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Impacts of Air Pollution on Colour Fading and Physical Properties of Wool Yarns Dyed with Some Natural Dyes in Residential Site

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Abstract

Wool yarns are dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using exhaustion method. These dyed yarns are pre-mordanted with different types of mordants. Different measurements have been carried out for the dyed wool yarns after exposure to air pollution in residential site (Kalla region) for one year. These measurements values include colour data (K/S, L*, a*, b*, ΔE, hue and chroma) and physical properties (tensile strength, tenacity and elongisity). Also, the present work studied the air pollution in (Kalla region), through determination of the suspended and deposited particulate matter and sulpher dioxide concentrations for different periods of time in one year.

Keywords: Wool Yarns; Cochineal; Turmeric; Madder; Mordants; Air Pollution; Colour Fading

Introduction

During a few last decades, revival and using of natural dyes has gained a great deal of attention and care. A renewed international interest has arisen in natural dyes due to remarkable increase of the environmental and health hazards associated with the awareness of synthesis, processing and use of synthetic dyes. Cochineal (red dye), Turmeric (yellow dye) and Madder (red dye) are extracted from (Daclylopius coccus) bug, (Curcuma longa. L, rotunda. L) plant and (Rubia tinctorum) plant respectively. When using these natural dyes for dyeing wool yarns, the light and washing fastness were very poor. Enhancement of fastness properties of wool yarns can be done by the help of mordants, usually metallic salts. Mordants have an affinity for both natural colouring matter and the fibre. After wool yarns being impregnated with such mordants, they were subjected to dyeing with different natural dyes (in case of pre-mordanting). In case of post mordanting method wool yarns were treated with different mordants after dyeing procedure. These metallic salts (mordants) after combining with dye in the fibre, they form an insoluble precipitate and thus both the dye and the mordant get fixed which improve light fastness to some extent [1-14]. Generally, concentrating residential and commercial activities without air quality management policy, led to complex mixtures of all types and sizes of uncontrollable air pollution sources.

Experimental

Materials

Natural colouring matter: Colouring substance used in this work was extracted from Cochineal as an animal source, Turmeric and Madder plants as a planted source.

Fabrics: Wool yarns were kindly supplied by El Mehalla spinning and weaving Company, Egypt.

Mordents: The following mordants were used: alum salt, copper salt, tin salt and iron salt. They were of pure grade chemicals.

Methods

Extraction of natural coloring matter: Cochineal dye (10 g/L) was immersed in water for 12 hours and then boiled for 15 minutes. Turmeric dye (powder form) was immersed in water with 15 g/L concentration for 12 hours and then boiled for 60 minutes. Madder dye (powder form) was immersed in water with 17 g/L concentration for 12 hours and then boiled for 60 minutes. At the end, the solution was filtered off and left to cool down [15-18].

Dyeing methods

Dyeing of wool yarns using traditional method: Wool yarns samples (10 gm each) were dyed with the dye extracted from Cochineal, Turmeric and Madder at liquor ratio 1:50. Dyeing was carried out at pH (4-5). Yarns samples were entered to the dyeing solution in a water bath at 70°C for 15 minutes. Then yarns were dyed for one hour (in case of Cochineal dye) and for 30 minutes (in case of Turmeric and Madder) and the dyed samples were rinsed with cold water and washed for 30 minutes in a bath containing 3 g/L of non-ionic detergent at 45°C. Finally, the yarns were rinsed and air dried [19-21].

Pre-mordanting of wool yarns: The pre–mordanting method was used in case of dyeing wool yarns with dyes extracted from Cochineal, Turmeric and Madder using alum salt, copper salt, and chromium salt. The mordant was dissolved and added to the bath with liquor ratio 1:50. Then wetted wool samples were added to the mordanting bath and the whole brought slowly to 90°C for one hour. It was then allowed to cool at room temperature and the wool samples were removed and squeezed. Mordanted wool should be used at once because some mordants are very sensitive to light [22].

Post-mordanting method was used in case of dyeing wool yarns with dyes extracted from Cochineal, Turmeric and Madder using iron salt and tin salt. In this method the mordant was added to the bath for the final ten minutes of simmering. The fabrics were lifted out while the

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dissolved salts are thoroughly mixed into the dye liquor. The wool yarns were interred into the bath and the dyeing process was continued for 30 minutes at 90°C, then rinsed and washed [23-25].

Preparation and exposure of samples to the ambient atmosphere: The dyed wool samples were placed over roofs of building in the investigated site. Wool samples were exposed for a period of one year. Five samples of each type were removed from each site after exposure of three months interval, and were taken off to the laboratory for the measurements. Unexposed samples were used as control.

Air pollution determination: The Area under investigation is residential site (Kalla region). It is located in the middle of Cairo city (residential area). It is characterized with heavy population and mixed activities commercial and residential beside the heavy traffic. The present investigation was undertaken to study the air pollution in residential site (Kalla region), through determination of the suspended and deposited particulate matter and sulpher dioxide concentrations.

Determination of deposited particulate matter: Deposition rate values for settled particulate matter were determined according to standard methods [26]. Dust fall collectors were used for collecting dust fall samples as previously used in Egypt [27]. The collectors consist of cylindrical glass beakers 17 cm in height and 8 to 9.5 cm diameter. The cylindrical glass beaker was half filled with distilled water to avoid re-entrainment of the collected dust and mounted on iron tripods at a height of 50 cm above roof level to avoid the collection of surface dust. Monthly collected samples were transferred quantitatively carefully to a dry, clean weighted beaker using successive washing with distilled water and a policeman until the inside of the jar became clean. Successive drying and weighing of the beaker was made until constant weight. The differences in weight represent the amount of deposit dust during the corresponding month at each site. Particulate deposition were calculated and expressed as gm/m².30 days.

Determination of suspended particulate matter: The filtration technique for collecting atmospheric suspended particulate matter [28]. Determination of sulpher dioxide: West and Gaeke method was used for the determination of SO_2 [26,28]. Air was aspirated (one liter / minute) through a glass bubbler sampler containing 50 ml of absorbing solution (0.1 M sodium tetrachloromercurate). Non-volatile dichlorosulfito mercurate ion was formed when the sulphur dioxide in the ambient air is absorbed in 0.1 M sodium tetrachloro mercurate. Addition of acid bleached pararosaniline and formaldehyde to the complex ion produces red-purple pararosaniline methyl sulphuric acid, which is determined spectrophotometrically at a wavelength of 560 mu.

Testing

Color measurements of the dyed fabrics: Colour-difference formula ΔE CIE (L*, a*, b*)

The total difference ΔE CIE (L*, a*, b*) was measured using the Hunter-Lab spectrophotometer (model: Hunter Lab DP-9000).

The total difference ΔE CIE (L*, a*, b*) between two colours each given in terms of L*, a*, b* is calculated from:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where:

ΔE* value: is a measure of the perceived colour size of the colour difference between standard and sample and cannot indicate the nature of that difference.

ΔL* value: indicates any difference in lightness, (+) if sample is lighter than standard, (-) if darker.

Δa* and Δb* values: indicate the relative positions in CIELAB space of the sample and the standard, from which some indication of the nature of the difference can be seen.

ΔH= arktan b*/a* Where (ΔH) indicates any difference in hue of colour

and $\Delta C = (a^2+b^2)^{1/2}$ Where (ΔC) indicates any difference in chroma (saturation of colour)

Physical measurement: The physical properties (tensile strength-tenacity- elongisity) are measured for the mordanted dyed yarn samples with Cochineal, Turmeric and Madder using (Uster tensor apid) device.

Results and Discussion

Air pollution: Both the gaseous and particulate components of an atmospheric aerosol contribute to deterioration in air quality. Dust-fall samples are generally indication of atmospheric particulate concentration. Particles of size larger than 20 μm has appreciable settling velocities and relatively short atmospheric residence time. The annual mean rate of deposited particulate matter over Kalla region during the year of study was illustrated in Table 1.

Table 1 shows that Kalla region (residential site) is highly polluted with a suspended dust comparing to Helwan city (industrial area). While Helwan city is highly polluted with fine particles and SO_2 more than Kalla region. Also, Table 1 indicated that the annual mean rate of deposited dust was 16.93 g/m².month. According to Pennsylvania guidelines for dust-fall, these values are considered a heavy deposition rates.

Pennsylvania guidelines for dust-fall [29].

Class Dust-fall (g/m².month)

Slight--------------------- (0-7)

Moderate---------------- (7-14)

Heavy-------------------- (14-35)

Very Heavy ------------ (>35)

The annual average concentration of suspended particulate in residential site (Kalla region) atmosphere was 951.04 μg/m³ this concentration is about 19 times higher than the value of 50 μg/m³ concentration limit of US National Ambient Air Quality Standards [28], which is the same value recommended by UK. Expert Panel on Air Quality Standards [30]. It is also about 13 times higher than the maximum allowable concentration that is given by the Egyptian Environmental Law No. 4, 1994 (70 μg/m³) [31]. The reactive acids such as sulfuric acid cause the melting of wool especially at high temperatures and transformation it into amino acids and peptides. In addition wool fibres release sulfur gases.

It was noticed that concentrations of suspended particulate matter varied from one season to another during the period of the study and the maximum concentration recorded during autumn. The amounts of deposited and suspended dust were also affected by the location of the study "Kasr El-Jawahara Museum" in Kalla region as it is near to both Moqattam Mountain and the downtown. The percentage of the acidic particles resulting from the exhaust and the large particles coming from Moqattam Mountain was carried by the wind. Although there is a certain level of dust in the air at all times. The amount and

Season	rates of deposition (g/m².month)		Suspended dust concentration(μg/m³)		SO_2 (μg/m³)	
	residential site (Kalla region)	urban area (Helwan city)	residential site (Kalla region)	urban area (Helwan city)	Residential site (Kalla region)	urban area (Helwan city)
Winter	15.32	19.18	922.45	328.6	32.6	111.38
Spring	13.73	19.88	900.59	381.0	36	60.14
Summer	12.76	19.31	637.28	267.3	7.02	44.6
Autumn	11.92	18.90	1343.84	362.3	3.20	74.6
Annual mean	13.43	19.32	951.04	334.8	19.71	72.68

Table 1: Seasonal variation the rate of deposition of dust-fall (g/m².month), Suspended dust concentration (μg/m³) and SO_2 (μg/m³) over a residential site (Kalla region) and urban area (Helwan city).

type of dust varies considerably and depends on many factors including source, climate, wind direction, and traffic. Dust is generated from man-made and natural sources and may be made up of soil, pollen, volcanic emissions, vehicle exhaust, smoke or any other particles small enough to be suspended or carried by wind. The stronger the wind the larger the particles lifted and the more dust carried. Sulpher dioxide: SO_2 is a prominent anthropogenic pollutant and contributes to the formation of sulphuric acid, the formation of sulphate aerosols, and the deposition of sulphate and SO_2 at the ground surface. Seasonal and annual concentrations of Sulpher dioxide in the atmosphere of the Kalla region are given in Table 1. From this table it can be noted that sulpher dioxide concentrations greatly varied from one season to the other maximum concentration of 32.6 was recorded during winter. While annual mean concentrations of sulpher dioxide, reaching. 19.71 μg/m³ These concentrations were lower than the value of 60 μg/m³ set by the US Ambient Air Quality Standard, and also the Egyptian limit for the annual concentration of SO_2 [31]. Also, It was less than the primary US National Ambient Air Quality Standard (80 μg/m³) for SO_2 [32,33]. Sulpher in the atmosphere originate either from natural processes or anthropogenic activity [34]. Fuel combustion as well as metal production is the dominant source for SO_2 emissions into the atmosphere [35].

Measurements of colorimetric data (CIE L*, a*, b*) in residential site (Kalla region)

Effect of exposure to air and light on the Change of colour (ΔE values) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: Tables 2-4 give values of change of colour (ΔE) for the three plants used. The change of colour (ΔE) increases with increasing the period of exposure to air and light. Good light resistance was observed in fabrics dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts. This is due to the formation of complex with the metal which protects the chromatophore from photolytic degradation.

From Table 2 it can be observed that the colour change (ΔE) for the mordanted wool samples dyed with natural colouring matter extracted from Cochineal using different kinds of mordants follows the order: alum salt> tin salt> iron salt> copper salt. While, Table 3 shows that change of colour (ΔE) for mordanted wool samples dyed with Turmeric using different kinds of mordants follows the order: alum salt> tin salt> iron salt> copper salt. Finally, Table 4 indicated that change of colour (ΔE) for mordanted wool samples dyed with Madder using different kinds of mordants follows the order: tin salt> alum salt> copper salt> iron salt.

Effect of exposure to air and light on the lightness (L* values) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: Tables 2-4 gives the (L* values) for the three plants used. From Table 2, it can be concluded that lightness (L*values) for the mordanted wool samples dyed with natural colouring matter extracted from Cochineal, become lighter comparing to standard sample in case of using Iron or copper salts, but in case of using alum or tin salts , the colour become darker after time of exposure to air and light. From Table 3, it can be observed that the lightness (L*values) for the mordanted wool samples dyed with natural colouring matter extracted from Turmeric, become darker comparing to standard sample in case of using Iron, copper, alum or tin salts after time of exposure to air and light. It is clear from Table 4, that the lightness (L*values) for the mordanted wool samples dyed with natural colouring matter extracted from Madder, has no change of colour comparing to standard sample in case of using Iron or copper salts, but in case of using alum or tin salts, the colour become slightly darker after time of exposure to air and light.

Effect of exposure to air and light on the nature of colour (a* values) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: Table 2-4 gives the (a*) values for the three plants used. Table 2 shows (a*) values for all wool samples dyed with natural colouring matter extracted from Cochineal using Iron salts which indicated that there is a slight change of colour in the direction of green region in the [CIE L*, a*, b*] zone, but in case of using copper salts the green colour concentration increases and in case of using alum and tin salts, a decrease in red colour concentration is happened. From Table 3 it can be observed that (a*) values for wool samples dyed with natural colouring matter extracted from Turmeric using Iron salt, copper salt, alum salt and tin salt show no change of colour after time of exposure (12 months). It is observed from Table (4) that (a*) values for wool samples dyed with natural colouring matter extracted from Madder using Iron salt or copper salts show a change of colour in the direction of green region in the [CIE L*, a*, b*] zone, but in case of using alum or tin salts a decrease in red colour concentration is happened.

Effect of exposure to air and light on the nature of colour (b* values) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: Tables 2-4 gives the (b*) values for the three plants used. It is observed from Table 2 that (b*) values for all wool samples dyed with natural colouring matter extracted from Cochineal using iron or copper salts show a decrease in blue colour concentration, but in case of using tin salt an increasing of blue colour concentration is happened, and there is no change in colour happened in case of using alum salt. It can be seen from Table 3 that (b*) values for wool samples dyed with Turmeric using iron salts, copper salts, alum salts and tin salts show a change of colour in the direction of blue region in the [CIE L*, a*, b*] zone after exposure to air and light comparing to the blank. Table 4 shows that, (b*) values for wool samples dyed with Madder using tin salt show a change of colour from yellow region to blue region in the [CIE L*, a*, b*] zone. Also, in case of using alum salt, the blue

Type of salt	Colour data	Blank (without exposure)	After 3 months	After 6 months	After 9 months	After 12 months
Iron salt	L*	28	28	31	31	31
	a*	0.4	-3	-4	-5	-5
	b*	-39	-33	-32	-30	-30
	ΔE	0	6.9	8.8	11	11.3
	H	89.41	84.81	82.87	80.54	80.54
	C	39	33.13	32.25	30.41	30.41
Copper salt	L*	37	37	38	38	40
	a*	-4	-7	-8	-8	-10
	b*	-32	-29	-26	-26	-23
	ΔE	0	4.4	7.2	7.3	11
	H	82.87	76.43	72.90	72.90	66.50
	C	32.25	29.83	27.20	27.20	25.08
Alum salt	L*	40	37	36	33	33
	a*	27	17	14	12	9
	b*	-34	-33	-31	-30	-28
	ΔE	0	10.4	13.2	14.3	18.1
	H	50.71	62.74	66.62	67.37	73.81
	C	42.63	37.12	36.77	34.93	32.28
Tin salt	L*	43	40	39	37	34
	a*	27	19	17	15	12
	b*	-16	-21	-23	-25	-28
	ΔE	0	10.4	11.5	13.2	14.8
	H	30.65	49.18	50.71	53.97	54.46
	C	31.38	29.07	28.43	27.20	25.81

Table 2: Values of L*, a* , b*, ΔE, H and C for the mordanted wool yarns samples dyed with dyes extracted from **Cochineal** using different salts in Kalla region.

Type of salt	Colour data	Blank (without exposure)	After 3 months	After 6 months	After 9 months	After 12 months
Iron salt	L*	60	47	46	46	45
	a*	-10	-9	-9	-9	-9
	b*	-22	-30	-29	-30	-29
	ΔE	0	15.3	16.7	16.2	16.6
	H	65.56	73.3	72.76	73.3	72.76
	C	24.17	31.32	30.36	31.32	30.36
Copper salt	L*	49	45	44	43	41
	a*	-12	-14	-15	-15	-16
	b*	-7	-15	-16	-17	-19
	ΔE	0	9	9.9	10.3	13.6
	H	23.63	45	46.85	47.85	53.62
	C	17.46	19.21	21.93	21.93	23.6
Alum salt	L*	67	56	53	52	50
	a*	-10	-11	-12	-12	-13
	b*	-16	-19	-22	-29	-29
	ΔE	0	39.6	40.2	47.5	49.5
	H	57.99	59.72	61.43	68.23	69.23
	C	18.87	24.6	25.60	31.02	32.02
Tin salt	L*	62	57	51	51	50
	a*	-13	-12	-11	-10	-10
	b*	-15	-28	-30	-30	-31
	ΔE	0	15.8	20.3	20.4	21.4
	H	52.43	70.34	71.12	71.57	72.4
	C	18.40	29.73	31.20	31.62	31.62

Table 3: Values of L*, a* , b*, ΔE, H and C for the mordanted wool yarns samples dyed with dyes extracted from **Turmeric** using different salts in Kalla region.

Type of salt	Colour data	Blank (without exposure)	After 3 months	After 6 months	After 9 months	After 12 months
Iron salt	L*	32	31	31	31	32
	a*	2	-0.3	-2	-2	-3
	b*	-21	-22	-23	-23	-23
	ΔE	0	2.7	4.6	5.6	5.4
	H	84.56	89.22	85.03	85.03	82.57
	C	21.10	22	23.08	23.09	23.19
Copper salt	L*	35	35	35	35	36
	a*	3	-1	-1	-2	-3
	b*	-20	-22	-21	-20	-20
	ΔE	0	4.1	4.4	6.5	6.9
	H	88.47	87.40	87.27	84.29	81.87
	C	23.22	22.02	21.02	21.10	20.21
Alum salt	L*	40	37	37	37	36
	a*	20	12	10	9	7
	b*	-7	-15	-16	-17	-18
	ΔE	0	11.7	13.7	15.2	17.5
	H	19.29	51.34	57.99	62.10	68.75
	C	21.19	19.21	18.87	17.94	17.31
Tin salt	L*	41	40	40	38	38
	a*	19	13	10	9	7
	b*	7	-1	-2	-3	-7
	ΔE	0	10	12.8	14.5	18.6
	H	20.22	18.4	17.31	16.44	15
	C	20.25	13.04	10.20	9.89	9.20

Table 4: Values of L*, a* , b*, ΔE, H and C for the mordanted wool yarns samples dyed with dyes extracted from **Madder** using different salts in Kalla region.

colour concentration increases. But in case of using iron salt and copper salt, there is no change of colour after exposure to air and light.

Effect of exposure to air and light on the hue of colour (H values) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: Table 2 shows that the hue of the colour values (H) for wool samples dyed with natural colouring matter extracted from cochineal and mordanted with iron salt is almost the same during all periods of exposure to air and light. However, when mordanted with copper salt, the H values shift towards the green axis. This may be because copper ions cause a bathochromic shift of the long wave length absorption bands of cochineal. When mordanted with alum or tin salt, the H values shift towards the blue axis. From Table 3, it can be observed that the H values for wool samples dyed with natural colouring matter extracted from turmeric and mordanted with iron or alum show no changes after exposure. On the other hand, when copper salt or tin salt is used, the H values shift towards the blue axis. This may be due to the fact that the ultraviolet (UV) visible spectra of turmeric show significant changes that have occurred in the band absorbance at the longest wave length in the presence of copper or tin ions, and these changes are characteristic of copper ions or tin ions. Copper ions and tin ions also cause a bathochromic shift of the long wave length absorption bands of turmeric. It is observed from Table 4 that the H values for wool samples dyed with natural colouring matter extracted from madder and mordanted with alum show a shift in the direction of the blue axis. The reason could be that alum cause a bathochromic shift of the long wave length absorption bands of madder. However, when iron, copper or tin salt is used, H values are almost the same during all periods of exposure to air and light.

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Effect of exposure to air and light on the saturation of colour (chroma- C values) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: It is observed from Table 2 that the chroma values (C) for all wool samples dyed with natural colouring matter extracted from cochineal and mordanted with iron, copper, alum and tin salts slightly decrease when exposure time to air and light increases. It can be seen from Table 3 that the C values for wool samples dyed with natural colouring matter extracted from turmeric and mordanted with iron, copper alum and tin salts slightly increase when the exposure time to air and light increases. Moreover, for almost all samples, the concentration of the chromophores decreased as the colour faded. Table 4 shows that the C values for wool samples dyed with natural colouring matter extracted from madder when tin salt is used decrease when the exposure time to air and light is increased. However, when mordanted with iron, copper or alum salt, the C values are almost the same during all periods of exposure to air and light.

Physical Measurement: The Physical measurements which have done on the dyed wool samples indicated that a severe decline in the tensile strength for the mordanted dyed wool sample with cochineal, turmeric and madder increases with increasing time of exposure to air and light.

Effect of time of exposure to air and light on the tensile strength (B-Force) for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: From Figure 1, it can be seen that, almost full damage of tensile strength occurred with copper salt after 9 months from exposure to air and light. Also, a complete damage happened in the tensile strength for the mordanted dyed samples with cochineal using iron, alum and tin salts after 12 months from the exposure to air and light compared to the standard.

It is observed from Figure 2, that, a severe decline of tensile strength occurred with all mordants used (iron, copper, alum and tin salts) after exposure to air and light for 12 months. Also, a complete decline happened in the tensile strength for the mordanted dyed samples with turmeric using iron and alum salts after exposure to air and light for 9 months.

Figure 3 shows that a severe decline of tensile strength occurred with copper salt for mordanted wool samples dyed with madder after

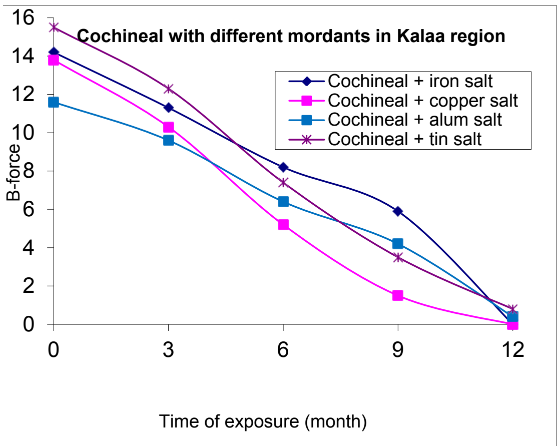

Figure 1: Effect of time of exposure to light on the tensile strength (B-Force) of the dyed mordanted wool yarns with Cochineal.

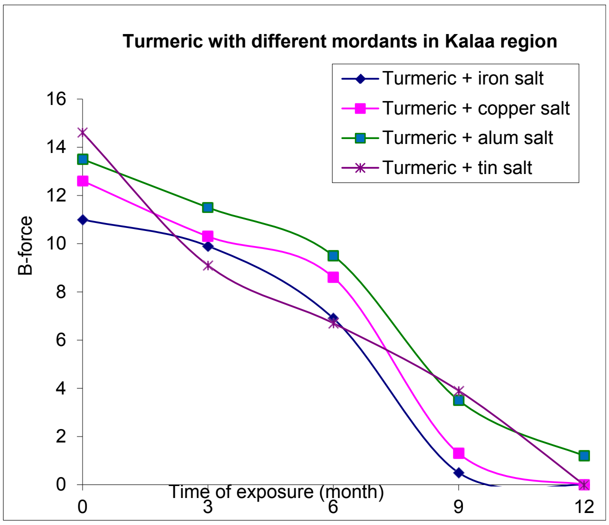

Figure 2: Effect of time of exposure to light on the tensile strength (B-Force) of the dyed mordanted wool yarns with Turmeric.

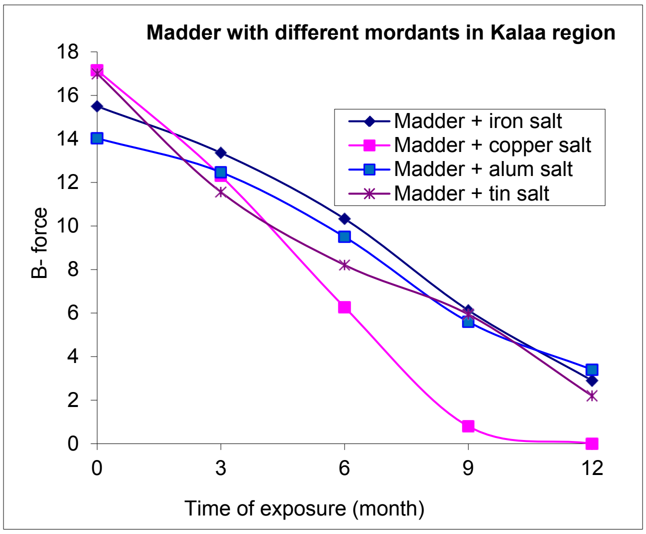

Figure 3: Effect of time of exposure to light on the tensile strength (B-Force) of the dyed mordanted wool yarns with Madder.

full time of exposure (12 months). Also, Figure 3 shows that good results of the tensile strength were obtained when using iron, alum and tin salts for mordanted wool samples dyed with madder after exposure to air and light for 12 months. Also, a gradual decline happened in the tensile strength for the mordanted dyed samples with Madder using iron, copper, alum and tin salts after exposure to air and light for 12 months compared to the standard.

However, the decline of tensile strength which occurred with mordanted wool samples dyed with Madder is better than the decline of tensile strength which occurred with cochineal and Turmeric during the time of exposure to air and light (12 months). Finally, the tensile strength for mordanted wool samples dyed with Madder using different kinds of mordants follows the order: copper salt > tin salt > iron salt > alum salt.

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Effect of time of exposure to air and light on the Tenacity for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: Figure 4 shows that, a severe decline in the tenacity of the mordanted dyed wool yarns with cochineal using different kinds of salts (iron, copper, alum and tin salts) is occurred with increasing time of exposure. A complete damage of tenacity is occurred for the mordanted wool yarns with all mordants used during the exposure time (12 months). Also, a complete decline of tenacity is occurred for the cochineal dyed yarns mordanted with copper salts after 9 months from exposure to air and light comparing to the standard.

It can be observed from Figure 5 that, a severe decline in the tenacity of the mordanted dyed wool yarns with turmeric using different kinds of salts (iron, copper, alum and tin) is occurred with increasing time of exposure to air and light. Also, a complete damage of tenacity is occurred for the dyed mordanted wool yarns with turmeric using tin salts after 9 months of exposure time comparing to the standard.

From Figure 6, it can be concluded that, a severe decline in the tenacity of the mordanted wool samples dyed with madder using copper salt is occurred with increasing time of exposure comparing to the standard. Good results regarding the tenacity of the mordanted wool samples dyed with madder using different kinds of salts (iron, copper, alum and tin) are obtained with increasing time of exposure comparing to the standard. Also, a gradual damage of tenacity is occurred for the dyed mordanted wool yarns with different kinds of salts (iron, copper, alum and tin) during the exposure time (12 months).

Finally, the tenacity for mordanted wool samples dyed with madder using different kinds of mordants follows the order: alum salt > tin salt > iron salt > copper salt. To sum it all up, the tenacity of mordanted wool yarns dyed with madder is the best one among the tenacity of other mordanted wool yarns dyed with Cochineal or Turmeric, due to its small decline during all periods of exposure time to air and light.

Effect of time of exposure to air and light on the Elongisity for mordanted wool yarns dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder using different salts in Kalla region: It can be observed from Figure 7 that, a severe decline in the elongisity of the mordanted dyed wool samples with cochineal using different mordants (iron, copper, alum and tin) salts occurs with increasing time of exposure to air and light comparing to the standard. Also, a complete decline of elongisity is happened for the mordanted wool yarns dyed with cochineal using iron and copper salts after 9 months from beginning of exposure to air and light comparing to the standard. Moreover, the elongisity for mordanted wool yarns dyed with cochineal using different mordants follows the order: alum salt > tin salt > iron salt > copper salt during all periods of exposure time to air and light.

Figure 8 shows that, a severe decline in the elongisity of the mordanted dyed wool yarns with turmeric using different mordants (iron, copper, alum and tin) salts occurs with increasing time of exposure to air and light comparing to the standard. Also, a complete

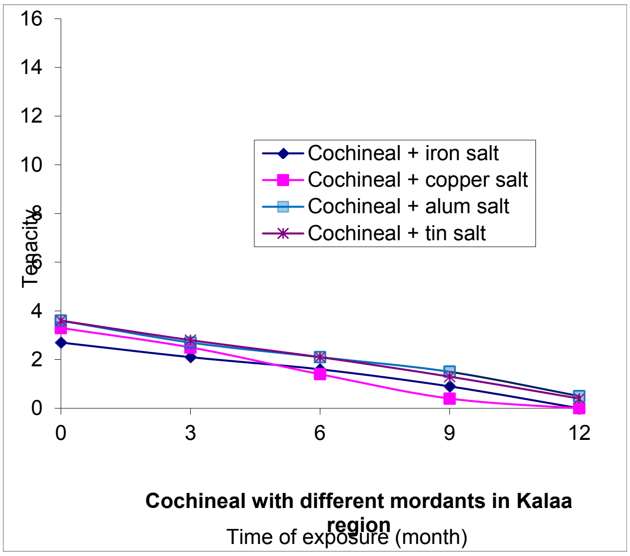

Figure 4: Effect of time of exposure to light on the Tenacity of the dyed mordanted wool yarns with Cochineal

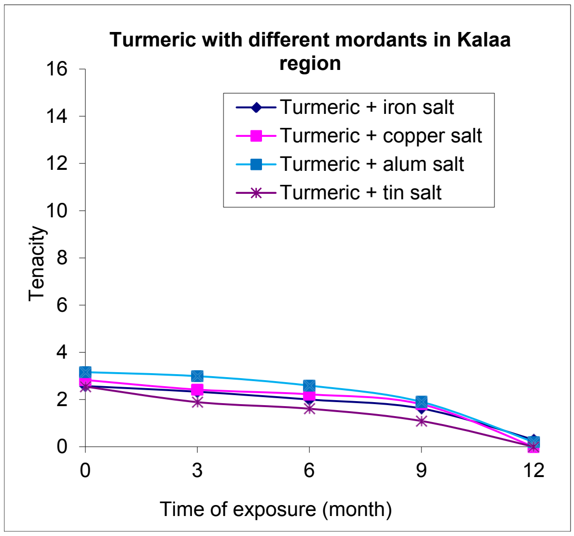

Figure 5: Effect of time of exposure to light on the Tenacity of the dyed mordanted wool yarns with Turmeric.

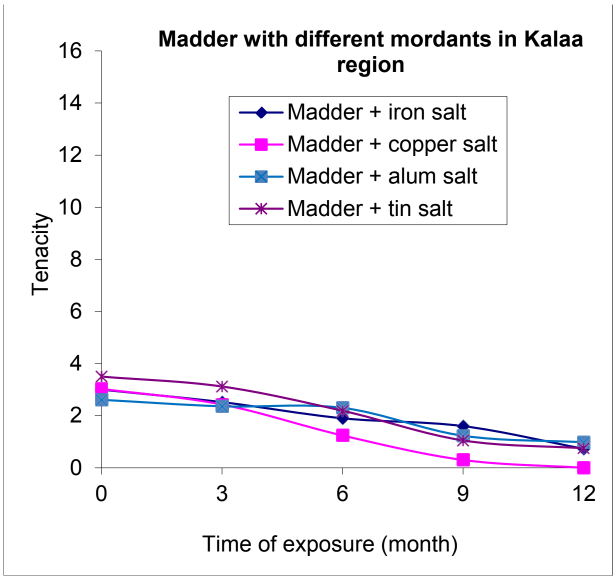

Figure 6: Effect of time of exposure to light on the Tenacity of the dyed mordanted wool yarns with Madder.

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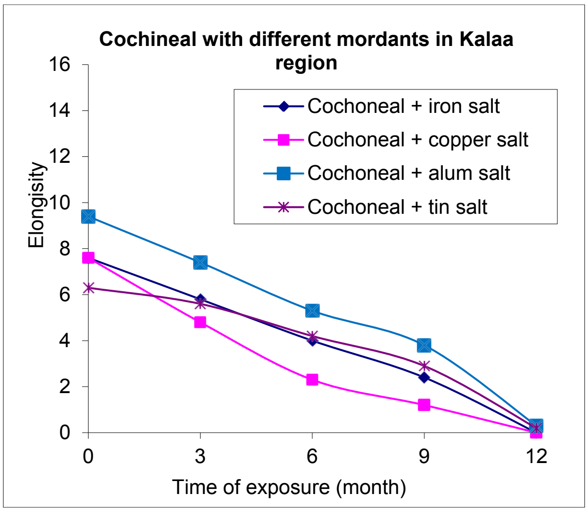

Figure 7: Effect of time of exposure to light on the Elongisity of the dyed mordanted wool yarns with Cochineal.

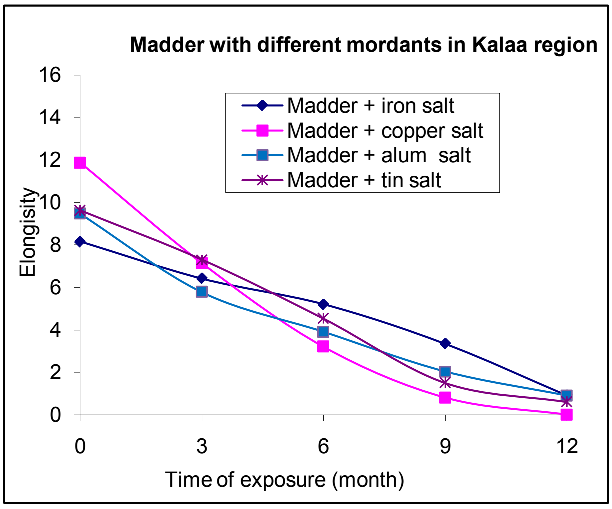

Figure 9: Effect of time of exposure to light on the Elongisity of the dyed mordanted wool yarns with Madder.

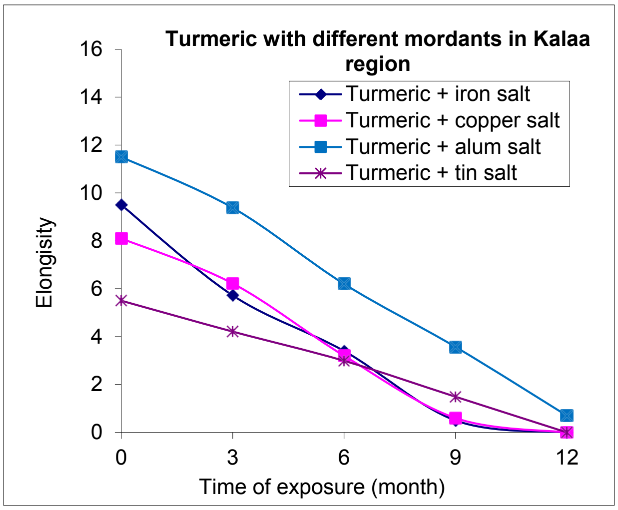

Figure 8: Effect of time of exposure to light on the Elongisity of the dyed mordanted wool yarns with Turmeric.

decline of elongisity is happened for the mordanted wool samples dyed with turmeric using copper and iron salts after 9 months from beginning of exposure to air and light comparing to the standard. In addition, the highest elongisity of mordanted wool samples dyed with turmeric salts using different mordants is alum salt then the rest of all salts after full time of exposure to air and light (after 12 months).

From Figure 9, it can be seen that, a severe decline in the elongisity of the mordanted dyed wool yarns with madder using different mordants (iron, copper, alum and tin) salts occurs with increasing time of exposure to air and light comparing to the standard. Moreover, a complete decline of elongisity is happened for the mordanted wool samples dyed with madder using copper salt after 12 months from the beginning of exposure to air and light comparing to the standard. Also, a gradual damage of elongisity is happened until it reach the complete damage of elongisity for the mordanted wool yarns dyed with madder using tin and copper salts after full time of exposure to air and light (12 months). Moreover, the elongisity for mordanted wool samples dyed with madder using different kinds of mordants follows the order: iron salt > alum salt > tin salt > copper salt during all periods of exposure time to air and light.

Finally, the elongisity of mordanted wool yarns dyed with madder is the best one among the elongisity of other mordanted wool yarns dyed with cochineal or turmeric, due to its gradual decline during all periods of exposure time to air and light.

Conclusion

Kalla region (residential site) is highly polluted with a suspended dust comparing to Helwan city(industrial area) [36]. While Helwan city (industrial area) is highly polluted with fine particles and SO_2 more than Kalla region (residential site). The values of change of colour (ΔE) of mordanted wool yarns dyed with madder are the lowest one among other yarns dyed with cochineal or turmeric. From these results, it can be concluded that the light fastness for wool yarns dyed with madder is the best one among other wool yarns dyed with cochineal or turmeric. Using different mordants as well as different kinds of sources of dyes for mordanted dyed wool yarns gives beautiful colorful wide range of hues.

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