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Sea water for reactive dyeing of cotton fabrics

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In this research work, trials have been taken up with sea water, as an alternative, for dyeing of cotton with different shades of reactive dye and different salt level contents. Dyeing has been carried out with hot brand reactive dye Red H8B using normal water, RO water and sea water (with and without salt). It is inferred that the exhaustion and fixation of the dye are better in case of sea water dyeing. The wash, rub and perspiration fastness are good for sea water dyeing and in some cases the ratings are comparable and in most case the ratings are similar to that of the ground water and RO water dyeing.

Keywords: Cotton, Dyeing, Electrolyte load, Fastness rating, Red H8B, RO water, Sea water

Seawater has a salinity of ~35,000 ppm, equivalent to 35 gram of salt per liter (or kilogram) of water. There are two ways for origin of seawater, one is from rain water which is staged for many years and the other is from oceans and rivers. On average, seawater in the oceans has a salinity of about ~3.5% (35 g/L) This means that every kilogram (roughly one liter by volume) of seawater has approximately 35g of dissolved salts [predominantly sodium ($Na+$) and chloride ($Cl-$) ions]. Average density at the surface is 1.025 kg/L. Seawater is denser than both ground water and pure water [density 1.0 kg/L at 4 °C (39 °F)] because the dissolved salts increase the mass by a larger proportion than the volume. The freezing point of seawater decreases as salt concentration increases and at a typical salinity, it freezes at about −2 °C (28 °F).

Sea water would serve as an alternate source of water in order to save a large quantity of normal water. It would be of great concern where normal water rich in salt content could be avoided, thereby reducing the cost of salt involved[1]. Hence, this indicates the possibility of establishing new processing mills, especially dyeing mills in the sea shores, which will further claim the advantage of less severe effluent water treatment[2]. When the mills are in the sea shore, the tertiary treatment of effluent water for removing the salt content could be eliminated. In the primary and secondary treatments, the objectionable color, BOD and COD values would be greatly reduced to the acceptable level[3]. In the tertiary treatment like reverse osmosis process, the salt is removed from the effluent to reduce the total dissolved solids to the acceptable level. But if the effluent is to be discharged in sea, the salt content need not be removed[4]. Hence, costly reverse osmosis process and its installation in the mill could be avoided. This, in turn, saves a lot of investment in industry and also could be considered safe as far as pollution control board's norms are concerned[5]. The major issue of effluent treatment which is found to be very costlier in processing industries could be reduced to a greater extent using this alternative method. This method not only reduces the water scarcity, but also reduces the other problems of effluent treatment.

Bifunctional dyes also require a definite quantity of salt which is less than that of hot brand mono functional dyes[6]. In this context, the attempts were made in dyeing, and trials have been taken up with latest classes of reactive dyes using sea water to optimize the level of salt required to be added for these dyeing using the same procedure as being used for normal water, except for the quantity of salt addition[7,8]. If the dyeing obtained from sea water is at par in quality with that of normal water, several advantages could be claimed. Hence, in this research work, dyeing using ground water, RO water and sea water with different shade classes of reactive dyes has been carried out. The dyed fabrics have been tested for quality parameters, such as color strength; color fastness to washing; color fastness to dry and wet rubbing; color fastness to perspiration; color fastness to light; and tensile strength.

Experimental

Fabric Particulars

100% Cotton fabric ($40^s \times 40^s$) with EPI 140, PPI 120, warp cover factor 19.79, weft cover factor 16.97,

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cloth cover factor 24.77 , warp crimp % 21.40 and weft crimp % 19.20 was used.

Dyes and Chemicals

Hot Brand reactive dye Red H8B was used in 1%, and 4% shades. For each shade %, the dyeing was carried out using normal water, RO water and sea water with salt (addition of NaCl) and without salt (without the addition of NaCl). Since sea water contains salt matter, addition of the electrolyte level (NaCl) in sea water is varied with two concentrations namely 1% and 4% with 20 and 80 gpl NaCl.

Dyeing of cotton fabric was carried out with MLR 1:30, temp. 80ºC, electrolyte conc. 20gpL for 1% shade using normal, RO and sea water and 80gpL for 4% shade using normal, RO and sea water.

Application

The half bleached fabric was treated with water and dye solution. The salt was then added with constant stirring. Dyeing was carried out with constant stirring for 30 min and at 80ºC. Alkali was then added to the above solution and dyeing was continued for 45 min. The dyed fabric was taken out and washed using hot water. The dyed sample was then treated in the boiling soap solution (1 mL/L) for 15 min and finally dried.

Testing

The samples were assessed for color fastness to washing (ISO 105 C06); color fastness to rubbing (IS 766-1956); color fastness to perspiration (IS 971-1956) and color fastness to light (IS 766-1956). Color strength (K/S) was assessed using computer color matching. A suitable comparison has been made between the two different dyed materials to evaluate their final quality. Tensile strength (DIN EN ISO 53857-1) has also been tested for possible fibre degradation.

Results and Discussion

Color Strength

Table 1 represents the color values for the fabric dyed with hot brand Hot H8B dye in 1% and 4% shades. In each shade, dyeing was carried out with ground water (2 samples), RO water (2 samples) and sea water (2 samples). For 1% hot brand Red H8G dyes, 1g of dye for 100g fabric is required and for 4% hot brand Red H8G dyes, 4g of dye for 100g fabric is required. Hence, for 1% dye, 20 gpL salt is added and for 4% dye 80 gpL salt is added. With respect to the variation in salt concentration of dye, the amount of salt varies. For example, if the concentration of dye increases as 0.4%, 1%, 2%, 3% & 4%, the amount of salt added also increases considerably as 10, 20, 40, 60 and 80 gpL respectively with respect to the concentration. Table 1 shows that in all the dyed samples the color strength seems to be similar for sea water dyed material. The reason for more colour yield is surface dyeing of pad- humidity fix method.

Color Fastness to Washing

Fastness to washing is another important test parameter, where ratings are given in two fields, one for the test specimen and another for staining on adjacently attached white cotton fabric. The ratings are distinctly higher for sea water dyed materials, which means that the fixation of dyes is better in case of sea water dyed material. The reason might be due to the nucleophilic addition of dyes which favors the enhancement of dye exhaustion by virtue of ionic bond formation between the sulfonate groups present in the dye molecules and the protonated groups present in the fabrics. This characteristic holds good for both shades of Hot Brand Red H 8B (Table 2).

Color Fastness to Rubbing

When rub fastness properties are compared for hot brand Red H 8B dyed materials, Table 2 infers that the fastness ratings are higher or in few cases equal for sea water dyed material compared to ground water dyed fabrics. The reason might be due to the fixation level of the dye with respect to fibre and it is mainly

Table 1 — Color strength of 1% & 4% shade Hot Brand Reactive Dye Red H 8B

Water	*K/S* value	
	1% shade	4% shade
Normal	100	179.80
RO	85.43	128.64
Sea (without salt)	100	70
Sea (with salt)	55.53	90

1% and 4% shades indicate use of 20 gpl & 80 gpl salt respectively.

Table 2 — Color fastness of 1% and 4% shades hot brand reactive dye Red H 8B

Water	Wash fastness	Rub fastness		Perspiration fastness		Light fastness
		Dry	Wet	Acid	Alkali	
Normal	4	4	3-4	4	4	4
RO	4	4	3-4	4	4	4
Sea (without salt)	4-5	4-5	4	4-5	4-5	4
Sea (with salt)	4-5	4-5	4	4-5	4-5	4

Table 3 — Tensile strength of 1% and 4% Shade of hot brand reactive dye Red H 8B

Water	Salt content gpL	Tensile strength, kg	
		Warp	Weft
Normal	20	11.5	11.0
	80	11.6	11.0
Sea water	20	12.0	11.0
	80	11.6	11.0

brought due to the strong covalent bonding formation between the dye and the fabric.

Color Fastness to Perspiration

Perspiration is another source of agency which can remove dyes from the fabric and so rating of fastness to perspiration is also a necessary parameter to study. As in other cases, here also the ratings for sea water are slightly higher (1-1.5). For sea water dyed material, the fixation is found to be better mainly due to the permanent chemical bond to the fiber and the strong reactivity level of the dye with respect to acid and alkali. The perspiration fastness ratings for hot brand dyes are given in Table 2.

Color Fastness to Light

Light is another source of agency which can remove dyes from the fabric and so rating of fastness to light is also necessary. As in other cases, here also the ratings are equal in all cases. The reason behind is that the dyeing made from sea water always brings in permanent fixation to the fabric and it is not confined to surface level adsorption which improves the overall light fastness rating of the samples. The light fastness ratings for hot brand dyes are given in Table 2.

Tensile Strength

The tensile strength of the fabrics for both warp-wise and weft-wise directions is assessed using Standard Test No: DIN EN ISO 53857-1. Table 3 shows that there is no considerable amount of strength loss (%) in the fabric, dyed with sea water as compared to the fabrics dyed with normal water. Hence, the tensile strength is maintained and no fabric degradation occurs for the samples dyed using sea water which shows a positive sign of our attempt.

Reproducibility of Dyed Samples

Sea water dyed samples using 1% and 4% shades show good depth of shades and ratings similar to the ground water dyed samples. The sea water has different salinity of about 35 g/L when it is taken from sea shore surface, but at the same time the sea water from various places of the sea shows slight difference in salt level. In this research work, the sea water is taken randomly from different areas in the same sea because variation of salt level and dyeing is done for each and every sample for at least five times in order to get the reproducibility and to get consistency of dyeing concentration. On analyzing, the salt level of sea water and fastness rating from grey scale reading, it is observed that there is no major difference in the rating level, and also the results are within the acceptable limit. Hence, the reproducibility is found to be excellent.

It is inferred that the sea water can be used as an alternative source for dyeing as it produces excellent results in all aspects. The dyed samples using sea water possess similar color strength as compared to the dyed samples with ground water and RO water. The exhaustion and fixation are found better in case of sea water dyeing. The color fastness properties, in general, are good for sea water dyeing; in some cases the ratings are comparable and in most case the ratings are similar compared to the ground water and RO water dyeing. The perspiration fastness ratings are also found to be similar for sea water dyeing. The wash fastness ratings in terms of change of color and staining on white are found to be good for sea water dyeing. When tensile strength properties are compared, the sea water dyed material does not degrade much compared, to the ground water dyed materials. Therefore, it is inferred that the severity is less in the case of sea water dyeing. Hence, there is a huge potential of using the sea shore area for establishing new processing mills.

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