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THE INFLUENCE OF MORDANT AND MORDANTING TECHNIQUES ON ECO-FRIENDLY DYEING OF COTTON FABRIC BY EXTRACTED USED TEA

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ABSTRACT

Natural dye extracted from waste tea (Camellia sinensis) used to dye cotton knitted fabrics and effect of some synthetic mordants was investigated. Three mordanting methods were employed during the use of $FeSO_4$, $CuSO_4$ *and* $K_2SO_4Al_2(SO_4)_3.24H_2O$ *as mordants. Influence of 2% & 3% concentration of mordants was compared. Effectiveness of pre mordanting, simultaneous mordanting and post mordanting for better color fixation on the cotton knitted fabric were analyzed. Reflectances of natural dyed cotton knitted fabrics were examined in reflectance spectrophotometer. Experimental data showed that wash fastness and rubbing fastness of alum mordant used samples were very excellent compared to other mordants used. The shade of the sample was comparatively darker when 3% mordant used. Environmental pollution became low due to high color fixation.*

Keywords: *Mordant, Mordanting process, Extracted used tea, Dyeing of cotton fabric, Fastness properties.*

1. INTRODUCTION

Textile materials are colored for value addition, looks and fulfilling the desires of the customers. Anciently, this purpose of coloring textile was initiated using natural source, until synthetic dyes were invented. Almost all the synthetic dyes being synthesized from non-renewable petrochemical resources through hazardous chemical processes which poses serious threat towards its eco-friendliness. However, it has generated the worldwide, growing consciousness about the organic value of eco-friendly products which renewed the interest of consumers towards the use of textiles (preferably natural fiber product) dyed with eco-friendly natural dyes Samanta and Konar (2011). Dyeing textile materials; natural or synthetic, is aimed to add value, improve look and enhance product desire of the customers. As pointed earlier, this purpose of colouring textile was initiated using colours of natural source. However, the uses of natural dyes subsequently diminish with the invention and commercialization of synthetic dyes. In addition, the ready availability of pure synthetic dyes of different types or classes and their cost advantages, propelled most textile dyers and manufacturers to shift towards the use of synthetic colourants.

Few natural dyes are colour-fast with fibers, therefore mordants used for textile dyeing are substances used to increase natural dyes' affinity for fabrics and colorfastness by chemically binding together Tiedemann & Yang, (1995). Mordants are essentially substances which are used to fix a dye to the fibers, they also improve the take-up quality of the fabric and help improve color and light-fastness. Mordants are usually metallic salt of aluminium, chromium, iron, copper and tin as well as other substance such as tanning agents Zubairu and Mshelia (2015). By variation in mordant concentration and using three mordanting methods within the studies shade variation, wash fastness and rubbing fastness identified.

In this study, the dyeing process was carried out with the dye extracted from waste tea leaves using boiling method. The dyeing properties on cotton fabric using dye extracted from waste tea leaves has been evaluated and comparative study of washing fastness & rubbing fastness have been done among pre-mordanting, simultaneous mordanting and post mordanting stage.

2. MATERIALS

2.1 Substrates

For this work, single jersey scoured and bleached cotton fabric with 43 CPI, 36 EPI, 2.74 mm stitch length, 160 GSM and 28 Ne carded yarn was collected from Alim Knit (BD) Ltd. (Mondol Group), Nayapara, Kashimpur, Gazipur, Bangladesh.

2.2 Natural Dye Source

Waste tea was collected from Local Tea Store, Teligati, Khulna. The tea were cleaned and dried and used to extract the natural dyestuff.

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2.3 Mordants

For this work there are three types of synthetic mordanting-agents were used such as $FeSO_4$, $CuSO_4$ and $K_2SO_4Al_2(SO_4)_3.24H_2O$.

3. METHODOLGY

3.1 Recipe formulation

There are two different percentages of three types mordants were used in this project work. The amount of mordant was normally determined by fabric weight. Amount of mordant (g) = fabric weight × percentage of mordant following in table 1.

Table 1: Recipe of different percentage of mordants for fabrics

Name of Mordants	Percentage (%)	Sample Weight(g)	M:L	Dyeing Liquor(ml)
Ferrous sulfate($FeSO_4$)	2 & 3	5	1:20	100
Copper sulfate($CuSO_4$)	2 & 3	5	1:20	100
Alum (Potassium aluminum sulfate)	2 & 3	5	1:20	100

3.2 Dyeing Procedure

3.2.1 Extraction of the Natural Dyes

Two aqueous extraction methods are available to extract color from tea such as boiling method and cold method. Among them boiling method was used for this project work. Boiling method: 30 g of waste tea powder was added into 1 Liter of water. The mixture was stirred, heated and kept at 100°C for 30 minutes, The mixture was then allowed to stand for 15 minutes and finally filtered. The filtrate was used for dyeing cotton fabric.

3.2.2 Dyeing of cotton fabric

5 g sample of cotton fabric (conditioned for 24 hrs at standard atmospheric condition) was taken and weighed. Tea extract was used for dyeing by maintaining the material to liquor ratio of 1:20. The process was moved further by using following recipe in table 2.

Table 2: Recipe of Dyeing of Cotton with Tea

Parameter	Values
Temperature	100°C
pH	Neutral
Time	60 minutes
MLR	1:20

The dyeing of the scoured cotton fabrics was carried out by three mordanting techniques i.e. pre-mordanting, simultaneous mordanting and post-mordanting. The fabric samples were mordanted with Copper Sulphate, Ferrous Sulphate, and Alum (Potassium aluminum sulfate) respectively. Two composition of each mordant was used 2% & 3% respectively. A separate fabric was also dyed with no mordant. The detailed procedures for each mordanting techniques are presented.

3.2.2.1 Pre-mordanting

For each of the selected mordants, 2% and 3% of each mordant was dissolved water. The scoured cotton sample was heated for 30 minutes at a temperature of 100°C in the mordant solution. The fabrics were dried without washing. The dried pre-mordanted fabrics were then placed in a tea dyebath, gradually raising the temperature to 100°C and allowed to simmer for 60 minutes showed in figure 1. The dyed fabrics were removed and cool washed at 30^{o}C in a 2g/L detergent solution.

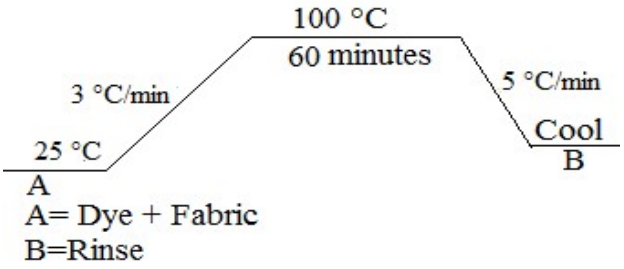

Figure 1: Pre-mordanting dyeing cycle

3.2.2.2 Simultaneous mordanting

For each of the selected mordants, 2% and 3% of each mordant was dissolved in tea dyebath solution. The dry scoured cotton fabric sample was placed in the dyed/mordant mix solution and allowed to simmer at a 100°C for 60 minutes showed in figure 2. The dyed fabrics were removed and cool washed at 30°C in a 2g/L detergent solution.

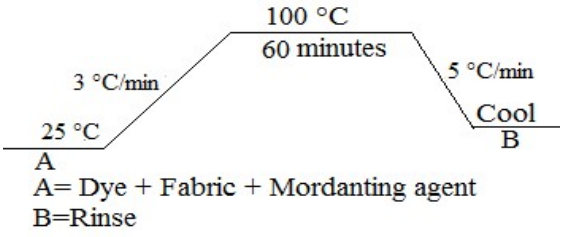

Figure 2: Simultaneous mordanting dyeing cycle

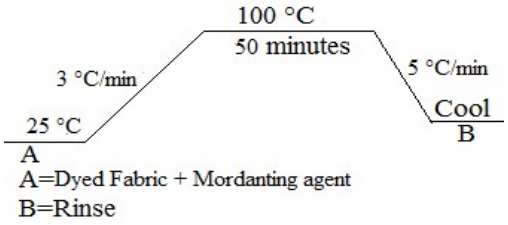

Figure 3: Post mordanting dyeing cycle

3.2.2.3 Post mordanting

The dried scoured cotton fabrics were placed in a tea dyebath, gradually raising the temperature to 100°C and allowed to simmer for 60 minutes. The dyed fabrics were dried. For each of the selected mordants 2% and 3% of each mordant was dissolved in water, the dyed cotton fabric was mordanted in the solution at 100°C for 50 minutes showed in figure 3.The dyed fabrics were removed and cool washed at 30°C in a 2g/L detergent solution

3.3 Evaluation of dyeing quality

3.3.1 Measurement of Color fastness to wash

Wash fastness testing was carried out in a Gyro-wash (GESTAR International Co. Ltd. China) using standard testing procedure ISO 105-C06 in wet processing lab at Department of Textile Engineering, KUET. ISO 105 C06 is the first choice of maximum buyers and this procedure was followed in the work, ISO-105-C06 C2S:1994.

3.3.2 Measurement of Color fastness to rubbing

The rubbing fastness of the dyed fabric was evaluated using GT-DO4 Electronic Crock-meter (GESTAR International co. Ltd. China) by standard testing procedure ISO 105-X12. The grading for rubbing was done with the help of Gray scale, ISO 105-X12:1993.

4. RESULTS AND DISCUSSION

4.1 Colorimetric data of cotton dyed fabric with used tea by using different percentage of mordants

It was seen that when mordants used by 2% then the shade was lighter respectively in table 3. However if 3% mordants were used then the shade became darker by 52.3%, and 117.8% for $CuSO_4$, and Alum mordants respectively but for $FeSO_4$ the shade transferred from 100% greener to 61% redder. For 2% of the mordants the shade was less redder then 3% of the mordants, when 3% mordants used the shade became redder by 88.5%, 161% and 129.4% for $CuSO_4$, $FeSO_4$ and Alum mordants respectively. For 2% of the mordants the shade was less yellowish then 3%, for 3% mordants the shade is more yellowish by 36.5% and 126.8% for $CuSO_4$ and

Alum mordants respectively but for $FeSO_4$ the shade become less bluer by 73.5%. All samples were tested with respect to waste tea dyed fabric without any mordanting agent.

Table 3: Colorimetric data of cotton fabric dyed with waste tea by using mordants in Pre-mordanting method

Shade	Mordanting in Pre-stage					
	$CuSO_4$		$FeSO_4$		Alum	
Percentage (%)	2	3	2	3	2	3
DL	-11.5	-17.52	-11.12	-18.95	-5.69	-12.39
Da	1.31	2.47	-1.00	0.61	0.68	1.56
Db	4.33	5.91	-1.85	-0.49	2.80	6.35
CMC DE	5.62	8.33	4.62	7.48	3.11	6.99

Table 4: Colorimetric data of cotton fabric dyed with waste tea by using mordants in Simultaneous mordanting method.

Shade	Mordanting in Simultaneous-stage					
	$CuSO_4$		$FeSO_4$		Alum	
Percentage (%)	2	3	2	3	2	3
DL	-10.00	-9.45	-15.42	-12.67	-6.47	-4.69
Da	0.70	1.28	-2.10	-1.69	0.80	0.99
Db	3.05	4.47	-7.15	-6.72	2.98	4.42
CMC	4.57	5.07	8.24	7.29	3.42	3.90

It was seen that when mordants used by 2%, then the shade was darker respectively in table 4. However by using 3% mordants the shade became lighter by 5.5%, 17.83% and 17.8% for $CuSO_4$, $FeSO_4$ and Alum mordants respectively. For 2% of the mordants the shade was less redder then 3% usually, for 3% mordants the shade was more reddish by 82.9% and 23.75% for $CuSO_4$ and Alum mordants respectively but for $FeSO_4$ the shade became less greener by 19.5%. For 2% of the mordants the shade was less yellowish then 3% of the mordants usually, when 3% mordants was used the shade become more yellowish by 46.6% and 48.3% for $CuSO_4$ and Alum mordants respectively but for $FeSO_4$ the shade became less bluer by 6.14%. All samples were tested with respect to waste tea dyed fabric without any mordanting agent.

Table 5: Colorimetric data of cotton fabric dyed with waste tea by using mordants in Post mordanting method.

Shade	Mordanting in Post-stage					
	$CuSO_4$		$FeSO_4$		Alum	
Percentage (%)	2	3	2	3	2	3
DL	-8.27	-9.62	-15.94	-18.74	-3.86	-3.45
Da	-0.13	0.34	-0.06	-0.44	-0.14	0.12
Db	4.23	5.74	2.72	0.18	-0.09	0.32
CMC	4.89	6.00	6.66	7.34	1.52	1.37

It was seen that when mordants used by 2% then the shade was lighter respectively in table 5. However when 3% mordants were used then the shade become darker by 16.32%, 17.6% for $CuSO_4$ and $FeSO_4$ mordants respectively but for Alum the shade became lighter by 10.62%. For 2% of the mordants the shade was less redder then 3% of the mordants, when 3% mordants was used the shade transferred from 13% greenish to 35% reddish for $CuSO_4$ mordant, for Alum it was transferred from 14% greenish to 12% reddish and for $FeSO_4$ the shade became greener by 633.33%. For 2% of the mordants the shade is less yellowish then 3% usually, for 3% mordants the shade was more yellowish by 35.7% and 126.8% for $CuSO_4$ and Alum mordants respectively but for $FeSO_4$ the shade became 32% yellowish from 9% blue tone. All samples were tested with respect to waste tea dyed fabric without any mordanting agent.

Table 6: Colorimetric data of cotton fabric dyed washed sample with waste tea by using mordants in Post mordanting method.

	$CuSO_4$				$FeSO_4$			
Shade	Washed		unwashed		Washed		unwashed	
Percentage (%)	2	3	2	3	2	3	2	3
DL	-4.23	-3.47	-8.27	-9.62	-8.49	-9.81	-15.94	-18.74
Da	-0.78	-0.60	-0.13	0.34	-0.35	0.21	-0.06	-0.44
Db	4.51	2.61	4.23	5.74	0.44	0.13	2.72	0.18
CMC DE	3.27	3.04	4.89	6.00	3.44	3.84	6.66	7.34

It was seen that when mordants used for unwashed sample by 2% then the shade was lighter respectively in table 6. However when 3% mordants were used then the shade became darker by 16.32%, 17.6% for $CuSO_4$ and $FeSO_4$ mordants respectively but for washed sample by 2% mordant then the shade was 21.95 darker for $CuSO_4$ and for $FeSO_4$ 14.8% lighter than 3% mordant. For unwashed sample when 2% of the mordants used the shade was less redder then 3% of the mordants, when 3% mordants was used the shade transferred from 13% greenish to 35% reddish and for washed sample 23% lighter for $CuSO_4$ mordant, for $FeSO_4$ the shade became greener by 633.33% and for washed sample shade transferred from 35% greenish to 21% reddish. For 3% mordants of unwashed sample the shade was more yellowish by 35.7% and for washed sample it became 42.12% less yellowish for $CuSO_4$ mordant. But for unwashed $FeSO_4$ the shade became 32% yellowish from 9% blue tone and for washed sample it became 70.5% yellowish. All samples were tested with respect to waste tea dyed fabric without any mordanting agent.

4.2 Color fastness to wash of cotton dyed fabric with using different percentage of mordants

4.2.1 Comparison the color fastness to wash for 2% of different mordants in different methods

If 2% of various mordant was taken and used then a variation of wash fastness value for different methods such as, Pre mordanting, Post mordanting, Simultaneous mordanting was observed in figure 4. Here Alum showed the highest wash fastness value as 4.5 in post mordanting method, 3.5 in Simultaneous mordanting and 3 in Pre mordanting. In general this graph showed that Alum was best for wash fastness parameter. After that $FeSO_4$ had the good wash fastness rating. And $CuSO_4$ showed comparatively lower wash fastness values.

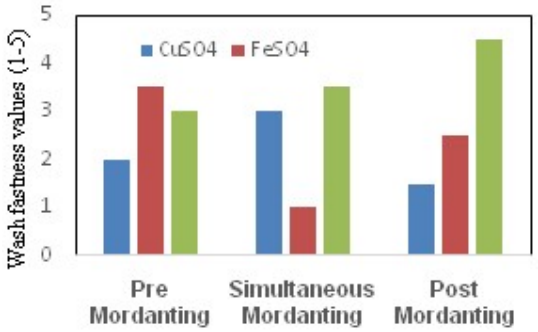

Figure 4: Comparison of the color fastness to wash for 2% mordants in different method

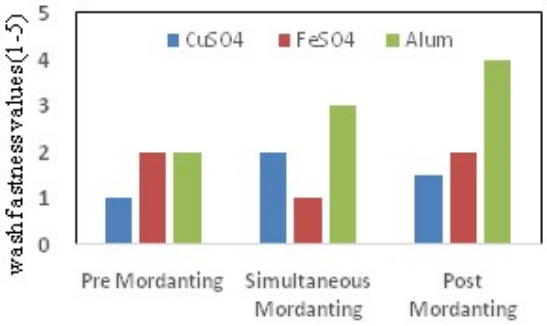

Figure 5: Comparison of the color fastness to wash for 3% of different mordant in different methods

4.2.2 Comparison of the color fastness to wash for 3% different mordants in different methods

Mordant has a huge importance in natural dyeing, by varying the percentage of that, a comparative study was done for 3% of different mordants as $FeSO_4$, $CuSO_4$ and Alum in figure 5. Here Alum showed the highest wash fastness value as 4 in post mordanting method, and 3 in Simultaneous mordanting and 2 in Pre mordanting. In general this graph showed that Alum is best for wash fastness parameter. After that $FeSO_4$ had the good wash fastness rating with a value of 2, 2 and 1, where $CuSO_4$ shows comparatively lower wash fastness values as 1.5, 1 and 2 in Post, Pre and Simultaneous mordanting. Washed sample of $FeSO_4$ showed a rating of 3.5 and $CuSO_4$ showed a value of 1.

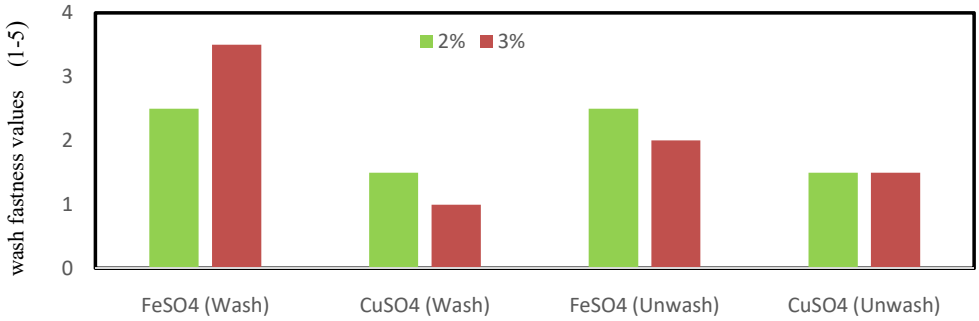

Figure 6: Comparing the color fastness to wash for after dyeing washed sample in post mordanting method

4.2.3 Comparison the color fastness to wash for after dyeing washed sample in post mordanting method

If the sample was washed after dyeing before of mordanting process in Post mordanting, the fastness property for washing was enhanced. For $FeSO_4$ it was seen that this rating was increased from 2 to 3.5 for 3% of it. And for 2% mordant the value remains same as 2.5. For 2% and 3% the value was 1.5 and 1 respectively. If the sample was unwashed the rating of $FeSO_4$ was 2.5 and 2 for 2% and 3% of mordant. And for $CuSO_4$ the rating was 1.5 for both 2% and 3% of the mordant showed in figure 6.

4.3 Color fastness to rubbing of cotton dyed fabric with using different percentage of mordants

4.3.1 Comparison of the color fastness to rubbing for 2% of different mordants in different methods

If 2% of various mordant was taken and used then a variation of rubbing fastness value for different methods such as, Pre mordanting, Post mordanting, Simultaneous mordanting was observed. Here Alum showed the highest rubbing fastness value as 5 in Pre-mordanting, Simultaneous and Post mordanting method for dry rub, Wherein wet rub alum showed the rating of rubbing fastness 4 in Pre mordanting and in simultaneous mordanting and post mordanting 4.5. In general in figure 7 showed that Alum was best for rubbing fastness parameter in all methods.

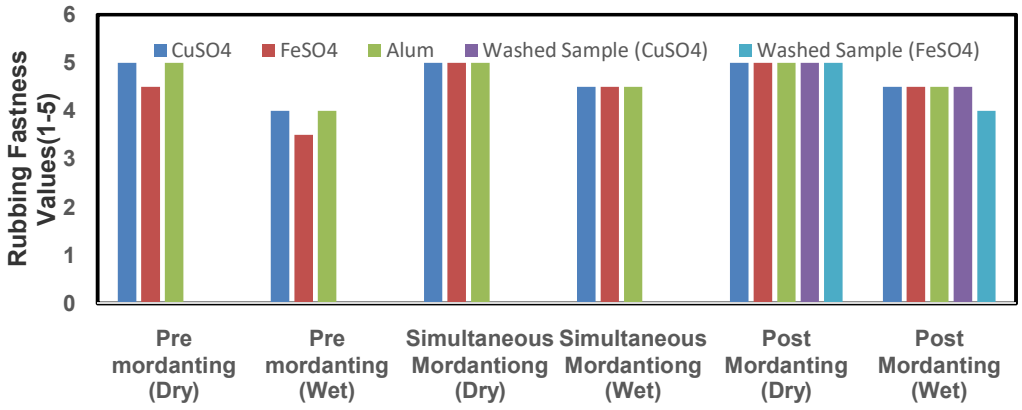

Figure 7: Comparing the color fastness to rubbing for 2% of various mordants in different methods

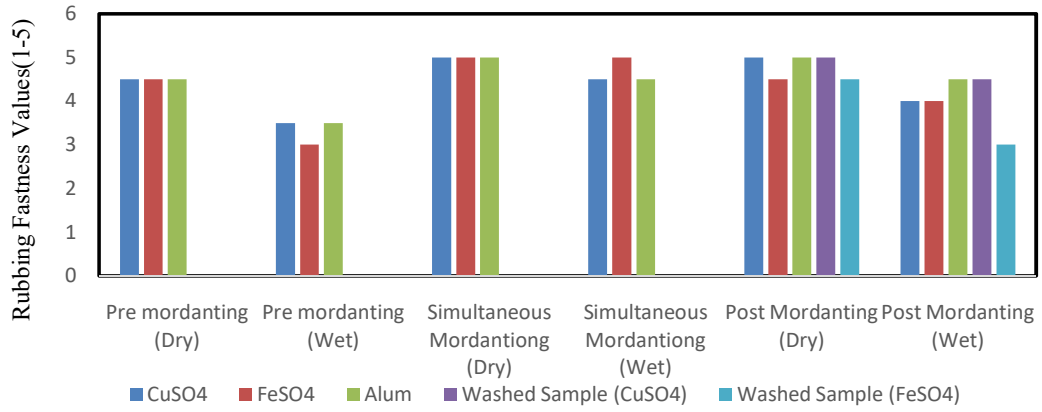

Figure 8: Comparing the color fastness to rubbing for 3% of different mordants in different methods

4.3.2 Comparison of the color fastness to rubbing for 3% of different mordants in different methods

Mordant has a huge importance in natural dyeing, by varying the percentage of that, a comparative study was done for 3% of different mordant's as $FeSO_4$, $CuSO_4$ and Alum. Here in figure 8, Alum showed the highest wash fastness value as 5 in simultaneous mordanting and post mordanting method, 4.5 in Pre mordanting as dry rub, where in simultaneous mordanting (wet rub) $FeSO_4$ shows the highest rating of rubbing fastness 5.

4.3.3 Comparison of the color fastness to rubbing for after dyeing washed sample in post mordanting method

If the sample was washed after dyeing before mordanting process in Post Mordanting method, the fastness property for rubbing was not changed with respect to unwashed sample for dry and wet rubbing of 2% mordant. But for 3% mordant there was a variation in wet rubbing. Washed sample for 3% wet rubbing showed a high value than unwashed sample in figure 9.

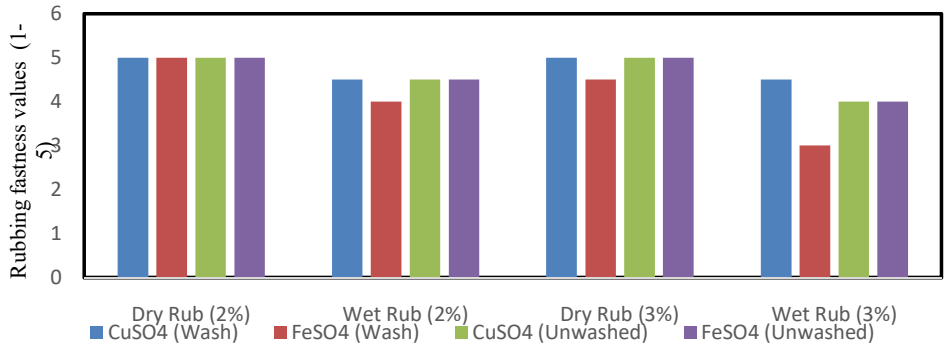

Figure 9: Color fastness to rubbing for after dyeing washed sample in post mordanting method

5. CONCLUSIONS

It is known that synthetic dyes have a bad impact on environment, so reducing the use of these dyes will be significant if possible. In this study we have successfully investigated the possibility of being dyed of cotton fabric by extracted liquor of used tea (*Camellia sinensis*) with the help of mordants. By varying the type of mordant and their percentages, we have measured the compatibility of the shade of dyed sample and various fastness properties. The rating of color fastness to wash is usually 4 to 3 and for color fastness to rubbing it is 5 to 4.5 in average. When Alum is used as mordant the shade of fabric is comparatively bright and for $FeSO_4$ it shows a comparatively dark shade and for $CuSO_4$ it has a medium bright shade. Alum mordant used fabric has high fastness rating and for $FeSO_4$ it has comparatively low fastness rating and for $CuSO_4$ it has very low fastness property. This study forms an important basis on which many more natural materials can be recycled to dye textile material as like synthetic dyes cotton and it will be more viable solution to make sustainable environment.

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