IMPACT OF AIR POLLUTION ON THE COLOUR & PHYSICAL PROPERTIES OF THE MORDANTED WOOL YARNS DYED WITH NATURAL DYES IN URBAN AREA

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Abstract

Wool yarns are dyed with natural colouring matter extracted from Cochineal, Turmeric and Madder and mordanted with different mordants using exhaustion method. Many measurements of the mordanted dyed wool samples after exposure to air & light for different periods of time in one year in urban area (Helwan city) has been carried out. These measurements are change of colour, physical properties (tensile strength, tenacity and elongation) of the mordanted dyed wool samples. Also, the air pollution in Helwan city was studied, through determination of the suspended and deposited particulate matter and sulpher dioxide concentrations.

Keywords: Wool yarns- Natural dyes- Mordants-Air pollution

Introduction

In recent years, growing interest in the revival of natural dyes has been manifested. This interest is the result of a worldwide movement to protect the environment for indiscriminate exploitation and pollution by industries. Natural dyes are considered to be complementary and not conflictive with the use of manufactured dyes in the textile industry as a whole. The Cochineal (red dye), the Turmeric (yellow dye) and Madder (red dye) are extracted from (Daclylopius coccus) bug, (Curcuma longa. L, rotunda. L) plant and (Rubia tinctorum) plant respectively. The present work is carried out to measure and evaluate the change of colour of dyed wool samples after exposure to air and light in urban area (Helwan city)(Miquel, 2002; Saravanan, 2006; Thakore, 1990; Ammon, 1991; Buescher, 2000; Kamel, 2005; Kamel, 2007; Kamel, 2008 and Kamel, 2009). 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.

Mordants:

The following mordants were used: alum salt, copper salt, tin salt and iron salt. They were of pure grade chemicals (Gogoi, 1997; Hill, 1997).

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 17 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 (Dalby, 1993).

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 immersed in 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 (Ansuri, 2000; Moses, 2000; Teli, 2000).

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 and copper salt. The mordant (2 g/L concentration) was dissolved and added to the mordanting bath. Then wetted wool samples were added to the mordanting bath with liquor ratio 1:50 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 instantaneous because some mordants are very sensitive to light.

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 dyeing process. The fabrics were lifted out while the 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 (Deo, 1999; Katyayini, 1999; Gulrajani 1993).

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 the city center of Helwan industrial district in Helwan city. It is located north east the industrial area (it up wind the industrial 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 Helwan city, 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 (Stern, 1986). Dust fall collectors were used for collecting dust fall samples as previously used in Egypt (Shakour, 2001). The collectors consist of cylindrical glass beakers 17cm 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 was used (Harrison, 1986). Determination of sulpher dioxide: West and Gaeke method was used for the determination of SO_2 (Stern, 1986). Air was aspirated (one liter / minute) through a glass bubbler sampler containing 50ml of absorbing solution (0.1M 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 nm (EL-Taieb, 2003).

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 colour measurement committee, 1976).

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

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

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* & 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.

$$H = \arctan b^*/a^* \quad \text{Eq. (2)}$$

$$C = [(a^*)^2 + (b^*)^2]^{1/2} \quad \text{Eq. (3)}$$

Where:

(H) Indicates hue of colour

(C) Indicates the colour chroma (saturation of colour)

Physical measurement:

The physical properties (tensile strength- tenacity- elongation) are measured for the mordanted dyed yarn samples with Cochineal, Turmeric and Madder using "Uster tensorapid tester" apparatus.

Results & 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 Helwan city during the year of study was illustrated in table (1). Table (1) shows that the annual mean rate of deposited dust was 19.32 g/m^2 per month. According to Pennsylvania guidelines for dust-fall, these values are considered a heavy deposition rates.

Pennsylvania guidelines for dust-fall (Stern, 1976).

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 industrial area over Helwan city atmosphere was 334.8 µg/m³ this concentration is about 7 times higher than the value of 50 µg/m³ concentration limit of US National Ambient Air Quality Standards, which is the same value recommended by U.K. Expert Panel on Air Quality Standards. It is also about five times higher than the maximum allowable concentration that is given by the Egyptian Environmental Law No. 4, 1994 (70µg/m³) (EEAA, 1994).

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 spring. Although there is a certain level of dust in the air at all times. The amount and type of dust varies considerably and depends on many factors including source, climate, wind direction, and traffic. Dust is generated from many 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.

Sulphur 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 investigated site are given in table1. From this table it can be noted that sulpher dioxide concentrations greatly varied from one season to the other maximum concentration of 111.38 was recorded during winter. While annual mean concentrations of sulpher dioxide, reaching 72.68 µg/m³. These concentrations were higher than the values of 60µg/m³ set by the Egyptian limit for the annual concentration of SO_2 (EEAA, 1994). While, it was less than the primary US National Ambient Air Quality Standard (80 µg/m³) for SO_2 (Colls, 1997; Heinsohn, 1999). Sulpher in the atmosphere originate either from natural processes or anthropogenic activity (Viney, 2001). Fuel combustion as well as metal production are the dominant sources for SO_2 emissions into the atmosphere.

Table 1: Seasonal variation rate of deposition of dust-fall, Suspended dust concentration and SO_2 over the investigated site during year 2004

Season	rates of deposition (g/m^2.month)	Suspended dust concentration ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)
Winter	19.18	328.6	111.38
Spring	19.88	381.0	60.14
Summer	19.31	267.3	44.6
Autumn	18.90	362.3	74.6
Annual mean	19.32	334.8	72.68

Measurements of color data (CIE L, a*, b*) in Helwan region:*
Change of colour (ΔE):

The change of colour difference (ΔE) changes with increasing the time of exposure to air and light for the three sources of dyes after one year. From table (2)It can be observed that (ΔE)for the mordanted wool samples dyed with Cochineal using alum salt shows a higher change of values, while Iron salt shows a lowest change of values all over the periods of the year. In table (3)It can be observed that (ΔE)for the mordanted wool samples dyed with Turmeric using alum salt shows a higher change of values, while copper salt shows a lowest change of values all over the periods of the year. Finally, table (4)indicated that (ΔE)for the mordanted wool samples dyed with Madder using alum salt shows a higher change of values, while Iron salt shows a lowest change of values all over the periods of the year.

(L) values:*

Tables (2, 3 and 4) gives the (L*, a*, b* values) for the three sources of dyes. From table (2), it can be concluded that lightness (L*values) for the mordanted wool samples dyed with 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 becomes darker after one year 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 Turmeric, become darker comparing to standard sample in case of using Iron, alum or tin salts after one year of exposure to air and light. But in case of using copper salt, the lightness is almost the same.

It is clear from table (4), that the lightness (L*values) for the mordanted wool samples dyed with Madder, has no change of lightness comparing to standard sample in case of using Iron, copper, alum or tin salts after one year of exposure to air and light.

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 Helwan region

Type of salt	Colour data	standard*	3 months	6 months	9 months	12 months
Iron salt	L*	28	29	28	29	31
	a*	-4	-4	-3	-3	-5
	b*	-36	-33	-32	-32	-29
	ΔE	0	3.16	4.12	4.24	7.7
	H	264	263	265	264	260
	C	35	33	32	32	29
Copper salt	L*	38	41	39	40	44
	a*	-4	-6	-8	-9	-10
	b*	-32	-29	-28	-27	-21
	ΔE	0	4.7	5.7	7.3	13.9
	H	263	258	254	252	242
	C	32	30	29	28	23
Alum salt	L*	40	37	38	42	35
	a*	27	16	15	6	7
	b*	-33	-33	-34	-33	-32
	ΔE	0	11.4	12.2	21.1	20.6
	H	231	244	246	260	258
	C	43	37	37	34	33
Tin salt	L*	43	42	41	39	38
	a*	27	18	16	13	12
	b*	-16	-24	-25	-25	-26
	ΔE	0	12	14.3	17.1	18.7
	H	211	233	237	243	245
	C	31	30	30	28	29

(*)Without exposure to air & light

Hue of colour values (H):

Table (2) shows that (H) values for wool samples dyed with Cochineal using Iron salt are almost the same during all periods of exposure to air and light, but in case of using copper salt the (H) values are shifted towards green axis. This may be because copper ion causes a bathochromic shift of the long wave length absorption bands of Cochineal. While in case of using alum or tin salts the (H) values are shifted towards Blue axis after exposure to air and light for one year.

From table (3) it can be observed that (H) values for wool samples dyed with Turmeric using Iron salt, alum salt or tin salt show no change of colour Hue (H) after time of exposure (12 months). While, in case of using Copper salt, the (H) values is shifted towards Blue axis after exposure to air and light for one year. This may be due to that UV visible spectra of Turmeric in the present of copper ion show significance changes occurred in the band absorbing at the longest wave length, and these changes were characteristic of the copper ion. Copper ion also causes a bathochromic shift of the long wave length absorption bands of Turmeric.

It is observed from Table (4) that (H) values for wool samples dyed with Madder using alum and tin salts show a shift of colour Hue (H) in the direction of Blue axis. This may be because alum and tin ions cause a bathochromic shift of the long wave length absorption bands of Madder. But in case of using iron or copper salts, the (H) values are almost the same during all periods of exposure to air and light.

Chroma values (C):

It is observed from table (2) that the chroma values (C) for all wool samples dyed with Cochineal using copper and alum salts decrease with increasing the time of exposure to air and light. But in case of using Iron and Tin salts, the chroma values (C) is almost the same during the all periods of exposure to air and light (one year).

It can be seen from table (3) that chroma values (C) for wool samples dyed with Turmeric using iron and copper salts increase with increasing the time of exposure to air and light. But in case of using alum and tin salts, the chroma values (C) is almost the same during the all periods of exposure to air and light (one year).

Table (4) shows that, chroma values (C) for wool samples dyed with Madder using tin salt shows a decrease with increasing the time of exposure to air and light.

But in case of using iron salt, copper salt or alum salt, the chroma values (C) is almost the same during the all periods of exposure to air and light (one year).

Physical measurements:

Tensile strength (B-force):

From figure (1), it can be seen that, a full damage of tensile strength is occurred for the mordanted dyed samples with Cochineal using iron, copper, alum and tin salts after 12 months from exposure to air and light compared to the standard. This result may be attributed to the long exposure to air and light (12 months) which have a pronounced effect on mordanted dyed wool samples especially photo-oxidation or degradation of cystine linkages present in the epicuticle and due to that a full damage of tensile strength was occurred compared to the standard sample (Shao, 1997) . Finally, the tensile strength for mordanted wool samples dyed with Cochineal using tin salt is the highest value among all salts used after full time of exposure (12 months). This result may be due to the highest strength of the cochineal / tin salt complex according to its dark colour which provide a minor protection against light (UV rays) and air and also the cystine linkage and due to that the tensile strength shows the highest value (Gies, 1994).

It is observed from figure (2), that, a severe decline of tensile strength for the mordanted dyed samples with Turmeric is occurred with all mordants used (iron, copper, alum and tin salts) after exposure to air and light for 12 months compared to the standard. Finally, the tensile strength for mordanted wool samples dyed with Turmeric using tin salt is the highest salt among all salts used after full time of exposure (12 months).

Figure (3), shows that, a gradual decline of tensile strength occurred with all mordants used (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 occurred with Cochineal and Turmeric during the time of exposure to air and light. This result may be attributed to the pale colours of mordanted wool samples dyed with madder compared to the dark colour complexes of cochineal and turmeric. The pale coloured mordanted wool samples absorb less intense UV radiation and also gave more protection against the cystine linkages

present in the epicuticle and due to that, the decline of tensile strength is better (Reinert, 1997)

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 Helwan region

Type of salt	Colour data	standard*	3 months	6 months	9 months	12 months
Iron salt	L*	60	44	55	56	43
	a*	-10	-9	-10	-11	-9
	b*	-22	-29	-31	-32	-33
	ΔE	0	7.7	10.3	10.8	20.3
	H	246	253	252	251	255
	C	24	30	33	34	34
Copper salt	L*	49	46	47	48	44
	a*	-16	-15	-16	-15	-13
	b*	-7	-16	-16	-18	-20
	ΔE	0	9.5	9.2	11	12.5
	H	204	227	225	230	237
	C	17	22	23	23	24
Alum salt	L*	67	53	53	52	49
	a*	-10	-11	-11	-11	-11
	b*	-25	-29	-28	-29	-29
	ΔE	0	15	14	16	18
	H	248	249	249	249	249
	C	27	31	30	31	31
Tin salt	L*	62	54	52	52	51
	a*	-10	-10	-10	-9	-9
	b*	-23	-27	-29	-29	-30
	ΔE	0	10.6	11.7	11.7	13.1
	H	247	250	251	249	253
	C	25	29	31	31	31

(*) Without exposure to air & light

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 Helwan region

Type of salt	Colour data	standard*	3 months	6 months	9 months	12 months
Iron salt	L*	32	31	31	30	30
	a*	-1	-1	-1	-1	-2
	b*	-21	-22	-22	-22	-23
	ΔE	0	1.4	1.4	2.5	3
	H	267	269	268	265	265
	C	21	22	22	22	23
Copper salt	L*	38	37	36	36	35
	a*	-3	-1	-1	-1	-1
	b*	-21	-20	-20	-19	-19
	ΔE	0	4.5	4.3	5.9	4.1
	H	261	267	267	264	267
	C	20	20	21	19	20
Alum salt	L*	40	40	36	38	38
	a*	15	13	12	11	10
	b*	-11	-11	-14	-14	-16
	ΔE	0	3.6	5.1	5.4	7.4
	H	216	227	233	232	238
	C	19	19	20	18	19
Tin salt	L*	41	41	39	38	38
	a*	14	12	12	11	9
	b*	-3	-3	-4	-4	-5
	ΔE	0	2	2.9	4.3	5.5
	H	192	194	198	195	209
	C	19	15	13	11	10

(*) Without exposure to air & light

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

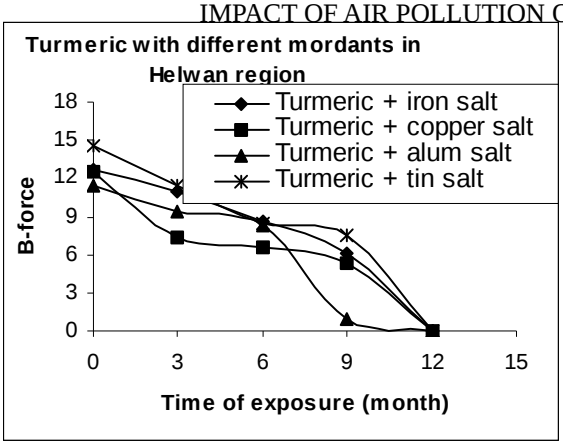

Fig. 2: Effect of time of exposure to light on the tensile strength (B-Force) of the dyed mordanted wool yarns with Turmeric.

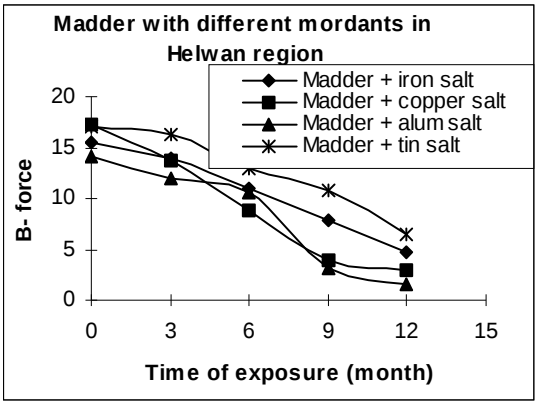

Fig. 3: Effect of time of exposure to light on the tensile strength (B-Force) of the dyed mordanted wool yarns with Madder.

Tenacity:

Figure (4) shows that, a severe decline in the tenacity of the mordanted dyed wool samples with Cochineal using different kinds of salts (iron, copper, alum and tin salts) is occurred with increasing time of exposure. A complete decline of tenacity is occurred for the Cochineal dyed samples mordanted with iron, copper and alum salts during the exposure time to air and light comparing to standard samples. Finally, the tenacity for mordanted wool samples dyed with Cochineal

using tin salt is the highest salt among all salts used after full time of exposure (12 months).

It can be observed from figure (5) that, a severe decline in the tenacity of the mordanted dyed wool samples with Turmeric using iron and tin salts is occurred with increasing time of exposure to air and light comparing to standard samples. Finally, the highest tenacity of mordanted wool samples dyed with Turmeric salts using different salts are iron salt after full time of exposure to air and light (12 months).

From figure (6), it can be concluded that, a gradual damage of tenacity of the mordanted wool samples dyed with Madder using (iron, copper, alum and tin salts) is occurred with increasing time of exposure (12 months). Finally, the tenacity for mordanted wool samples dyed with Madder using different kinds of mordants follows the order: tin salt > iron salt > alum salt > copper salt. However, the tenacity of mordanted wool samples dyed with Madder is better than the tenacity of mordanted wool samples dyed with Cochineal and Turmeric, due to its gradual decline during all the time of exposure to air and light. This result may be due to that mordanted wool samples dyed with cochineal and turmeric in deeper shades and darker colours which show a pronounced effect after exposure to air and light for 12 months and due to that the decline of tenacity was higher (Gies, 1994).

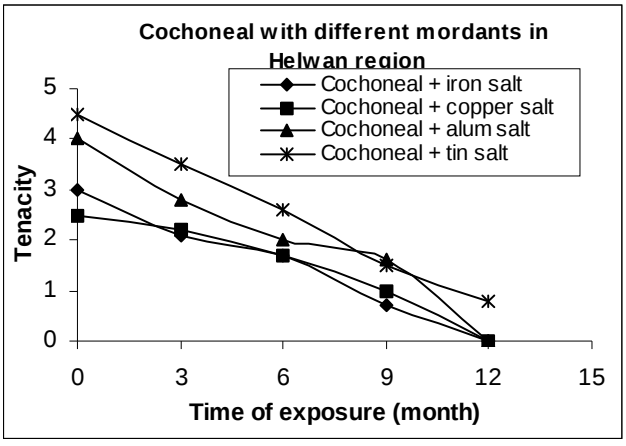

Fig. 4: Effect of time of exposure to light on the Tenacity of the dyed mordanted wool yarns with Cochineal.

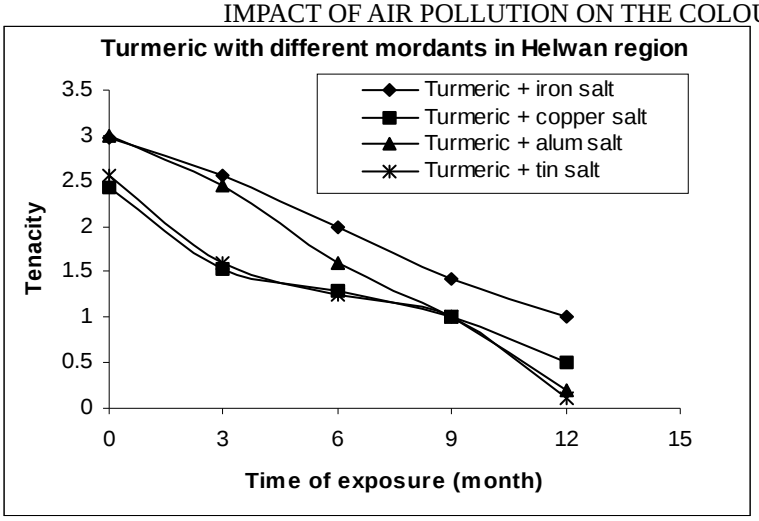

Fig. 5: Effect of time of exposure to light on the Tenacity of the dyed mordanted wool yarns with Turmeric.

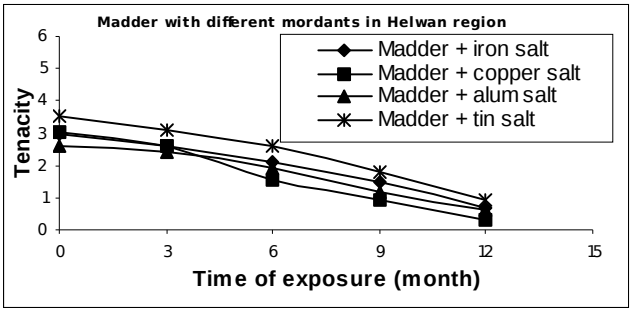

Fig. 6: Effect of time of exposure to light on the Tenacity of the dyed mordanted wool yarns with Madder.

Elongation:

It can be observed from figure (7)that, a gradual decline in the elongation of the mordanted dyed wool samples with Cochineal using different kinds of salts (iron, copper, alum and tin) occurs with increasing time of exposure to air and light comparing to standard samples. Also, a complete decline of elongation is happened for the mordanted wool samples dyed with Cochineal using copper and alum salts after 12 months from beginning of exposure to air and light comparing to standard samples. However, the highest elongation of mordanted wool samples dyed with Cochineal salts using different salts is iron salt then the rest of all salts after full time of exposure to air and light (after 12 months).

Figure (8)Shows that, a severe decline in the elongation of the mordanted dyed wool samples with Cochineal using (iron, copper, alum and tin)occurs with increasing time of exposure to air and light comparing to standard samples. Also, a complete decline of elongation is happened for the mordanted wool samples dyed with Turmeric using alum and tin salts after 9 months from beginning of exposure to air and light comparing to standard samples. However, the highest elongation of mordanted wool samples dyed with Turmeric salts using different salts is copper 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 gradual decline of elongation of the mordanted dyed wool samples with Madder using different kinds of salts (iron, copper, alum and tin) occurs with increasing time of exposure to air and light (1-12 months) comparing to standard samples. This result may be attributed to the long exposure to air and light which have a pronounced effect on mordanted dyed wool samples especially photo-oxidation or degradation of cystine linkages present in the epicuticle and due to that a complete decline of elongation was occurred compared to the standard sample (Shao, 1997). Finally, the elongation for mordanted wool samples dyed with Madder using different kinds of mordants follows the order: tin salt > alum salt > iron salt > copper salt.

However, the elongation of mordanted wool samples dyed with Madder is better than the elongation of mordanted wool samples dyed with Cochineal and Turmeric, due to its gradual decline during all the time of exposure to air and light.

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

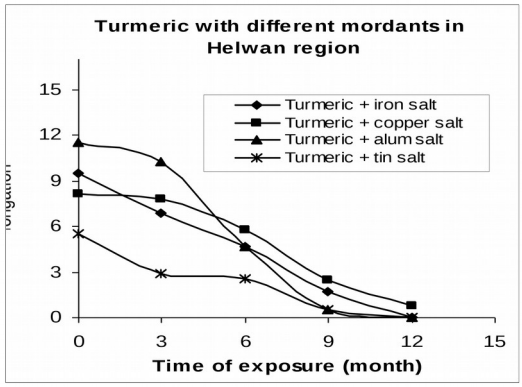

Fig. 8: Effect of time of exposure to light on the Elongation of the dyed mordanted wool yarns with Turmeric.

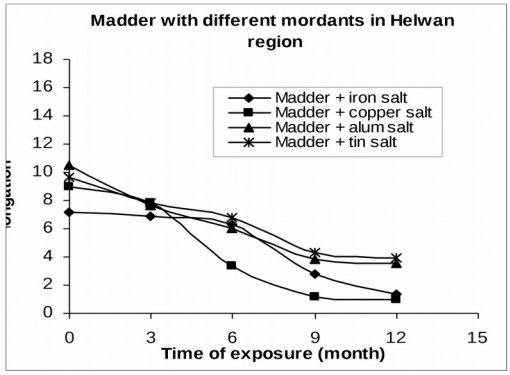

Fig. 9: Effect of time of exposure to light on the Elongation of the dyed mordanted wool yarns with Madder.

Conclusion

- Helwan city is highly polluted with fine particles and sulphur dioxide.

- The change of colour (ΔE) increases with increasing the period of exposure to air and light for the three sources of dyes. In addition to this, the lightness (L*values) for the mordanted wool samples dyed with cochineal, become lighter comparing to standard sample in case of using Iron or copper salts. Also, (a*) values for all wool samples dyed with cochineal using Iron salt 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 salt the change of colour in the direction

of green region increases. Also, it can be observed that (b*) values for all wool samples dyed with cochineal using iron and copper salts show a decrease in the direction of blue region, but in case of using tin salt an increasing in the direction of blue region is happened, and there is no change in colour happened in case of using alum salt.

- The Physical measurements show that there is a severe decline happened in the tensile strength for the mordanted dyed samples with turmeric using alum and tin salts after certain exposure time (6, 9 months) from exposure to air and light compared to the standard. Finally, the tensile strength for mordanted wool samples dyed with turmeric using copper salt is the highest salt among all salts used after full time of exposure (12 months).

- Meanwhile, there is a severe decline in the tenacity of the mordanted dyed wool samples with cochineal using different kinds of salts (iron, copper, alum and tin) is occurred with increasing time of exposure. Also, a complete decline of tenacity is occurred for the cochineal dyed samples mordanted with alum and Iron salts after 9 months from exposure to air and light comparing to standard samples. Also, a gradual damage of elongation is happened until it reach the complete damage of elongation for the mordanted wool samples dyed with tin, iron and alum salts during the exposure time (12 months).

- The change of colour (ΔE) of mordanted wool samples dyed with dyes extracted from madder is the lowest one among other samples dyed with dyes extracted from cochineal and turmeric. Therefore, the light fastness for samples dyed with madder is the best one among the other sources of dyes.

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References

1. AMMON, H.P.T., WAHL, M.A. 1991 "Pharmacology of Curcuma longa", *Planta Med*., vol. 57, pp. 1-7.
2. ANSARI, A.A. AND THAKUR, B.D. 2000 "Extraction, Characterisation & Application of a Natural Dye: The Eco-friendly Textile Colorant", *Colourage*, vol. 47, no. 7, pp. 15-20.
3. BUESCHER, R., YANG, L., LAURO, G.J., FRANCIS, F. J. 2000, "Turmeric In Natural Food Colorants", *Science and Technology*, NY, pp. 205-226.
4. COLLS, J. 1997, "*Air pollution:* An introduction", 1st Edition, London, E & FN SPON.
5. DALBY, GILL 1993, *"Greener mordants for natural coloration" J. Soc. Dyers & Colorists*, vol. 109, no. 1, pp. 8-9.
6. DEO, H.T., DESAI, B.K., (1999) "Dyeing of cotton and jute with tea as a natural dye" *J.S.D.C.*, 115, 7/8, 224-228.
7. *Egyptian Environmental Affair Agency* (EEAA) 1994, Environmental Protection Law No.4.
8. EL-TAIEB, N.M. AND SHAKOUR, A.A. AND SALEH, I.A. 2003, "Study of the effects of air pollution on textiles exposed to Cairo's ambient atmosphere", *Int. J. Environmental and pollution*, vol. 19, no. 6, pp. 1-12
9. GIES, H.P., RAY, C.R., ELIOT, G., WANG, Z. 1994, "Ultraviolet radiation factors for clothing", *Health physics*, vol. 67, no. 2, pp. 131-139.
10. GOGOI, A., AHMED, S.S., BARUA, N. 1997, "Natural Dyes & Silk", *The Indian Text. J.*, vol. 8, pp. 64-68.
11. GULRAJANI, M.L., DEEPTI, B.,GUPTA PREETI AND KUMARI, A. 1993, "Dyeing with red natural dyes", *The Ind. Text. J.*, vol.103, no. 5, pp. 90-96.
12. HEINSOHN, R.J. AND. KABEL, L. R. 1999, "*Sources and control of air pollution"*, (stenquist, B. and Horton, M.eds.). Prentice-Hall, Inc. Upper Saddle River, New Jersey, USA.
13. HILL, D.J. 1997, "Is there a future for natural dyes?", REV. PROG. *Coloration*, vol.27, pp. 18-25.
14. KAMEL, M.M., EL-SHISHTAWY, R. M., YOUSSEF, B.M. AND MASHALY, H. 2005, "Ultrasonic Assisted Dyeing III. Dyeing of Wool with Lac as a Natural Dye", *Dyes and Pigments*, vol. 65, no. 2, pp. 103-110.

15. KAMEL, M.M., EL-SHISHTAWY, R. M., YOUSSEF, B.M. AND MASHALY, H. 2007, "Ultrasonic assisted dyeing. IV. Dyeing of cationised cotton with lac natural dye", *Dyes and Pigments*, vol. 73, no. 3, pp. 279-284.

16. KAMEL, M.M., YOUSSEF, B.M. AND HELMY, H. M. 2008, "Dyeing of cotton fabrics using Some Natural Dyes Part II: Some studies on dyeing properties of cotton fabrics using Chelidonium majus (roots)", *Egyptian Journal of Chemistry*, vol. 51, no. 1, pp. 141-157

17. KAMEL, M. M., EL-HOSSAMY, M., HELMY, H. M. AND EL-HAWARY, N.S. 2008, "Some studies on dyeing properties of cotton fabrics with Curcuma Longa (turmeric) (roots) using ultrasonic method", *Polish journal of applied chemistry*, vol. LII, no. 1-2, pp. 101-121.

18. KAMEL, M.M., EL-ZAWAHRY, M.M., AHMED, N.S.E., ABDELGHAFFAR, F. 2009, "Ultrasonic dyeing of cationized cotton fabric with natural dye. Part 1: Cationization of cotton using Solfix E", *Ultrasonics Sonochemistry*, vol. *16, no. 2*, pp. *243-249*.

19. KATYAYINI, V.K.L.T., JACOB M., 1999, "Dye extraction from mesta calyx and its assessment", *Colourage*, vol. 46, *no*. 7, pp. 39-43.

20. MIQUEL, J., BERND, N., SEMPERE, J.M., DIAZ-ALPERI, J., RAMIREZ, A. 2002, **"**The curcuma antioxidants: pharmacological effects and prospects for future clinical use", *Arch Gerontol Geriatr.*, vol. 34, no. 1, pp. 37-46.

21. MOSES, J.J. 2000, "Natural dye & jute/cotton fabric", *The Ind. Text. J.*, vol. 110, no. 4, pp. 48-51.

22. REINERT, G., FUSO, F., HILFIKER, R., SCHMIDT, H. 1997, "UV- protecting properties of textile fabrics and their improvement", Textile Chemist and colorist, vol. 29, no.12, pp. 36-43.

23. SARAVANAN, D. 2006, "Ultrasonics assisted textile processing – An update", *Colourage*, vol. LIII, no. 4, pp. 111-116.

24. SHAKOUR, A.A., HASSANIEN, M.A. AND EL-TAIEB, N.M. 2001, "Atmospheric Heavy Metals in The Industrial Area North Cairo", Egypt, *Central European Journal of Occupational and Environmental Medicine*, vol. 7, no. 3-4, pp. 245-252

25. SHAO, J., HAWKYARD, C.J. AND CARR, C.M. 1997, "Investigation into the effect of UV/ozone treatments on the dyeability and printability of wool", JSDC, vol. 113, no. 4, pp. 126-130.

26. SHAO, J., JONES, D.C., MITCHELL, R., VICKERMAN, J.C. AND CARR, C.M. 1997, "Analyses of the Surface Lipids of Wool", J. Textile Inst., Vol. 88, No. 4, pp. 317- 324.

27. STERN, A.C. 1976, *Air Pollution* (3rd Ed) Vol.11.Academic Press. Inc. New York.

28. STERN, A.C. 1986, *Air Pollution* (3rd Ed) Vol.V1.Academic Press. Inc. New York.

29. TELI, M.D.; PAUL, R. AND PARDESHI, P. D. 2000, "Natural Dyes: Classification, Chemistry and Extraction Methods", *Colourage*, vol. 47, no. 12, pp. 43-48.

30. THAKORE, K. A., SMITH, C.B. 1990, "Application of ultrasound to textile wet processing", *American Dyestuff Reporter*, vol. 10, pp. 30-38.

31. The colour measurement committee 1976, "The SDC Recommended colour difference Formula: Change to CIELAB", *JSDC*, no. 9, pp. 337-343.

32. VINEY, P., ANEJA, A., AGARWAL PAUL, A., ROELLE, SHARON, B. PHILLIPS, Quansong Tong, Nealson Watkins, Richard Yablonsky. 2001, *Environment International*, vol. 27, no. 1, pp. 35-42.