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An innovative concept in the effective utilization of sea water for dyeing of textile materials

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Abstract
Water is the ultimate and mostly used media during textile materials processing, especially in colouration. This study investigated the possibilities of using seawater for cotton and polyester fabrics dyeing. Single jersey fabrics made of 100 percent cotton and polyester were dyed using a standard recipe and two separate water source as dyeing mediums. It has been focused on the assessment of colour fastness to wash, perspiration, saliva, rubbing, water, light and colour difference value due to compare the efficiency of dyeing media. The results revealed that the cotton fabric dyed with seawater showed lighter shade than that of ground water sample. But for polyester fabric darker shade was obtained compared to ground water. The cotton sample dyed with sea water carried about 15% higher colour strength than ground water dyed sample but for polyester it was very negligible, only 3%. Moreover, the results of colour fastness to wash, perspiration, saliva, rubbing, water and light for seawater dyed samples of cotton and polyester were shown satisfactory outcomes having the grading of 4–5 in most of the cases. This exploration established that commercial dyeing processes were robust and can be practically transferable into the seawater medium for cotton and polyester fabrics.
Keywords: *Colour fastness, Ground water, Seawater, Water consumption, Colour difference.*

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I. Introduction

About 71% of earth's surface is ornamented with water where only1% of this water is fresh and suitable for humans for drinking [1].Actually, seas and oceans consume about 96.5% of water on Earth whereground water consumes 1.7% and 1.7% of the water is in the ice caps. So,about 2.5% of this water is fresh, where 98.8% of that water is in ice capsor in ground layer [2, 3]. From this scenery, it is clearly visible that thereis a huge scarcity of fresh water all over the world.About all of the textile industries in Bangladesh using the undergroundwater for textile wet processing due to its ready availability andcost-effectiveness. Obviously, it consumes a large quantity of water forthis purpose because there is a series of operation involved with textilewet processing e.g., scouring, bleaching, dyeing and finishing. So, day byday the ground water level is decreasing rapidly. These types of activitiesmay cause serious threat for our next generation [4, 5]. Nearly, 70–150 Lof fresh water is required to dye 1 kg of cotton fabric [6, 7].Consequently, the water consumption of a dyeing industry having capacity8 tons/day is about 880000 L per day. So, it is a high time to lookforward in order to use surface water for industrial purposes.The surface water may come from rivers, canals and seas. Due to theready availability and cheapness, water has been used almost in textileprocessing as medium. Seawater would serve as an alternative source ofwater in order to minimize the load of using ground water. But salinity isthe main reason to use seawater for industrial purposes. Seawater has asalinity of 3.5% as well as denser than ground water due to presence ofdissolved salts [8]. So, it would be supportive for the salt involvementcost during the dyeing process because huge amounts of salt are required

for dyeing treatment. Seawater may be one of the great opportunities andalternative resources for the dyeing sector as a dyeing medium. The advantagesof seawater over the normal ground water are- it's low cost,easily available near the coastal area. For this reason, as a dyeing medium,seawater would capture an important position beside the groundwater. For dyeing of cotton goods reactive dyes are so much suitable andextensively used and whereas dyeing of polyester goods disperse dyes areused in the textile dyeing industries due to have good colour fastnessproperties and a wide range of shade can be achieved by these dyes [9,10, 11]. Because, the fastness properties of cotton knitted fabric areaffected by its shade percentages [12].Studies found that while introducing of seawater as a reactive dyeingmedia, the dyed fabrics give comparatively lighter shade along with nosignificant difference for various colour fastness parameter compared toground water dyed sample. As the parameters of sea water dyed samplesremain unchanged, so it may encourage the use of sea water as reactivedyeing media on a larger scale [12, 13, 14].

A few researchers have worked on seawater for cotton colouration [8,14, 15, 16]. Unfortunately, all of them have been analyzed only for cottonfabric. No work has been identified for polyester fabric colouration withseawater including comparison of cotton colouration. In this work, theaim was to utilize the seawater in dyeing of cotton and polyester fabric aswell as compare the performances of dyed fabric using ground water.Colour fastness to wash, perspiration, saliva, rubbing, water and light ofdyed samples were reported to evaluate the performance. The colourstrength and colour coordinates were also investigated.

II. Colour fastness to wash

Colour fastness to wash was introduced to evaluate the colourchange of produced sample as well as the colour staining. The outcomes of colour fastness to wash for dyed samples have been determined. Theoverall results of colour fastness to wash of samples were very good toexcellent.CGW, CSW, PGW and PSW were shown to change in colour due towash and results indicate the good to excellent grade.But considerably staining has ascended on nylon for PGW. Simultaneously,slightly staining was observed on all multi-fibre except polyesterfor PGW and PSW. However, cotton samples dyed with sea and groundwater exhibited better wash fastness grade in staining compared topolyester samples dyed with sea and ground water but the same scenariowas noticed for all specimens in colour change. Theseawater dyed sample gives a distinctly higher rating because the fixationof dye molecules is better in this medium. For cotton fabric, the reasonmight lie in ionic phenomenon between dye and fibre. Basically nucleophilic CGW, CSW, PGW and PSW were shown to change in colour due towash and results indicate the good to excellent grade.

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Colour fastness to perspiration (acid/alkali)

The evaluation of fastness to perspiration has been determined.The overall results of colour fastness to perspiration of samples in bothalkaline and acidic medium were very good to excellent.It is necessary to evaluate the rating of perspiration fastness asperspiration is an agency that can destroy the colour from the fabricsurface. All the samples were shown in the same rating (good toexcellent) in case of change in colour as well as staining excluding PGWdue to alkaline perspiration. Slightly colour change occurred only forPGW. On the other hand, for acidic perspiration nosamples were shown different grades and indicated well to excellentgrade (4–5). The reason forhigher perspiration rating for all dyed material is that the dyes haveexcellent withstands capacity against the activity of acid and alkaliperspiration.

Colour fastness to saliva

The colour fastness to saliva has been determined. The overall results ofcolour fastness to saliva of samples were very good to excellent.No changes appeared for CSW and PSW due to the introduction ofseawater instead of ground water. The all dyed specimens i.e. CGW, CSW,PGW, and PSW were shown good to excellent grades in colour changeand staining against saliva. The reactivity level of dyemolecules with fabrics is higher than that of saliva that's why all dyedsamples showed higher saliva rating.

Colour fastness to rubbing and light

The grade of colour fastness to rubbing and light of the samples have been determined. The overall results of colour fastness to rubbing ofsamples are very good to excellent. Wetrubbing properties are shownlower than dry rubbing.CGW and CSW showed excellent dry rubbing and good wet rubbingproperties whereas PGW and PSW were same in dry and wet rubbing.However, both cotton and polyester samples dyed with seawater wereindifferent in grading compared to the samples dyed with ground water. It has been inferred that the rub fastness ratings are equalfor seawater dyed material compared to ground water dyed fabrics.

Thismight be happened due the higher dye fixation into the fibre through adye-fibre strong bond formation. In water, reactive dyes and cellulosefibers both are electronegative. So, there is an electrostatic repulsionbetween them. To minimize this repulsion, a dyeing promoter must beused. During cotton dyeing with reactive dyes, different salt serves as adyeing promoter. The positive charge of salt shows electrostatic attractionto cellulose fibers and adsorbed by cellulose fibers. Thus, the presenceof salt increases the exhaustion of dyes to the cellulosic fibre andfollowed by enhance the fixation rate of dyes into the fibre [29]. It hasbeen found that sea water contains sodium, magnesium, calcium andTable 10. Recipe and testing condition for saliva test. potassium ions [18, 19]. So, these ions are also act as the positive site aslike as the positive site of salt. Therefore, using seawater along withGlubers salt facilitates the exhaustion rate of dyes into the cellulosic fibreand gives better rubbing fastness.

In presence of light, textile colourants absorb a certain wavelengthand then prone to some fading. So, the rating of colour fastness to light isalso a major concern. Regarding light fastness, the sample orders werefound as CGW < CSW < PGW/PSW. So, this order proclaimed that theseawater dyed cotton fabric displayed higher light fastness values thanthat of ground water dyed sample. Significant fading occurred for CGWduring light exposure. But the value was unchanged for polyester dyedsamples in both sea and ground water medium (see in Table 16). Thereason for the improvement of light fastness in case of seawater dyedcotton fabric is that seawater contains comparatively more metal componentswhich may present on the surface of the dyed sample andinterfere with the fading during exposure to light [21].

3.5. Colour fastness to water

Table 17 illustrates the grading of colour fastness to water. Theoverall results of all samples were shown very good to excellent.In case of colour fastness to water, no samples were in different gradesfor colour change and staining. Good to excellent grade was obtained byapplying both seawater and ground water as dyeing medium simultaneously(see in Table 17).

3.6. Measurement of colour co-ordinates

The colour coordinates of the dyed samples were evaluated by aspectrophotometer using D65, TL83 illuminant and 10_ observer settingsconsidering the seawater dyed samples as standard and others as samplebatches. The colour co-ordinate values of tested samples are given inTable 18.

Table 18 depicted that the total colour difference value is out of rangei.e. more than 1 for cotton dyed fabrics. Hence the result of colourmatching is rejected. On the other hand, the total colour difference valueis in the range of 1 i.e. the result is accepted for colour matching forpolyester dyed fabrics with seawater medium. It has been also observedthat for the same recipe in cotton fabrics dyeing, dyes absorption is lessfor seawater dyed samples than ground water dyed samples whereaspolyester fabrics absorb more dyes in seawater medium and shade differencewith ground water treated fabric is in the acceptable range. Thephysical appearance of CGW, CSW, PGW and PSW are illustrated inFigure 4.

The dyeing behavior of cotton fabric completely depends on theinteraction between fibre and dye molecules. So, the medium of dyeingplays a vital role during cotton dyeing as a medium influences themovement of reactive dyes. It is well known that seawater containscomparatively more metal and the hardness of seawater is also very highdue to the presence of these metals. The hardness of seawater is the majorfactor that influences the dyeing characteristics of cotton fabric, and maylead to poor shade and poor quality of dyed samples.

On the other hand, there is no chemical interaction between dye andfibre for polyester fabric dyeing like cotton. Disperse dyes are physicallybound into polyester fibre which is facilitated by free volume of polymermolecules by means of high temperature. So, the dyeing medium has alittle influence on the characteristics of dyeing.

3.7. Colour strength (K/S)

Colour strength of all dyed samples was measured by reflectancespectrophotometer using Kubelka-Munk theory of reflectance. Figure 5illustrates the colour strength of dyed samples.

The order of colour strength values for cotton samples were found asCGW < CSW and for polyester PGW < PSW. The K/S value of CGW, CSW,PGW, and PSW were 7.9, 9.1, 18.1 and 18.7 respectively. Colour strengthwas increased for both cotton and polyester dyed specimens whileseawater was used as medium. The maximum colour strength has beennoticed at 560 nm for cotton fabrics and at 520 nm for polyester fabrics.The colour strength was increased 15.19% for cotton while dyed fabricsas seawater medium compared with dyed samples as ground water. Onthe other hand, the colour strength was increased 3.31% for polyesterwhile dyed fabrics as seawater medium compared with dyed samples asground water. So, colour yield significantly increased for seawater dyedmaterials for cotton fabric rather than polyester (see in Figure 5). Seawater contains sodium, magnesium, calcium and potassium ions [18,19]. These ions minimize the electrostatic charge between dyes and fibre.

Thus, they serve as a dyeing promoter. So, the presence of ions increasesthe exhaustion of dyes onto the cellulosic fibre and followed by enhancethe fixation rate of dyes into the fibre [29,30]. Finally, gives the shade withhigher colour strength.

III. Conclusions

Cotton and polyester are the most common and popular fabric. So, thedyeing of cotton and polyester consume huge amount of ground waterand thereby the searching of an alternative water source is the demand oftime. This project describes the influence of seawater on cotton andpolyester fabric dyeing with reactive dyes and disperses dyes respectively.The result shows that seawater dyed cotton fabric with 2% owf ofreactive dyes are lighter than ground water dyed samples whereasseawater dyed polyester fabric with 1% owf disperse dyes are darker thanground water dyed samples with an acceptable range. It is visualized thatwash, perspiration, saliva, rubbing, water, light fastness is very good forboth fabric samples. This exploration established that commercial dyeingprocesses were robust and can be practically transferable into theseawater medium.

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