

NATURAL DYES: ARE THEY REALLY ENVIRONMENTALLY FRIENDLY?

M.SUBRAMANIAN SENTHILKANNAN,

Key Account Management Executive,

Consumer Testing Services Lab,

SGS India (P) Limited,

Bangalore, India.

E-mail: senthilkannan@gmail.com

Are Natural Dyes really environmentally friendly?

Answer to this question is needed of the hour...

Natural Dyes

- Comprise those colorants – dyes & pigments that are obtained from animal or vegetable matter without chemical processing.
- The name natural dye covers all the dyes derived from the plants, insect and minerals i.e. derived from natural resources.

History of Natural Dyes (1 of 3)

- Natural dyes are as old as textiles themselves.
- Man has always been interested in colours; the art of dyeing has a long past and many dyes go back into the prehistory.
- Practiced during the Bronze age in Europe.

History of Natural Dyes (2 of 3)

- China: in 2600 BC.
- Egypt: chemical tests of red fabrics found in the tomb of king Tutankhamen – alizarin.
- Alexander the Great – Purple Robes dating to 540 BC, when he conquered Susa, the Persian capital.
- Brazil- Named after the Brazilwood found.

History of Natural Dyes (3 of 3)

- *Henna* – used even before 2500 BC.
- *Saffron* – Mentioned in Bible.
- Primitive men used to crush berries to colour mud for his cave paintings & used plant dye stuff to colour animal skin, their own skin during religious wars, festivals.
- Dyes might have been discovered accidentally, but their use has become so much a part of man's customs.

Sources of Natural Dyes

- The common sources of vegetable dyes :
 - Parts of Plants such as leaves, flowers, fruits, seeds, barks, roots of dye yielding plants.
 - Minerals such as prussion blue, red ochre and ultramarine blue
 - Animal origins such as Lac, cochineal and kermes.

Sources of Natural Dyes

A Few Examples...

Catechu

- **Common Name:** Cutch, Catechu, Kala Kaththa
Botanical Name: *Accacia catechu*
Trade Name: BEE
Natural Dye: Brown dyestuff for Textiles.

Catechu is purified extract of wood *Accacia catechu*. The plant of *Accacia catechu* is about 15 meter high.

This is mainly composed of Catechu-tannic acid with catechin, catechu red and quercetin.

Catechu is among cheap Extract form of Natural Dyes & it gives light brown to good brown with acceptable fastness rating.



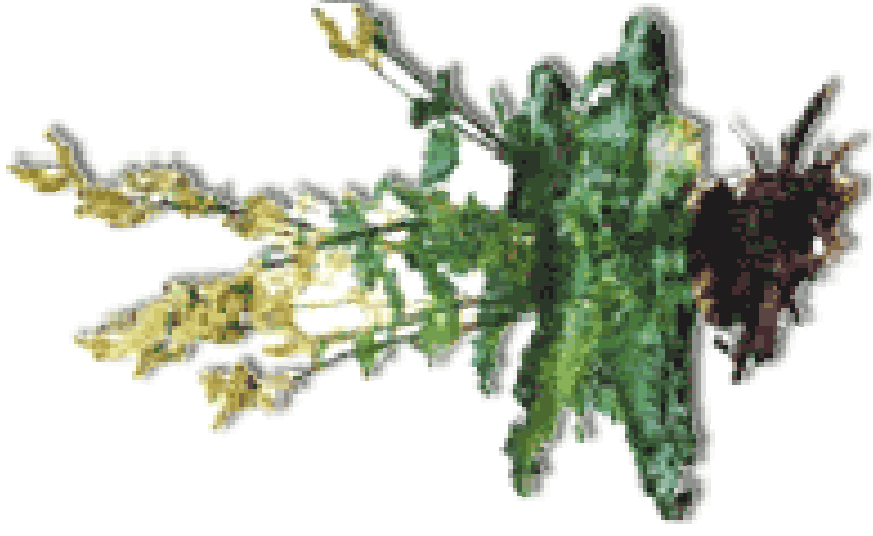
Himalayan Rubrub

- **Common Name:** Dolu, Himalayan Rubrub
Botanical Name: Rhum emodin
Trade Name: INSECT
Natural Dye: Yellow dyestuff for Textiles.

Dolu is about 1.5 to 3 meter high stout herb. It is grown at an altitude of about 3000 to 5000 meters high. The color is extracted from its wood.

This consists of many anthraquinone derivatives based on emodin, chrysophanol, alooe-emodin and rhein.

It dyes wool in range of color mainly in yellow and exhibit good fastness ratings.



Mayrabolan

- **Common Name:** Harad, Harda, Botanical Name: Terminalia chebula
Trade Name: Kareel
Natural Dye: Greenish yellow dyestuff and Natural Mordant for Textiles.

Mayrabolan is fruit of tree Terminalia chebula. This is used as greenish yellow dyestuff for textile. This is also used as Natural Mordant in many cases.

This is also used as a substitute of Tannic acid.



Lac

- **Common Name:** Lac, Lac Dye
Botanical Name: Kerria lacca
Trade Name: Nimbus
Natural Dye: Red & violet dyestuff for Textiles.

Lac is probably most ancient of all Animal Dyes. The dye is taken from insect Kerria Lacca.

This insect is cultivated on Kusumbh and Tesu trees. This has its history of use as Natural Dye in South Asia and India since the beginning of recorded History.

The principal coloring component in this dye is identified as Laccaic Acid. The dye shade exhibit very good fastness to washing, rubbing and light.



Madder

- **Common Name:** Madder, Manjistha, Majith
Botanical Name: *Rubia cardifolia* (Indian Madder) *Rubia tinctoria* (European Madder)
Trade Name: RUBIA
Natural Dye: Red, Pink and Orange dyestuff for Textiles.



Madder is one of the oldest Natural Dyes. In a way Indigo and Madder are the main ancient Natural Dyes used by man for dyeing textile for ages.

The cultivation of Madder needs sub tropical climates and prefers moist soil. It is cultivated in the foots of Himalayas in huge quantity.

Synthetic & Natural Dyes (1 of 2)

- Natural dyes derived from plant material represent a more sustainable source of colorants.
- Natural dyes colour natural fibres (cotton, wool, silk) to a greater or lesser extent.
- Natural dyes have found limited success in coloration of synthetic fibres

Synthetic & Natural Dyes (2 of 2)

- The synthetic dyes are obtained from petrochemical feedstock. The reaction conditions (high temperature and pressure and in some cases, toxic solvents and catalysts) are drastic.
- On the other hand, natural dyes are considered to be much less hazardous and eco-friendly.

Natural Vs Synthetic Dyes

NATURAL

- Use of renewable resources
- Lack of toxicity during production and reduction of work hazard
- Full biodegradation and reduction of the environmental impact
- Lack of toxicity of the end products

SYNTHETIC

- Consumption of non-renewable resources such as oil and by-products
- Work hazard during production
- High environmental impact during production and waste disposal
- Danger of allergies (dermatitis by contact) for the consumers

Limitations of Natural Dyes (1 of 2)

- Availability
- Colour yield - The yield of colour from vegetable dye plants is very low. The research shows that yield of colouring matter varies from 0.3% to 4% in the plant.
- Complexity of dyeing process - The process of dyeing is complicated mainly due to non-availability of technical know-how and trained personnel.
- Reproducibility of shade - The non-reproduction of some shades is one of the drawbacks of these dyes due to variation in colouring matter present in the plants.
- Traditionally yield and concentration are lower than synthetic dyes.
- Large quantities of raw material required to obtain the same depth of colour.

Limitations of Natural Dyes (2 of 2)

Technical drawbacks:

- Limited number of suitable dyes.
- Allow only wool, natural silk, linen and cotton to be dyed.
- Great difficulty in blending dyes - The problem of blending of dyes to get secondary colors restricts the versatile use. Only few dyes can be blended.
- Non-standardized.
- Inadequate degree of fixation.
- Inadequate fastness properties.
- Water pollution by heavy metals and larger amounts of organic substances - Due to use of heavy metals in the form of mordants, the discharge from the unit is enriched with heavy metals and huge amount of organic contents causing pollution and disposal.

Benefits of Natural Dyes

- They are obtained from renewable resources and the raw material for production of vegetable dyes are plentifully available.
- No health hazards, some times they act as health cure.
- Practically no or mild chemical reactions are involved in their preparation.
- No disposal problems.
- They are unsophisticated and harmonized with nature.
- The chemical reaction is almost absent in the manufacture of vegetable dyes and no pollution problem.

Fiber Choice for Natural Dyeing

- Wool is generally the best fiber to color with natural dyes.
- Cotton is less suitable for many natural dyes.
- Synthetic fibers usually cannot be dyed with natural dyes.

Forte of Natural Dyes

- Proponents of natural dyes have eulogized them by pronouncing them as **environmentally friendly, nontoxic and may be ultimate in Eco-friendliness**, while almost diagonally opposite views have been expressed by producers and some users of synthetic dyes.
- A word of caution has also been given to the proponents of these dyes.

Eco Concerns on Natural Dyes (1 of 2)

- Though they are obtained from the natural resources, some of the sources and dyeing procedures may not be safe with respect to health hazards and environmental issues.
- Pesticides are used in large quantities in growing crops.
- Contamination of chlorine-based pesticides is likely to occur during the growth of natural dye yielding plants from soil or storage.

Eco Concerns on Natural Dyes (2 of 2)

- Most of the natural dyes being non-substantive require mordants for their fixation.
- Mordants are also used for enhancement in fastness as well as to obtain variability in color.
- Most of these mordants are salts of heavy metals.

Mordants (1 of 2)

- Mordants are adhesive compounds that fix plant dyes to fibers and can be added to the dye bath, or a separate bath, before or after dyeing.
- Chemical mordants, such as ammonium hydroxide and chrome, are caustic and can cause skin and respiratory-tract irritation.
- Chrome is toxic to kidneys and a potential human carcinogen, and chrome-based mordant baths must be treated as household hazardous waste.
- Non-chemical mordants, such as rhubarb leaves, staghorn sumac (as opposed to poison sumac) leaves and oak galls, work just as well, but these can also be harmful.

Mordants (2 of 2)

- Rhubarb leaves, a natural source for the chemical mordant oxalic acid, are poisonous if consumed in large quantities, so these have to be kept away from children and pets.
- Alum and urea are safer chemical mordants, but take care in handling alum as it can cause skin irritation.
- Two of the most effective mordants, copper & chrome, are red listed.
- Limits are also imposed on the discharge of heavy metals in the effluent.

How a Mordant Functions?

- The word ‘ Mordant’ has been derived from the Latin word ‘ morderere’ which means ‘ to bite’ .
- The mordant bites the surface of a fibre so that a dye can sink in.
- It combines with a fibre & dye, both forming a link between dye and fibre which otherwise has no affinity for the dye.
- It forms with a dye complex which is insoluble in water and thus gives a fast colour.

Eco- friendliness of Dyes

- For a product to be graded eco-friendly, it should abide by the eco-norms.
- These norms have been stipulated in respect of textile products on the basis of **Cradle to Grave Approach**, i.e. the criteria are developed on analysing the product's entire life cycle, commencing from extraction of raw material, processing through stages of production, distribution, utilization and disposal after use.

Major Global Regulations Impacting Dye Industry

- Eco Labels (Government as well as Commercial)
- The Globally Harmonized System (GHS)
- Registration, Evaluation and Authorization of Chemicals (REACH)

Formulation of Norms

- While formulating these norms, different chemicals used in textiles were taken into consideration, out of which the following are of relevance to dyeing:
 - Heavy Metals
 - Azo dyes which release carcinogenic amines
 - Toxic Pesticides
 - The pH of the aqueous Extract
 - Product

Eco- Norms for Heavy Metals

| S.No. | Heavy Metals | Range |
|-------|----------------|----------------------|
| 1. | Arsenic | 0.001 – 0.1 mg/kg |
| 2. | Lead | 0.004 – 0.04 mg/kg |
| 3. | Cadmium | 0.0005 – 0.005 mg/kg |
| 4. | Zinc | 0.5 – 5.0 mg/kg |
| 5. | Mercury (Gen) | 0.0001 – 0.1 mg/kg |
| 6. | Nickel (Gen) | 0.02 – 10 mg/kg |
| 7. | Copper (Gen) | 0.3 – 100 mg/kg |
| 8. | Chromium III | 0.01 – 20 mg/kg |
| 9. | Cobalt (Gen) | 0.02 – 20 mg/kg |

Eco-Norms for Azo Dyes

| S. No. | Eco- Label | Criteria as regards azo dyes |
|--------|---------------|--|
| 1. | M.S.T. | No application of dye stuff that can release amines of the MAK groups III A2 and dye stuff classifies as Carcinogenic. |
| 2. | OTN 100 | No application of dye stuff that can release amines of the MAK groups III A1 & A2. |
| 3. | Clean Fashion | Ban |
| 4. | Steilmann | Ban |
| 5. | Comitextile | No application of dye stuff that can release amines of the MAK groups III A2 and dye stuff classifies as Carcinogenic. No use of Disperse Dyes Blue 124 & 106 on acetate fibers. |
| 6. | EC Approach | No use of Benzidene based dyes/pigments, azo dyes/pigments based on aromatic amines. |

Eco- Norms for Pesticides

| S.No. | Eco-Label | Sum Parameter of Pesticides |
|--------------|------------------|---|
| 1. | M.S.T. | 1 mg/kg |
| 2. | OTN 100 | 5 mg/kg |
| 3. | Clean Fashion | 1 mg/kg |
| 4. | Steilmann | 1 mg/kg |
| 5. | Comitextile | 0.1 to 1 mg/kg depending on category of textile item |
| 6. | EC Approach | No pesticides considered hazardous to health or environment must be used. |

Eco- Norms for Product Behaviour in Use

| Parameter | Comitextil | MST | Oekotex |
|--------------|------------|-----|---------|
| Water | 3 | - | 3 |
| Washing | 3 | - | 3-4 |
| Perspiration | 3 | - | 3-4 |
| Dry Rubbing | 3 | - | 4 |
| Wet Rubbing | 2 | - | 2-3 |

Eco- Norms for pH of Aqueous Extract

| S.No. | Eco – Label | Criteria |
|-------|-------------|-------------|
| 1. | M.S.T. | 4.5-7.5 |
| 2. | Oekotex | 4.8-7.5 |
| 3. | Comitextil | 4.8-7.5 |
| 4. | EC Approach | No Criteria |

Eco-Friendliness of Natural Dyes

(1 of 2)

- The aforesaid parameters have to be tested to assess the eco-friendliness of natural dyes too.
- The presence of any banned amines is ruled out as most of the natural dyes are based on quinines, flavones, anthraquinones etc.

Eco-Friendliness of Natural Dyes (2 of 2)

- Hence, the important eco-parameters to be tested for natural dyes are:
 - Traces of heavy metals on textiles.
 - Heavy Metal contamination in effluent.
 - pH of the aqueous extract of the textile
 - pH of the effluent.
 - Product Behaviour in use, etc.

Current Scenario in Reality (1 of 2)

- Contrary to popular opinion, natural dyes are often neither safer nor more ecologically sound than synthetic dyes.
- They are less permanent, more difficult to apply, wash out more easily, and often involve the use of highly toxic mordants.
- Some natural dyes, such as the hematein derived from logwood, are themselves significantly poisonous. Of course, the color possibilities are far more limited; the color of any natural dye may be easily copied by mixing synthetic dyes, but many other colors are not easily obtained with natural dyes.
- However, some mordants are not very toxic, and the idea of natural dyestuffs is aesthetically pleasing.

Current Scenario in Reality (2 of 2)

- Unmodified natural dyes may have a significantly lower environmental impact (broken down through biological processes)
- Should NOT assume that '*natural*' means *safe*.
- Toxicology of successful natural dyes needs to be researched extensively.
- Any chemical modification of the dyes may require new toxicology testing.

Selection of Mordants - Criteria

- It should be done on consideration of toxic / carcinogenic effect of these metals & salts.
- The upper limits of the presence of metals vary from product to product are different for different eco standards.
- However there is no upper limit on Al, Fe & Tin, and the upper limit on Copper is fairly high. Hence one may safely use these salts for complexing & mordanting. One has to, of course, optimise the quantities so as to minimise the pollution load.

Research Work in Store / Suggestions

- Identification of the key variables affecting the production of sustainable, consistent plant based dye compounds.
- Development of environmentally friendly extraction and concentration processes.
- Development of a range of natural and environmentally safe textile dyes.
- Development of coloration processes using natural dyes to obtain high colour depth and high fastness dyeings on natural fibres.
- Employment of non-metal mordants to enhance these parameters.
- Development of coloration processes using natural dyes to obtain high colour depth and high fastness dyeings on synthetic fibres.
- Application of natural dyes using scCO_2

Research Work in Store / Suggestions

- Chemical modification of natural dyes to enhance fastness and to secure additional colour gamut (range of shades) on a variety of substrates.
- Desirable to extract using superheated water.
- ‘Clean’ solvent with minimal environmental impact.
- Recently reported that polyphenol dyes have been successfully and rapidly extracted from elderberry, raspberry and blueberry using water at 120°C.
- Superheated water under pressure between 125 and 175°C has been shown to rapidly extract the oxygenated compounds.
- Extraction by superheated water could be a viable process for production of high quality natural colorants.

Natural Dyes Suppliers in India

- Shivam Exim Pvt. LTD, Gujarat.
- Alps Industries (P) Ltd.
- Hind Natural Dyes, Rajasthan
- Shree nath ji Dyestuffs, Delhi.
- Aeromax Synthetic Industries, Gujarat.
- A.B. Enterprises, Mumbai.
- K. S. G. Enterprises, Tamilnadu.

Products out of Natural Dyes

- Ready made shirts



- Paintings



Natural dyes can work wonders in
Textile Industry provided we ensure
the usage of:

- Right Source**
- Safer methods of
Extraction**
- Eco friendly Mordants**

**Thank
You!**