UNRAVELLING SOURCES OF ORGANIC DYES FOR TEXTILE: AN APPRAISAL OF APPROACHES AND ECO-FRIENDLY APPLICATIONS

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Abstract: Usually organic dyes come from plants including roots, berries, bark, leaves, and wood. Novel organic dye signifies as environment-friendly, non-polluting, safe and substitution of synthetic dyes for fabrics in textile industries. The effects of natural dyeing with their safe non-toxic, non-allergic, and non-carcinogenic soothing effects are regarded to be very promising. These dyes are both less expensive and environmentally friendly. Hence, natural colorations are desirable: To save the environment by cultivating massive plantation, to a healthier and safer life for human civilization and to decrease pollution issues by synthetic dyes. This paper is a detailed study of application of natural dyes on synthetic fabrics. Synthetic fabrics dyeing with natural dyes requires pre-treatments, post treatments, fabric scouring, mordanting to generate quality product. It focuses on different procedures employed to conduct dyeing synthetic fabrics using natural dyes.

Index Terms **- Eco-friendly, Mordant, Organic dye, Textile**

I. INTRODUCTION

Natural dyes or colorants derived from flora and fauna are believed to be healthy due to nature's non-toxic, non-carcinogenic, and bio-degradable. In addition, natural dyes do not cause pollution or wastewater problems. As the current movement shifts across the globe towards the use of environmentally friendly and biodegradable products, demand for natural colors is growing daily. [1]

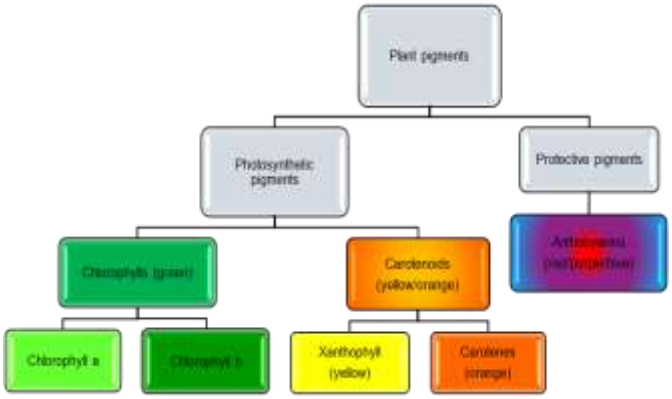


Figure 1: Pigments of Photosynthesis with different shades

Natural colors slacked popularity because synthetic colors had some advantages over natural colors like fastness of color, good reproducibility of shades, color beauty and easy to use. [2] Natural colors, since prehistoric times, have been used in fruit, leather and textiles. [3] The demand for eco-friendly and non-toxic dyes is growing.[4] Coloring derived from natural sources has emerged as an important alternative to toxic synthetic coloring for applications such as food and clothing dyes.[5,28] Plants typically have fewer coloring components on water extraction for coloring component on water extraction for textile coloring. Therefore, the yield of natural dyes influences the cost of production, which is also one of the factors restricting the use of natural dyes compared to synthetic colors. Synthetic dyes have significant environmental implications in their short history. Developed countries such as Germany, the Netherlands and France have banned particular synthetic colors since 1956 because of their carcinogenic, allergic, polluting and environmental hazards. [6] Hence, For textile coloring, people turned to environmentally friendly, non-allergic, non-carcinogenic and safe natural colors.[7] Environmentalists are also concerned about the widespread use of synthetic colors in the textile sector, because they cause problems with water pollution and its disposal.[8] On the plant coloring includes removing the mordants on the fabrics. The different mordants, including alum, copper sulphate, iron sulphate, potassium dichromate, stannic and stannic chloride, were used to bind natural colors to cotton , wool and silk.[9] It has been shown that natural colors from plants such as *Syzydium cumini*, *enna*, Tea, *Foeniculum vulgare* and from fungi sources such as *Monascus purpureus*, *Isaria farinosa*, *Emericella nidulans*, *Penicillium purpurogenum* are effective in coloring. [10,11,12,13,14,15] Yet only 1% of all textiles are produced in natural colors.[16] The aim behind this review paper is to compare the color fastness properties of natural dyes using various chemical mordants and to highlight the application of environmentally friendly dyeing.

II. DYEING TECHNIQUES

Different dyeing methods add color to the fabric for various types of fabrics and at different stages of the textile manufacturing process. Dyeing can be done at any time during the textile manufacturing process. Such methods include: direct dyeing, stock dyeing, top dyeing, yarn dyeing, piece dyeing, garment dyeing, pigmentation or dope dyeing solution, etc. Among these are the most common methods of direct tinting and yarn dyeing. [6]

i. Mordant dyes: - Are dyes in their application that require a mordant because they have no connection to the dyed fiber. A mordant dye should form a transitional complex of metal salts such as madder, fustic, Persian, berries, kermes, cochineal, etc.

ii. Vat dyes: - Are water-insoluble dyes which are first converted to their water-soluble form reducing with Na-hydrosulphite, solubilizing it with alkali and then adding to the fibers. The true color is only created by oxidation and then treated with a hot soap solution, *e.g.*, indigo.

iii. Direct dyes: - Are certain dyes with a significant affinity to cellulose fibers. They're dyed from a boiling bath of coloring. Turmeric, harda, grenade rind etc. are only a few of the existing direct colors.

iv. Acid dyes: - Are derived from an acidic material. The dye molecules have either sulphonic group(s) or carboxylic group(s) which may form an electrovalent bond with amine groups of wool and silk. Tannic acid after treatment, known as back tanning, increases the speed of such coloring, *e.g.*, saffron.

v. Disperse dye: - It has a relatively low molecular mass, medium solubility and no solubilization in solid groups. This can be applied on hydrophobic synthetic fiber, from neutral to mildly acidic pH. They can be applied to silk and wool, too. These colors can be post-mordant with chromium, copper and tin salts, e.g., lawsone, and many other flavones and anthroquinone.

vi. Basic or cationic dyes: - Ionisation produces colored cations and forms an electrovalent bond with the-COOH group of wool and silk. These dyes are applied from pH neutral to moderately acidic. They have low luminosity, e.g., berberine. Seeds, flowers, leaves, berries, stem (wood), barks, and roots are the most common herbal parts used for extracting dyes. [17] Table 1. Showing the list of dye yielding plants and their parts and family.

Table1. List of dye yielding plants with plant parts

Sr. No.	Plant Parts	Example	Family
1	Flower	*Althaea rosea* cav. *Carthamus tinctorius* Linn. *Impatiens balsamina* Linn. *Nyctanthes arbor-tristis* Linn. *Tagetes erecta* Linn.	Malvaceae Asteraceae Balsaminaceae Oleaceae Asteraceae
2	Fruits	*Annona reticulate* Linn. *Mallotus philippensis* *Terminalia chebula* Retz. *Ziziphus jujube* Mill.	Annonaceae Euphorbiaceae Combretaceae Rhamnaceae
3	Root	*Alpinia galangal* Willd. *Butea superb* Roxb. *Rubia tinctorum* Linn. *Prunus persica* Batsch. *Morinda citrifolia* Linn. *Ventilago madraspatana* Gaertn. *Rubia cordifolia* Linn.	Zingiberaceae Fabaceae Rubiaceae Rosaceae Rubiaceae Rhamnaceae Rubiaceae
4	Wood	*Acacia catechu* Wild. *Adenanthera pavonina* Linn.	Mimosaceae Mimosaceae
5	Bark	*Terminalia arjuna* *Mangifera indica* Linn. *Dipterocarpus* spp. *Alnus glutinosa* Linn. *Acacia nilotica* Linn. *Bauhinia purpuea* Linn. *Pterocarpus marsupium* Roxb.	Combretaceae Anacardiaceae Dipterocarpaceae Betalaceae Mimosaceae Caesalpiniaceae Fabaceae
6	Leaves	*Lawsonia alba* Linn. *Isatis tinctoria* Linn. *Urtica dioica* Linn. *Woodfordia fruticosa* Kurz *Chukrasia tubularis* A.Juss *Convallaria majalis* Linn.	Lythraceae Brassicaceae Urticaceae Lythraceae Meliaceae Lilliaceae
7	Seed	*Wrightia tinctoria* *Cassia tora* Linn.	Apocynaceae Caesalpiniaceae

III. MORDANT

This acts as a material used to set dyes on sections of tissues or fabrics by creating a complex arrangement with the dye that then binds to the cloth or tissue. Mordants are of following type: -

1. Metallic mordants: - Typically metal salts are aluminium, chromium, iron, copper, and tin. The metallic mordants are of two different forms.
2. Brightening mordants:
i. Alum: Potash alum among all forms of alum is inexpensive, readily available and safe to use mordant. It usually yields pale versions of the dominant color dye of the plant.
ii. Chrome *(Potassium dichromate):* This is also called red chromate. It is pretty much more expensive. Nonetheless, Cr3+ or Cr6+ are considered to be harmful to human skin as poisonous heavy metal beyond a certain stage of its life. The use according to the eco-standards standards was restricted. The dichromate solution is light-sensitive, and thus changes color under light exposure.
iii. Tin *(stannous chloride):* It gives shinier colors than any other mordant. But They become oxidized when exposed to sunlight, and can add a stiff hand to the fabric. Stannous chloride (SnCl2), when added above a certain concentration, often causes higher loss of tissue tenacity (tensile force).
3. Dulling mordants: -
i. Copper *(cupric sulphate):* Known as blue vitriol, it is easy to apply in water and is readily soluble. It gives some special shadow effects. However, as undesirable heavy metals, copper often falls beyond the eco-standard norms above a certain level.
ii. Iron *(ferrous sulphate):* It is also known as green vitriol, and can be easily soluble in water. It is used to darken / brown and blacken the shades / colors. It's easy to get to, and one of the oldest known mordants. This is commonly used to bring shades of grey to black.
iii- Tannins*:* The term 'tanning agent' is originally given to those water-soluble cellulosic materials that predict gelatin from solution. Yet all gelatine precipitation did not serve as tanning agent. Tannins are polyphenolic compounds which have the gelling capacity under certain conditions as follows:
(a) Tannic acid, Chinese or Turkish gallotannins (galls), and Sicilian and Stagshorn sumac can serve as examples. (b) Hydrolysable ellagitannins, exemplified with valonea and chestnut, which give hydrolysis to ellagic acid or related acids. (c) Condensed or catecholic tannins that contain few to no carbohydrates and converted in acids into insoluble amorphous polymers. Among tannins, myrobalan (harda), and galls / sumac are the most critical.

4. Oils type mordants
These mordants are vegetable oils, or Turkish red oil (TRO). TRO is used as a mordant especially in dark red madder coloring. The primary aim of the TRO as an oil mordant, when used as a principal mordant, is to create an alum complex. Sulfonated oil has greater binding power, speed and color than natural oils. [18] Table 2. Showing list of plants used for extraction of natural dyes along with the dyeing techniques.

Table 2. List of plants used for extraction of natural dyes along with the dyeing techniques

Shade	Plant	Plant parts	Extract	Mordant
Red	Red sandalwood	Bark	Acidic	Alum
	Red sandalwood	Bark	Basic	Alum
Orange	Madder	Roots	Neutral	Alum
	Madder	Roots	Alcoholic	Alum
	Red sandalwood	Bark	Neutral	Alum
Yellow	Safflower	Dried-Petals	Alcoholic	Alum
	Safflower	Dried Petals	Neutral	Alum
	Turmeric	Rhizome	Neutral	Copper Sulphate
	Harda	Fruits	Neutral	Alum
	Berberis	Roots	Neutral	Alum
	Mulberry	Leaves	Neutral	
	Red sandalwood	Bark	Acidic	Ferrous

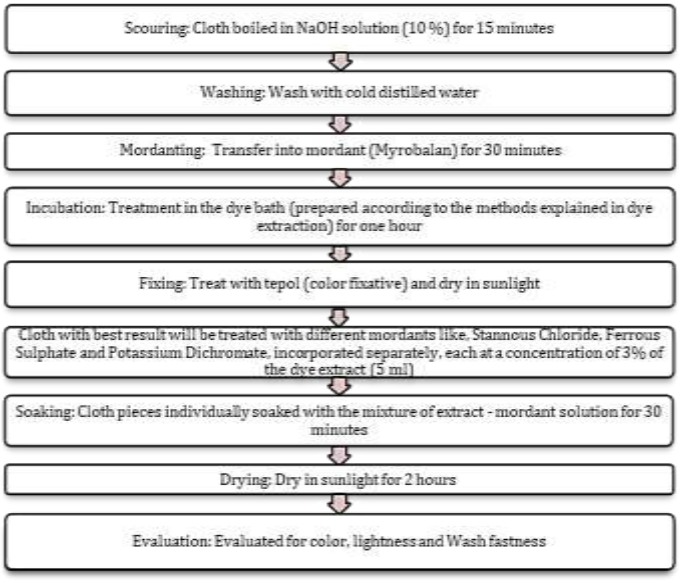
Violet	Alkanet Jamun	Roots Fruit pulp	Alcoholic Neutral	Sulphate Alum Alum
Brown-Green	Eucalyptus Basil Onion peel Spinach(unboil-ed) Henna Hibiscus Hibiscus	Leaves Leaves Dried Peels Leaves Leaves Petals Petals	Acidic Neutral Neutral Neutral Neutral Basic Acidic	Copper Sulphate Alum Alum Alum Alum Alum Alum

Mordants play a critical role in bringing color to the fabric. The mordants used combined in different ratios gave different shades. Better results in color intensity depend on the salt which is used in metal. [19]

IV. METHODS

The coloring of the cotton, silk and wool clothes takes place in four stages; pretreatment, extraction of coloring from the flower, mordanting and dyeing as defined in the. [20]
The dyeing is carried out in four stages: - Extraction of dye**,** Pre-Treatment**,** Mordanting and Dyeing, as shown in figure no. 3.

Figure 3: Flow chart showing dyeing procedure [21]



Extraction of Dyes : Plant flowers are soaked in distilled water and heated in a beaker which is kept for 2 hours in a water bath to facilitate fast extraction. It is then filtered, and a separate beaker gathers the filtrate. The filtrate is concentrated to the state of high viciousness. This extract is used for the cotton dyeing. Color dye extraction is performed using four different methods.

i) Aqueous extraction method-The required 10 gm of fresh plant parts can be boiled for 30 minutes in 100 ml distilled water at 100 ° C. The decolorated residue is removed from the solvent for extraction.

ii) Alkaline method: -10 gm of fresh plant parts are boiled for 30 minutes in 1 % sodium hydroxide. The decolorated petals are taken from the solvent for extraction. Eventually, the solution is filtered and used for further analysis.

iii)Acidic methods: - In acidic extraction method, desired plant parts of 10 gm fresh are treated for a few minutes with 1 % of acidic solution boil at 100 ° C. The solution is eventually filtered and used for further analysis.

iv)Alcoholic Extraction methods- In alcoholic extraction process, desired plant parts of 10 gm are boiled for 30 min in 50 % alcohol. Using filtrate for further analysis. [22]

Pre-treatment (Scouring of cotton, silk & wool): Cotton, silk, or wool fabric is washed at 50 ° C for 25 min in a solution containing 0.025 g / L of sodium carbonate (Na_2CO_3) and 0.06 g / L of non-ionic detergent. Maintaining ratio of content to liquor 1:40. The scoured material is

washed thoroughly with tap water, and dried at room temperature. The scoured material is soaked 30 minutes before dyeing or mordanting in clean water. [20,23]

V. Mordanting

The samples of wetted-out cotton are entered in dye baths containing the appropriate amount of extract of dye and water. Necessary amount of sodium carbonate and sodium chloride is added after 10 minutes. Around 60^0C the dyeing is done for 1 hour. The dye samples are dried in air without washing to prepare them for pre-, simultaneous and post-mordant usage of different metallic salts and natural mordants. [24]

1) Pre-mordanting:
Scoured cotton samples with or without pre-mordanting are further mordantised before dyeing using 1-3 per cent of any chemical mordants, such as $CuSO_4$, $FeSO_4$, $FeCl_3$ and K_2Cr2O_7 and natural mordants, such as myrobalan and cow dung, at 600ºC for 30 minutes with a material-to-liquor ratio of 1:20. The samples treated with metal salts are stained with the dye extract, as shown in figure 4. [25]

2) Simultaneous-mordanting:
Scoured cotton samples are treated simultaneously with both dye extract and metal salts using 1-3 per cent of all chemical mordants such as $CuSO_4$, FeSO4, $FeCl_3$ and K_2Cr2O_7 and natural mordants such as myrobolone and 600ºC cow dung for 30 minutes with a material-to-liquor ratio of 1:20. Figure 5 shows the overall flow of the procedures. [25]

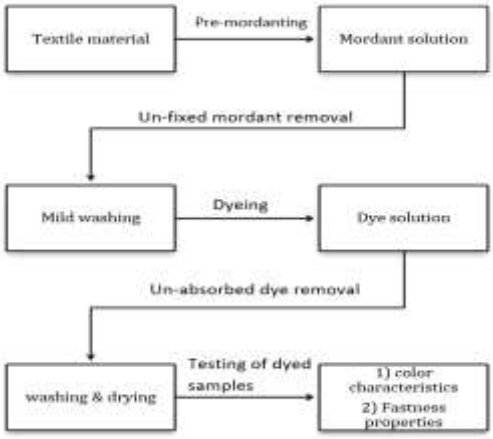


Figure 4. Flow chart showing Pre-mordanting Procedure

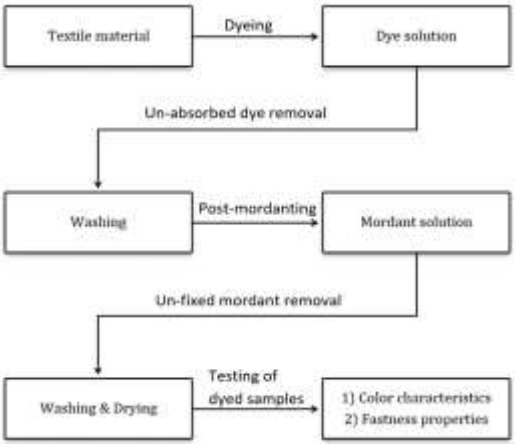


Figure 5. Procedure for simultaneous-mordanting

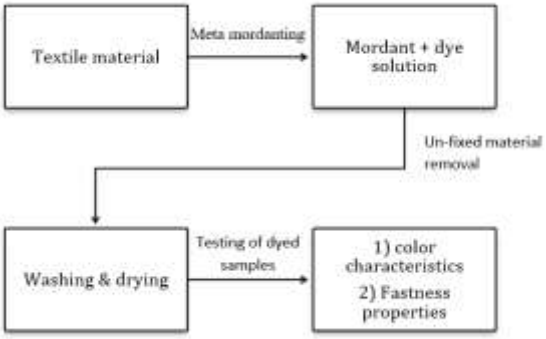


Figure 6. Flow chart showing Post-mordanting Procedure

3) Post-mordanting
Scoured cotton samples are painted with dye extract. The wetted-out cotton samples are inserted into different coloring baths, containing the necessary amount of dye and water extract. After 10 minutes apply necessary amount of sodium sulfate. After 20 minutes, add required amount of sodium chloride. The dyeing is done 1 hour at 500C. Taking out the samples that are dyed. Squeezed and used unwashed for the metal salts processing. Dyed cotton samples are treated with specific metal salts using 1-3 per cent of each mordant chemicals such as CuSO4, $FeSO_4$, $FeCl_3$ and K_2Cr2O_7 and natural mordants such as myrobalan and cow dung with a material-to-liquor ratio of 1:20 at 600C for 30 minutes.[25]

4) Dyeing

Dyeing is achieved by combining the correct amount of color with a liquor ratio of 1:15, 20g / L sodium carbonate and 50g / L sodium sulphate at a dyeing temperature of 65 ° C for 60 min, using different shades of reactive color. The color coordinates are executed after rinsing and cleaning using the data color spectrophotometer SF 650 and the speed properties.[26]

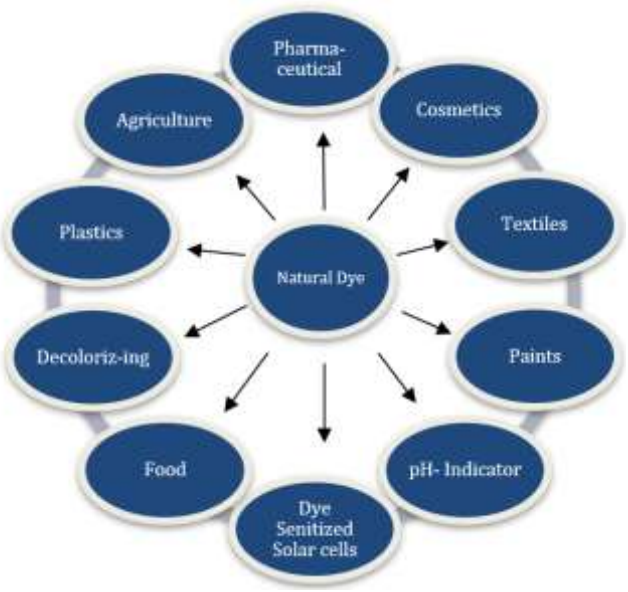
VI. ADVANTAGES OF NATURAL DYES

A wide variety of applications (Figure 6) and benefits for natural dyes are expected in various fields.

- Synthetic colors, such as azo dyes, are cancerous and can cause toxic and allergic reactions.

- Be eco-friendly and elegant,
- Biodegradable, non-toxic and allergy free.
- Easy color extraction by boiling the heads of plants, berries, leaves, bark or flowers.
- Natural-colored fabric has higher UV absorption which can help reduce melanoma incidence.
- Many natural dyes are antibacterial in character.
- Natural colors are primarily organic, as most are plant-based, while synthetic pigment is petroleum-based and is a non-renewable energy source.
- The use of natural colors as opposed to synthetic fossil-fuel (petroleum) colors has the potential to achieve carbon credits.
- In some cases, the isle produced may be used as biofertilizers, such as indigo dyeing, and as a consequence, waste disposal is no problem.
- There is a wide variety of mixing and matching colors.
- A small variation in the mordant or extraction medium or coloring technique may result in drastic color changes.
- Natural colors bleed, except for the turmeric, but other materials do not stain.
- Natural colors are indicative of moth and can substitute synthetic colors for protection in clothing and foodstuffs for children.[27]

Figure 6. Commercial application of natural dye



VII. LIMITATIONS OF NATURAL DYES

- Lack of detailed knowledge of the extraction and tainting method.
- The same shade can be hard to reproduce.
- Fastening of the dye to the fabric requires mordant.
- It takes the power of a professional person.
- Expensive, lack of color and light speed.[27]

VIII. CONCLUSION AND FUTURE SCOPE

Much research is carried out in the field of natural dyes, but concentrated work on the application of natural textile dyes is not yet advanced. Because the shade, rapidity, and color properties of synthetic fabric depend on several factor-like types of mordant, mordanting technique, different kinds of fabric treatments, dye extraction technique, solvent method, medium pH, etc., in-depth research is required in each parameter. The demand for natural dye in textiles on a wide scale is growing day by day. However, the benefits of natural dyes are huge but the sector has become vulnerable due to lack of R&D. Although natural coloring requires synthetic mordants to fix colour, organic / natural mordants must be researched or implemented to enhance the eco-friendliness of natural colours. Pretreatment process is an important step, primarily mordanting before dying, as it contributes to successful speed properties. Research on data base creation with correct shade card is needed.

IX. CONFLICT OF INTEREST

The authors declare that they have no competing interest.

X. ACKNOWLEDGEMENT

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