withdrawal of ground water is responsible for the depletion of our underground water resource and this continuous lowering of the underground water level is threatening our existence. Nowadays, many experts are raising awareness among the government and the general people for the upcoming danger of underground water level lowering problem. But the solutions are not available for us to reduce the daily huge water consumption rate. As the industries do not need water as pure as for drinking purpose, they can reuse their waste water. At present there is little information available where they tried to reuse the textile wastewater for dyeing purpose and could not succeed. But no literature is found regarding reusing of wash water for pretreatment purpose. This research project has illustrated the possibilities of this type of reusing in textile sector as this sector is drawing the maximum amount of water per day. Being a poverty driven country, we should consider both the prosperity of the textile sector as well as the water source and water quality of the country. So an appropriate, cost effective water recycling method could be an option for reducing the pollution level and water withdrawal rate. The main source of water in Bangladesh is the underground water. The increasing demand of water for domestic and industrial purpose creates a large pressure on underground water. The object of the project is to use textile wash water for the pretreatment process of textile goods, instead of using fresh water for the same purpose and thus to reduce the daily fresh water consumption.

The outcome of the research work is directly applicable in the wet processing section (cotton yarn fabric) of the textile industries. The day is coming soon when the underground water sources will not be available for the industrial uses and the factory owners must search for the alternatives.

## 2. Methodology

The methodology followed in the study is according to the flow diagram shown in Fig.1. However, the raw materials used are grey knitted fabric (Single Jersey) and different chemicals as required in the textile wet processing industries. Major equipments used are Laboratory Dyeing Machine (Sandolab), Woven dryer, Color matching cabinet, Electronic Balance, Data Color and Crocking Meter.



Factories are selected from different areas of Gazipur districts of Bangladesh which are producing cotton goods by Knit Dyeing. Different water quality parameters like BOD5, COD, TSS, TDS, pH, color and hardness were measured of these collected wash water samples. The results are presented in Table-1.

### **Selection of Less contaminated wastewater in cotton dyeing cycle:**

Less contaminated wastewater means the bath drained with a very few amount of contaminants or almost no contaminants. The following steps of cotton dyeing cycle are considered as comparatively less contaminated wastewater producing steps:

1. Water wasted by *demineralization (Demi.)* process.
2. Water wasted by *rinse after peroxide killing (AKR)* process.
3. Water wasted by *neutralization (A.W)* process
4. Water wasted by *rinse before dyeing (BDR)* process.
5. Water wasted by *rinse before finishing (BFR)* process.

Other types of water used are: Mixture of various types of selected wastewater *mixed water (MW)* and Factory *fresh water (FW)*.

TABLE-I: Test results of collected water samples.

Water types	pH	Hardness (CaCO <sub>3</sub> ) (mg/l)	TSS (mg/l)	TDS (mg/l)	BOD <sub>5</sub> (mg/l)	COD (mg/l)	Color (Pt-Co)
Standard for Drinking Water (ECR '97)	6.5-8.5	200-500	10	1000	0.2	4	15
Standard for Textile dyeing	7 – 8						
Knit Fresh water	7.3	38	6	330	0	0	NT
DUET fresh water	7.1	140	0	180	0	0	NT
Knit BDR		100	14	663	264	538	150

NT - Not Traceable

### Comparison between FW Samples with Different Wastewater Samples:

The suitability of different wastewater have determined on the basis of performance testing. The following quality measures are considered:

#### Measurement of weight loss [3]:

The weight loss is measured to determine the scouring-bleaching effect. It is measured in percentage by the following formula-

$$\text{Weight loss} = \frac{\text{Grey weight} - \text{Bleached weight}}{\text{Grey weight}} \times 100$$

If the weight loss is above 8% it means excess loss of weight or fiber damaged and if it is below 4% it means not scoured properly.

#### The absorbency test (Spot/drop test) [3]:

##### Drop test and spot test:

Drop of 1% Direct Red dyes solution is placed on the fabric surface from a height of 2.5cm with the help of pipette. A stop watch is started as soon as the drop falls on the fabric and stopped no sooner the image of the reflected light disappears at the edge of the drop i.e. the water drop is completely absorbed by the fabric. This is termed as 'drop absorbency time'. A drop absorbency of about 5 sec is generally considered satisfactory for well-prepared cellulosic materials. From the drop test effect it is easy to understand about the absorbency achieved by the fabric, which is usually the first object of scouring and bleaching. Again, by observing the shape of fallen drop the amount and evenness of scouring can be evaluated which is termed as spot test.

#### Reflectance value of Whiteness [2, 3]:

The whiteness of FW sample and the different selected wastewater samples are measured on the basis of reflectance values in percentage. The standard value of the reflectance is 75% to 85% for bleached good [2]. The values are compared in a chart with the reflectance of FW sample to find out whether the residual chemicals present in different less contaminated wastewater can largely hamper the whiteness or its effect is within acceptable limit.

#### CMC ΔE values of different less contaminated wastewater's Scoured & Bleached sample with Fresh Water Samples.

The color difference CMC ΔE (Color matching committee ΔE) is the difference between the Standard and the sample in the space. CMC ΔE<sup>[9]</sup> is calculated by the following formula-

$$\Delta E_{CMC} = \sqrt{\left(\frac{\Delta L^*}{l \times S_l}\right)^2 + \left(\frac{\Delta C_{ab^*}}{c \times S_c}\right)^2 + \left(\frac{\Delta H_{ab^*}}{S_H}\right)^2}$$

Where,  $l$  &  $c$  is the weighting factor and  $S_l$ ,  $S_c$ ,  $S_H$  are the coordinates factor.

[N.B.: CMC P/F means, if CMC  $\Delta E > 1$  is known as fail or higher difference and if CMC  $\Delta E < 1$  it will indicate very minor difference or pass.]

Here,  $L^*$  = The lightness coordinate, same as  $L^*a^*b^*$

$c^*$  = The chroma coordinates, the perpendicular distance from the lightness axis (more distance being more chroma)

$H^*$  = The hue angle, expressed in degrees, with  $0^\circ$  being a location on the  $+a^*$  axis, then continuing to  $90^\circ$  for the  $b^*$  axis,  $180^\circ$  for  $-a^*$ ,  $270^\circ$  for  $-b^*$  and back to  $360^\circ = 0^\circ$ .

In the present study CMC  $\Delta E$  for whiteness is measured by taking FW as standard and other wash water samples as batch. Dyeing performance for shade matching is also determined by applying the above mentioned procedure.

#### **Measuring of Wash Fastness [4]:**

Wash fastness tested in three laboratories namely NITTRAD, Apex Spinning and Knitting Mills Ltd. and Textile Laboratory, DUET by following ISO 105 C06 testing method. The contrast is compared between the treated and untreated sample with the Changing Grey Scale and staining of color in the adjacent multifibre fabric with the Staining Grey Scale. This assessment is done in a color matching cabinet under standard lighting of D65.

#### **Measuring of Colorfastness to Rubbing [3]:**

Rubbing fastness is measured at Textile Lab of DUET through ISO 105 X12, 1993; BS EN ISO 105 X12, 1995 testing method. The contrast between the untreated and treated white rubbing cloth with the Staining Grey Scale measured and rated 1 to 5. This assessment is done in a color matching cabinet under standard lighting of D65.

#### **Color fastness to Perspiration, [3]:**

Perspiration fastness is tested in two laboratories namely NITTRAD and Apex Spinning and Knitting Mills Ltd. by applying ISO 105 E04, 1994; BS EN ISO 105 E04, 1996 testing method. The color change and staining of each test specimen is rated under standard lighting D65 using Grey Scale for Color Change and Color Staining.

### **3. Results and Discussion**

The present study was undertaken to explore the possibility of reusing textile wash water in the same process for the same purpose without or with minor treatment. For this, different types of wash water samples were collected regularly from the selected factories and analysed. Five tests per sample per collection were performed and average values were recorded. Absorbency was found satisfactory for almost all the wash water samples. One example is presented in this section. Other test results are presented through charts and table.

#### **Shade card for absorbency, whiteness and dyeing performance**

The shade card is a proof that sample processed with the wash water representing proper absorbency, proper whiteness and proper dyeing. A typical scanned copy of spot/drop test, whiteness and white color difference test and color difference test shade card is observed. In respect to spot test performance, it can be said that the selected wash waters are showing quite satisfactory absorbency.

#### **Graphical presentations of Scouring-bleaching and Dyeing performance**

The performances for Weight loss (%), Whiteness (Reflectance %), and Color difference ( $\Delta E$ ) are presented through figure 1 to figure 7 and discussion is made with the help of appropriate charts and data tables.

#### **Discussion of results and selection of the best reusable wash water**

Based on the results presented in the earlier section, following discussions could be derived:

- i) Demi. (Demineralization Water): Demineralization produces bad odor after a few days of storing due to fermentation of the cellulose and other particles. Also the reflectance (68%) showed least value in comparison with the other wash water treated sample, so rejected.
- ii) ASR (After Scoured-bleached Rinse): ASR is the rinse water collected from Knit Dyeing cycle. High weight loss is found. Whiteness and shade matching performance is found very good. It can be reused in pretreatment bath of cellulosic fabric with the same chemical recipe as performed. The pH value is slightly higher and the water is not visually very clear like the BDR.
- iii) AW (Acid Water, neutralization bath water): The fabric sample treated with AW found quite satisfactory for reusing. It is same like BDR and the shade matching performances are also very good. This water can be the perfect alternative for BDR where the knit dyeing factories use dye bath enzyme in the absence of BDR. But, if BDR is available, it is surely preferable than AW.

**Graphs on Weight Loss:**

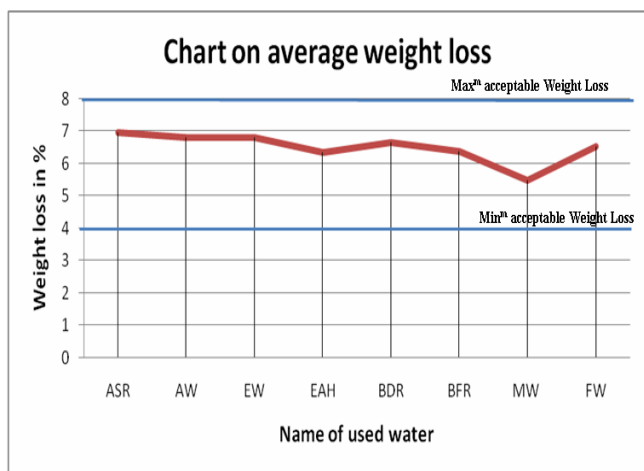


Fig. 1: Comparison of average weight loss of sample pretreated in wash water against FW collected from Knit Dyeing industry.

**Graphs on Reflectance:**

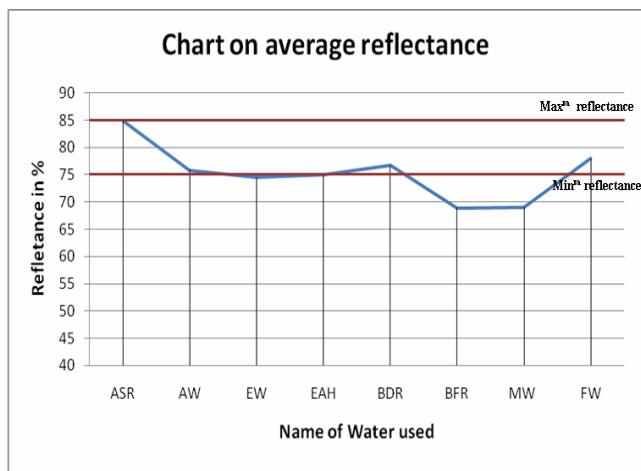


Fig. 2: Comparison of average reflectance of whiteness of sample pretreated in wash water against FW collected from Knit Dyeing industry.

**Graphs on CMC ΔE of Whiteness Difference-**

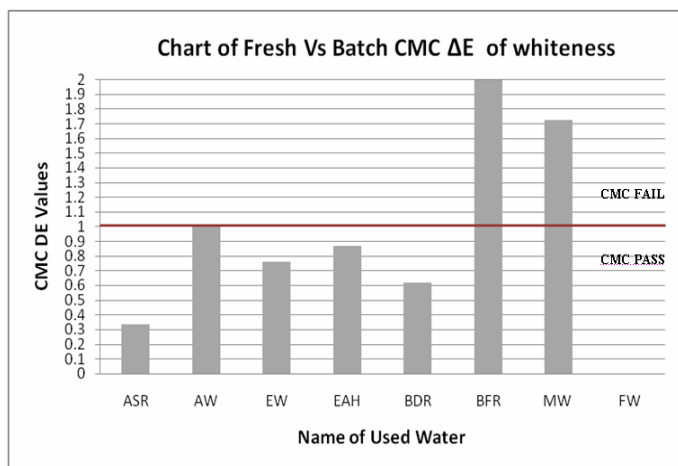


Fig. 3: Comparison of average CMC ΔE of whiteness of sample pre-treated in wash water against FW collected from Knit Dyeing industry

**Graphs on CMC ΔE of Color Difference-**

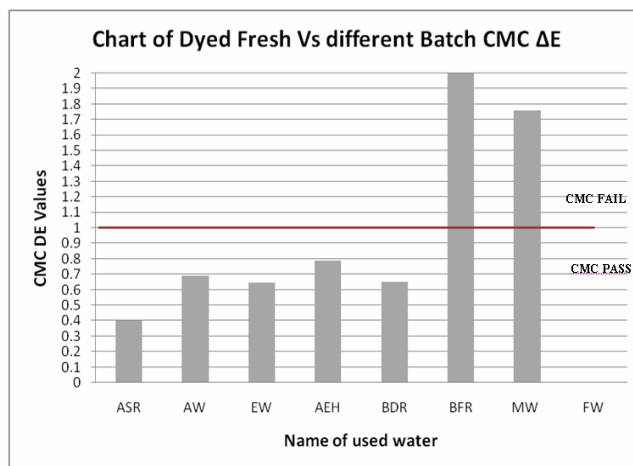


Fig. 4: Comparison of average CMC ΔE of color difference of sample pre-treated in wash water against FW collected from Knit Dyeing industry.

- iv) BDR (Before Dyeing Rinse): BDR is the most suitable and highly acceptable than the all other selected wash water, due to the presence of least amount of contamination. It has been found the best performing in respect of visual assessment, water quality analysis, absorbency, weight loss, color difference, shade matching performance and all the fastness tests.
- v) BFR (Before Finish Rinse): BFR is also the less contaminated as BDR, but it contains faint color after dark shade dyeing (Black, Navy etc). The presence of color has a great shading effect on the pretreated fabric. It has been found that required reflectance is not achieved and CMC  $\Delta E$  values in comparison with for both in whiteness difference and color difference become failed. In the assessment it did not give any good result for all parameters tested. Thus BFR has been rejected considering the above cases.
- vi) MW (Mixed water): MW is the even mixture of all less contaminated wash water. MW will provide better result if BFR and Demi water is absent in the mixture. But surely it is not as clear as BDR and also not capable to show the best whiteness and shade.

**On the basis of above charts and discussions, finally the BDR is selected as the best suited wash water for reusing.**

**The performance of BDR:**

The scouring, bleaching and dyeing performances of samples scoured-bleached with BDR wash water is tested against Fresh water samples from the same factory. The performances are shown through charts and tables below. Here the wash water samples are collected from different factories at different dates. “Collections” in the charts means the different collection dates. Data given are the average values of five tests for each individual type of wash water samples for each factory at each date.

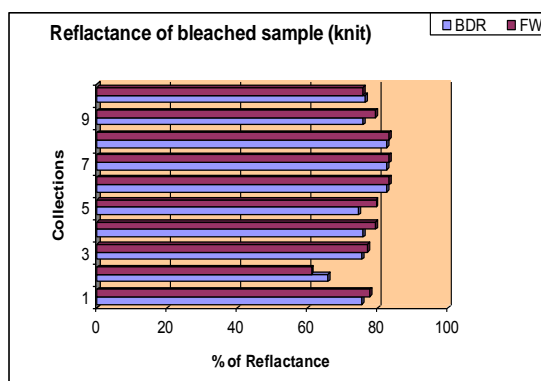
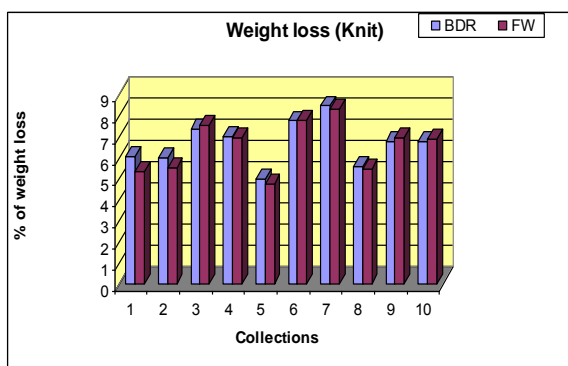


Fig. 5: Weight loss performance of BDR and FW sample (Knit).

Fig. 6: Reflectance value of BDR and FW for bleached sample (Knit)

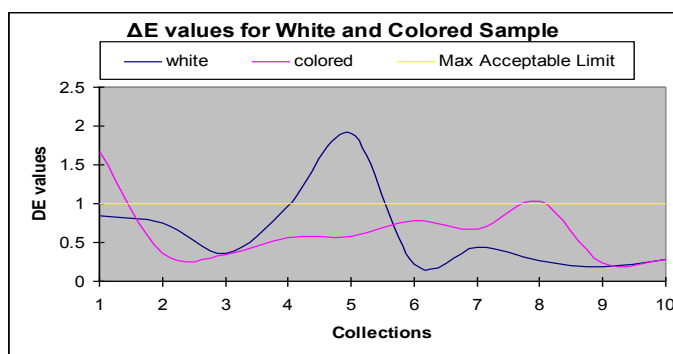


Fig. 7:  $\Delta E$  values for white and colored sample (Knit)

The Figure 5 shown that the weight loss of the Scoured-bleached samples with Before Dyeing Rinse (BDR) wash water is similar to the Factory-Fresh Water (FW) samples for knit dyeing. The reflectance values are not as

good as the fresh water samples but it is quite acceptable. Again the  $\Delta E$  values for the white samples and dyed samples are very good. Almost all the  $\Delta E$  values lie below maximum acceptable limit i.e., 1.

#### **Water Saving:**

The other objective of the present work was to reduce the load on underground water and also to reduce the load on Effluent Treatment Plant (ETP) eventually saving environment. A quantitative explanation of the above possibility is given below for a dyeing factory of 25 tons/day capacity at M:L = 1:8.:

A dyeing machine (capacity 500 kgs.) will use  $500 \times 8 = 4000$  liters of water for each bath. Thus BDR will also need 4000 liter of water, which can be saved for 500 kgs fabric (0.5 ton). That is, 8000 liters of water can be saved for dyeing 1 ton fabric. Thus, total saving of water per day =  $(25 \times 8000)$  200000 liters and per year amounting 70 million liters or  $70,000 \text{ m}^3$  for one dyeing factory.

#### **4. Conclusions**

In batch wise dyeing of cotton knit fabric with reactive dyes, the most clear, less contaminated used water, from the pretreatment processes before taking the dye bath water, is reusable for the scouring and hydrogen peroxide bleaching bath/bathes of next batch/batches with satisfactory results in respect of absorbency, weight loss and whiteness. However, the shade matching performance is very good for deep shade, good for medium shades and good to satisfactory for the light shades. The rubbing, wash, and perspiration fastness is very good.

So, it can easily be said that the Before Dyeing Rinse (BDR) wash water can directly be used for the scouring bleaching purpose of cotton knit fabric. Also water saving of 8000 liters per day could be achieved for dyeing 1 ton fabric. In the present work, only one step is selected for reusing purpose. But there were several other steps from which one can reuse water without any hesitation, specially for deep shades.

#### **5. Acknowledgements:**

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