International Journal of Research in Advent Technology, Vol.8, No.3, March 2020
E-ISSN: 2321-9637
Available online at www.ijrat.org

Revealing Explanation on Organic Dyes: A Review

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Abstract— Dye is a substance which is used to colour various materials such as textiles, leather, and paper which is not altered with factors such as heat, light, washing, or any other exposure. However, the concept of dyes is completely different from the concept of pigments. Pigments in a nutshell can be defined as a material diffused in liquid forming a paint or ink. Dyes contain organic compound while pigments contain inorganic compound. Natural dyes have the privilege of causing minimal impact on environment, being renewable, sustainable, and safe. The paper here by aims to pile up the particulars of organic dyes, its history, types, sources, preparations and its medicinal use as well as pigments from which we get dyes. It further sheds some light on the comparison of natural dyes and synthetic dyes, concluding with unignorable advantages and disadvantages.

Index Terms- Environment**,** Medicinal value Organic dyes, Pigments.

I. Introduction

Green is probably the most common plant colour in most leaves. The green pigment chlorophyll in leaves helps to absorb the energy of the sun and turn it into chemical energy, which is then processed and used as plant food. Flowers colours are adaptations that attract insects and other species, which in effect pollinate and help replicate the plants. Some plants have colourful fruits which attract animals to eat them, spreading the seeds of the plant as they do so inadvertently. Scientists think other pigments may help protect plants from diseases. Given what we know about the role of a few thousand plant pigments, we still have a mystery about the role of most colours in plants (R.Siva, 2007).

While plants show a wide variety of colours, not all these pigments can be used as colours. Some do not dissolve in water, others cannot be adsorbed onto fibres, while others dissolve when washed or exposed to sunlight or air (R.Siva, 2007).

Designers used natural dyes as a design tool in a very effective way. The non-reproducibility and non-uniformity of shades make a unique piece of every development. Different design techniques, such as tie-and-dye or sewing, resist, painting, stencilling, batik, Indian Ajrakh, Kalamkari, Ikat, etc., are being practiced by the designers in order to produce unique products (M. L. Gulrajani, 2001).

With over 9000 plants, Turkey is, from the flora standpoint, one of the richest countries in Europe and the Middle East. More than 3000 of these are known as endemics. The number of dye plants in Turkey is relatively high, as a contrast to this floristic richness (Ozlenen Erdem Ismal, 2016).

II. History

Natural colouring, colours, and dyeing are as common as textiles themselves. It was practised in Europe during the Bronze Age. Dating from 2600 BC, China has found the earliest written record of the use of natural dyes. Dyeing was established as early as in the Indus Valley period (2500 BC); this knowledge was confirmed by discoveries of coloured cloth garments and traces of madder dye in the ruins of Mohenjo-daro and Harappa's Indus Valley Civilization (3500 BC).

Mummies covered in dyed cloth were discovered in Egypt. Chemical tests of red fabrics found in King Tutankhamen's grave in Egypt indicate alizarin, a pigment derived from madder, is present. In more modern times, when he defeated Susa, the Persian, Alexander the Great mentioned having found purple robes dated to 541 BC in the royal treasury. Dyes such as woad, madder, weld, brasil wood, indigo and a deep reddish-purple were identified by the 4th century A.D. Brazil was named after where the woad was found (Gulrajani, M.L., 1992). Even before 2500 BC, Henna was used, while the Bible mentions saffron (M. L. Gulrajani, 2001).

In prehistoric times, for his cave paintings, man used to smash berries to mud pigment. During religious festivals as well as during battles, primitive people used plant dyes to paint animal skin and to their own bodies. They believed the colour would grant them magical powers, shield them from evil spirits and help them attain victory in battle (Oktav Bulut M & Akar E, 2012).

Primitive dyeing methods included pressing plants into fabric to render or rub crushed pigments. With time and techniques, the methods were produced using natural dyes from crushed fruits, berries and other plants, which were boiled into the fabric and gave light and water fastness (resistance).Some of the well-known ancient dyes include madder, a red dye made from the Rubia tinctorum L. roots, blue indigo from the Indigofera tinctoria L. leaves, yellow from the saffron plant stigmas (Crocus sativus L.) and turmeric (Curcuma longa L.) (R.Siva, 2007).

Manuscript revised on April 03, 2020 and published on April 10, 2020
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doi: 10.32622/ijrat.83202012

The Englishman Sir William Henry Perkin was only 17 when, in 1856, he found and produced the first synthetic organic dye (mauveine). The hue of Mauveine was identical to that of the ancient "Royal purple" (Tyrian purple) (Vanker, P.S., 2000).

III. Types of Natural Dyes and Mordants

A. Mordant

Natural colours are substantive and require a mordant to adhere to the fabric, avoiding either fading with light exposure or washing out. Such compounds bind the natural tints to the textiles. Tints require mordants to help them adhere to fabric. If no mordants, such as lichens and walnut hulls, are required, they are called substantive dyes. These are called adjective dyes if they need a mordant. Common mordants are alum (usually used with tartar cream, which helps uniformity and brightens slightly); iron (or copper) (which saddens or dark colours, producing green shades); tin (usually used with tartar cream, which blooms or brightens our colours, especially reds, oranges and yellows) and blue vitriol (which saddens colours and brings out green shades) (R.Siva, 2007).

B. Natural dyes are obtained from different plants

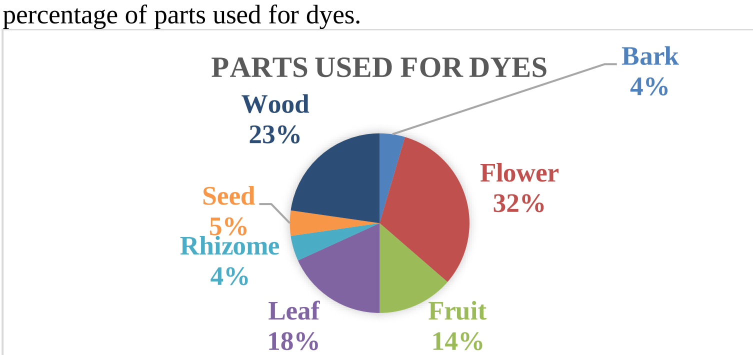
With over 9000 plants, Turkey is, from the flora standpoint, one of the richest countries in Europe and the Middle East. More than 3000 of these are known as endemics. The number of dye plants in Turkey is relatively high, as a contrast to this floristic richness. In the regions where natural dyeing is alive, the colours obtained from the number of species have been described as follows: yellow from 84 species, green from 41 species, brown from 33 species, grey from 10 species, red from 7 species, pink from 5 species, violet from 4 species, blue from 3 species and black from 3 species (P Miller, 1759).

Most natural dyestuffs and stains were derived predominantly from plants and dominated as natural colour sources, creating various colours such as red, yellow, blue, black, brown and a mixture of these nearly all parts of plants such as root, bark, leaf, fruit, wood, seed, flower, etc. produce colouring. It is interesting to note that over 2000 pigments are synthesized through different parts of plants, only about 150 of which have been commercially exploited (R.Siva, 2007).

Table 1. Source of different coloured dyes and mordants
(W Blith, 1652)

Botanical name	**Common name**	**Colour**	**Mordants**	**Parts used**
Mallotus philippinensis Muell.	Kamala	Red dye	Alum	Flower
Morinda tinctoria L.	Indian mulberry	Red dye	Alum	Wood
Rubia tinctorium L.	Madder	Red dye	Alum	Wood
Haematoxylon campechianum L.	Log wood	Red dye	-	Wood
Caesalpinia sappan L.	Caesalpinia	Red dye	Alum	Wood
Carthamus tinctorius L.	Safflower	Red dye	-	Flower
Rumex dentatus L.	Khat palak	Red dye	Alum	Wood
Solidago grandis DC.	Golden rod	Yellow dye	Alum	Flower
Crocus sativus L.	Saffron	Yellow dye	Alum	Flower
Tagetes sp.	Marigold	Yellow dye	Chrome	Flower
Butea monosperma (Lam) Taubert.	Flame of forest	Yellow dye	Alum	Flower
Alnus glutinosa (L.) Gaertn.	Alder	Black dye	Ferrous sulphate	Bark
Loranthus pentapetalus Roxb.	Rofblamala	Black dye	Ferrous sulphate	Leaf
Terminalia chebula Retz.	Harda	Black dye	Ferrous sulphate	Fruit
Anona reticulata L.	Custard apple	Black dye	-	Fruit
Convallaria majalis L.	Lily	Orange dye	Ferrous sulphate	Leaf
Dhalia sp.	Dhalia	Orange dye	Alum	Flower
Urtica dioica L.	Nettles	Orange dye	Alum	Leaf
Bixa orellena L.	Annota	Orange dye	Alum	Seed
Ligustrum vulgare L.	Pivet	Blue dye	Alum and Iron	Fruit
Nymphaea alba L.	Water lily	Blue dye	Iron and Acid	Rhizome
Isatis tinctoria L.	Woad	Blue dye	-	Leaf

According to Table 1, below is the chart showing the percentage of parts used for dyes.



Here we have list of plants from which dye is extracted as well as they contain some medicinal value in table.

doi: 10.32622/ijrat.83202012

Table 2. Dye yielding plants (R.Siva, 2007)

Botanical Name	Family	Common name	Parts Used	Colour
Abies spectabilis (D. Don.) Spach.	Pinaceae	East Himalayan silver fir	Cone	Purple or Violet
Acacia catechu (L.f.) Wild	Mimosaceae	Cutch tree	Bark	Brown / Black
Acacia dealbata Link	Mimosaceae	Silver wattle	Bark	Brown / Black
Acanthophonax trifoliatum (L.) Merr.	Araliaceae		Fruit	Black
Actaea spicata L.	Ranunculaceae	Banberry grape wort	Seed	Black, red, green
Adathoda vasica Nees.	Acanthaceae	Adalsa	Leaf	Yellow
Aegle marmelos (L.) Corr.	Rutaceae	Bael fruit	Fruit rind	Yellow
Ailanthus triphysa (Dennst.) Alston.	Simaroubaceae		Leaf	Black
Aloe barbadensis (L.) Burm.f.	Lilliaceae	Curaco aloe; Indian aloe	Whole plant	Red
Althea rosea Cav.	Malvaceae	Holly hock	Flower	Red
Ardisia solanacea Roxb.	Myrstinaceae		Berry	Yellow
Arnebia benthami (Wall. ex G. Don)	Boraginaceae	Pan	Underground parts	Purple
Arnebia guttata Bunge	Boraginaceae		Root	Red
Azadirachta indica A. Juzz	Meliaceae	Neem	Bark	Brown
Barleria priontis L.	Acanthaceae		Flower	Yellow
Bassia latifolia Roxb. /*Madhuca indica* J.F.Gmel	Sapotaceae	Butter tree	Bark	Yellow, brown
Bauhinia tomentosa L.	Caesalpinaceae		Leaf	Yellow
Bauhinia variegate L.	Caesalpinaceae	Mahua tree	Bark	Yellow
Betula utilis D.Don	Betulaceae	Himalayan silver birch	Tree gum	Brown
Briedelia stipularis L.	Euphorbiaceae		Fruit	Black
Butea monosperma (Lam) Taubert.	Papilonaceae	Flame of the forest	Flower	Yello, orange
Caesalpinia sappan L.	Caesalpinaceae	Bastard teak, Bengal kino	Wood, bark	Red
Carthamus tinctorius L.	Asteraceae	Safflower	Flower	Red, Yellow
Cassia auriculata L.	Caesalpinaceae	Tanner's cassia	Flower, seed	Yellow
Cassia occidentalis L.	Caesalpinaceae	Negro coffee	Seed	Brown
Cassytha filiformis L.	Lauraceae		Stem	Brown
Cedrela toona Roxb. / *Toona ciliata* Roem		Red Cedar	Flower, seed, leaf	Yellow /red
Citrus medica L.	Rutaceae	Citron, lime	Bark	Black
Clitoria ternatea L.	Fabaceae		Flower	Blue
Cordia myxa L.	Boraginaceae		Roots, leaf	Yellow, red
Coscinium fenestratum (Gaertn.) Clolebr.	Menispermaceae	Tree Turmeric	Seed, bark, wood	Red
Crocus sativus L.	Iridaceae	Saffron	Flower	Yellow, orange

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Cyanometra ramiflora L.	Caesalpinaceae		Wood	Black
Dioscorea bulbifera L.	Dioscoreaceae	Potato yam, air potato	Tuber	Pale colour
Diospyros embryopteris Pers.	Ebenaceae	Gaub persimmon	Fruit	Brown
Dipterocarpus turbinatus Gaertn.	Dipterocarpaceae	Common Gurjan tree	Twig, bark	Yellow, brown
Elaeodendron glaucum (Rottb.) Pers.	Celasteraceae		Bark	Red
Eugenia jambolana Lam.	Myrtaceae		Bark, leaf	Red
Euphorbia tirucalli L.	Euphorbiaceae		Wood	Red
Flemingia congesta Roxb.	Fabaceae		Pod	Red, Yellow
Galium aparine L.	Rubiaceae	Goose grass	Root	Purple
Galium rotundifolium L.	Rubiaceae		Root	Yellow, brown
Galium verum L.	Rubiaceae	Cheese rennet	Root	Yellow, red
Garcinia mangostana L.	Guttiferae	Mangosteen	Fruit	Black
Gardenia jasminoides J. Ellis.	Rubiaceae	Cape Jasmine	Fruit	Yellow
Garanium wallichianum D.Don	Geraniaceae	Wallich cranesbill	Fruit, root	Yellow, red, brown
Haematoxylon campechianum L.	Mimosaceae	Log wood	Heart wood	Red
Heliotropium trigosum L.	Boraginaceae		Leaf	Black
Indigofera aspalathoides Vahl.	Fabaceae	Wiry indigo	Leaf	Blue-black
Indigofera hirsuta L.	Fabaceae		Leaf	Indigo
Indigofera tinctoria L.	Fabaceae	Indian indigo, common indigo	Leaf	Blue, blue-black
Jatropha curcas L.	Euphorbiaceae	Physic nut, purging nut	Bark, leaf	Blue
Kirganelia reticulate (Poir) Baill.	Euphorbiaceae		Bark, root	Red
Lawsonia inermis L.	Lythraceae	Henna	Leaf	Orange, red
Lycopus europaeus L.		Gipsy wort	Fruit	Green
Mallotus philippiensis Muell.	Euphorbiaceae	Kamala tree	Fruit	Red
Malphigia glabra L.	Malpigiaceae	Barbedos cherry	Flower	Yellow
Melastoma malabathricum L.		Indian rhododendron	Fruit	Black, purple
Michelia champaka L.	Magnoliaceae	Champak	Flower	Yellow
Mimusops elengi L.	Sapotaceae	Bullet wood	Bark	Brown
Morinda Citrifolia L.	Rubiaceae		Root	Red, Yellow
Morinda umbellata L.	Rubiaceae		Root	Red
Naregamia alata Wight & Arn.	Meliaceae		Leaf	Red
Nyctanthes arbortristis L.	Oleaceae	Coral jasmine	Flower	Yellow
Oldenlandia umbellata L.	Rubiaceae	Chay-root	Root	Red
Oxalis corniculata L.	Oxalidaceae	Indian sorrel	Leaf	Blue
Papaver rhoeas L.	Papaveraceae	Corn poppy	Petal	Red
Peltophorum pterocarpum (DC.)	Caesalpiniaceae	Copper pod	Wood, leaf	Brown, black

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Perilla ocimoidea L.	Labiatae	Kumboo millet	Fruit	Black
Pistacia intergerrima L.	Anacardiaceae	East Indian mastechae	Flower, leaf	Yellow
Toddalia asiatica (L.) Lam.	Rutaceae	Wild orange	Root	Yellow

Here we have some plants which contain dye pigments with its amount of content, habitat and distribution.

Table 3. Pigments of dye yielding plants (R.Siva, 2007)

Plant	**Colour obtained**	**Pigment**	**Dye content**	**Habitat and distribution**
Acacia catechu (L.f.) Willd.	Brown, black	Catechin, catechutannic acid	The chief constituents of the heartwood vary from 4 to 7% and are distributed throughout the heartwood from the root to the branches.	Occurs throughout India in dry types of mixed forest on a variety of geological formations and soils.
Adhatoda vasica Nees.	Yellow	Adhatodic acid, carotein, lutolin, quercetin	-	Distributed throughout India, up to an attitude of 1300 m; grows on waste land and in a variety of habitats and soil. It is sometimes cultivated as hedge.
Bixa orellena L.	Orange, red	Bixin, norbixin	The dye content is 5-6% by weight of seed. A carotenoid bixin comprises 70-80% in each seed.	the small tree is found to thrive at elevations of 600-900 M; native to tropical America, it has become naturalised in the hotter parts of India.
Butea monosperma (Lam) Taubert.	Yellow or orange	Butrin	-	Commonly found throughout India, except in the arid region. It grows on black cotton soil, even on saline, alkaline and swampy badly drained soils and in barren lands.
Carthamus tinctorious L.	Yellow, red	Carthamin	The chief constituent carthamin ranges from 3 to 6% of the flower.	Cultivated throughout India. It requires fertile, moisture-retentive and well-drained soil.
Curcuma longa L.	Yellow	Curcumin	Percentage of curcumin varies from 5.4 to 8.7.	Turmeric grown generally as an annual crop. It is cultivable from sea level up to 1200 M. it thrives in will-drained, fertile, sandy and clayey, black red soil.
Indigofera tinctoria L.	Blue	Indigotin, Indican	Indigotin content varies according to season and age of the plant. Best grade contains 70-90% in dried leaves.	Distributed commonly in the tropical region.

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lawsonia inermis L.	Orange	Lawsone	The principle colouring matter, lawsone is present in dried leaves at a concentration of 1.0-1.4%.	It is mainly cultivated in Tamil Nadu, Madhya Prades and Rajasthan. It can grow on any type of soil from light loam to clay loam but grows best on heavy soil.
Mallotus philippenis Muell.	Red	Rottlerin	The yield of powder rottlerin is 1.4-3.7% of the weight of the fresh fruits.	Found throughout India; occasionally ascending to 1500 m in the outer Himalayas. Commonly found in Sal and certain shrub and mixed forests.
Morinda citrifolia L.	Yellow, red	Morindone	Roots are guh out when the plants are 3-4 years old, dried and sorted for use by the dyeing trade.	A small tree distributed throughtout the tropics.
Oldenlandia umbellata L.	Red	Alizarin, Rubichol ric acid	-	Prostrate herb distributed in the tropical and subtropical region.
Pterocarpus santalinus L.	Red	Santalin	Red sanders contain 16% of a colouring matter, santalin (santalic acid).	Grows typically of dry, hilly, often rocky ground and is occasionally fround growing on precipitous hillside.
Punica granatum L.	Yellow	Petargonidon 3,5, diglucoside	-	Mostly found cultivated in many parts of India. The tree is also common and gregarious in the gravel and boulder deposits of dry ravines and similar places in the outer Himalayas up to 1800 m.
Rubia cordifolia L.	Red	Purpurin	Purpurin per cent vary from 2.0 to 4.0	A hardy climber common thoughout India, ascending to an altitude of 3750 m.
Semecarpus anacardium L.f.	Black	Bhilawanol	Bhilawanol ranging from 28 to 36% of dry weight of seed.	The tree is common in forests often found occuring with Sal, throughout the hotter parts if India.
Toddalia asiatica (L.) Lam.	Yellow	Toddaline	-	In South India, the plant is common in the Nilgris and Palani hills, and also in the scrubby jungles of Orissa.
Wrightia tinctoria R. Br.	Blue	β-amyrine	Leaves are the source of blue dye called Mysore pala-Indigo and β-amyrine ranges from 3.3-5.0% of dried leaves.	Distributed in Rajasthan, Madhya Pradesh and peninsular India, ascending to an altitude of 1200 m in the hills.

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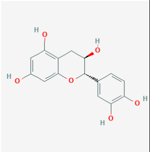
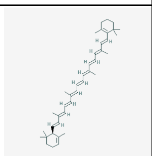
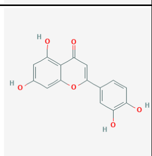
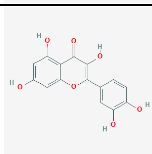
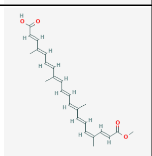
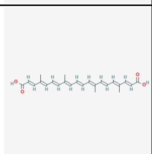
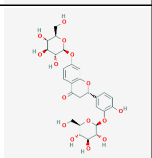
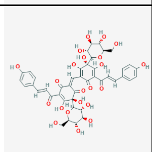
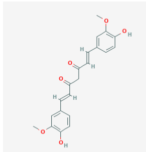
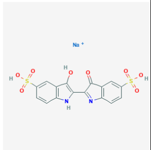
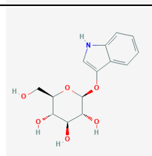
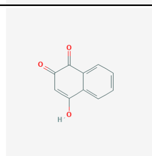
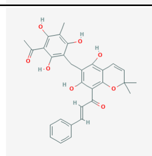
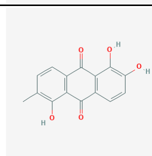
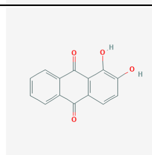
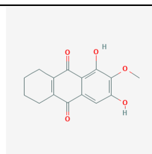
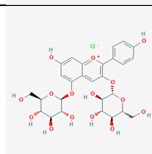
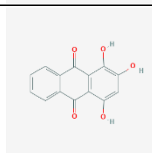
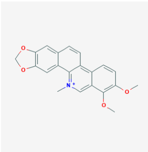
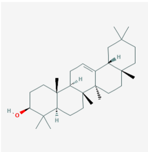
Table 4. Plants and its Pigment's Chemical structure and Molecular formula

Plant name	Pigment	Chemical structure	Molecular formula
Acocia catechu (L.f.) Willd.	Catechin		$C_{15}H_{14}O_6$
	Catechutannic acid		
Adhatoda vasica Nees.	Adhatodic Acid		
	Carotene		$C_{40}H_{56}$
	Luteolin		$C_{15}H_{10}O_6$
	Quercetin		$C_{15}H_{10}O_7$
Bixa orellena L.	Bixin		$C_{25}H_{30}O_4$
	Norbixin		$C_{24}H_{28}O_4$
Butea monosperma (Lam) Taubert	Butrin		$C_{27}H_{32}O_{15}$
Carthamus tinctorious L.	Carthamin		$C_{43}H_{42}O_{22}$
Curcuma longa L.	Curcumin		$C_{21}H_{20}O_6$
Indigofera tinctoria L.	Indigotin		$C_{16}H_{10}N_2NaO_8S_2^+$
	Indican		$C_{14}H_{17}NO_6$
Lawsonia inermis L.	Lawsone		$C_{10}H_6O_3$
Mallotus philippenis Muell.	Rottlerin		$C_{30}H_{28}O_8$
Morinda citrifolia L.	Morindone		$C_{15}H_{10}O_5$
Oldenlandia umbellata L.	Alizarin		$C_{14}H_8O_4$
	Rubicholric acid		
Pterocarpus santalinus L.	Santalin		$C_{15}H_{14}O_5$
Punica garnatum L.	Pelargonidin 3,5 diglucoside		$C_{27}H_{31}ClO_{15}$
Rubia cordifolia L.	Purpurin		$C_{14}H_8O_5$
Semecarpus anacardium L.f.	Bhilawanol		

doi: 10.32622/ijrat.83202012

Toddalia asiatica (L.) Lam.	Toddaline		$C_{21}H_{18}NO_4$
Wrightia tinctoria R. Br.	β-amyrine		$C_{30}H_{50}O$

IV. Preparation of Dyes

Two hundred years or more ago it was necessary to produce crops such as indigo and woad, weld and madder based on labour-intensive agronomy, and time-consuming downstream manufacturing processes to prepare the dye (Dogan Y, 2003, W Crokes, 1874, Krishnamurty T., 1993). All of that started dying out in the mid-19th century. Agriculture has since become a technologically advanced industry, yet our understanding of how to grow dye crops has become fossilized.

The dye is usually prepared by boiling water in the crushed powder, but sometimes it is left to soak in cold water. In general, the solution obtained then is used to dye coarse cotton fabrics. Alum is usually employed as a mordant. Butea monosperma (Lam) flowers at Taubert. Make an orange-coloured dye that is not quick and easy to wash away (R.Siva, 2007). The material is steeped in a hot or cold decoction of the flowers for colouring purposes. Whether by first preparing the cloth with alum and wood ash, or by adding these substances to the dye bath, a more permanent colour is created. The indigo dye is produced by steeping the plant in water and permitting fermentation. The solution is then oxidized with air in a separate vessel. Muell of Mallotus philippinensis. Provides an orange colour, used to dye silk and wool. Preparing the B Annatto Dye. Orellena L., when almost ripe, the fruits are harvested. The seeds and pulp are separated from the mature fruit, and water is macerated. These are either ground up in an' annatto paste' or dried and sold as annatto seeds afterwards. Sometimes when the seeds and pulp are macerated with water, the substance is stained through a sieve and the colouring content that settles out is collected and partly heat-evaporated and eventually dried in the light (B Glover and J H Pierce, 1993).

V. Conclusion

Natural dyes Vs Synthetic dyes & Conclusion

Without particular conclusive evidence, several people in the textile industry have argued that natural colours are poor have fastness, that the colours produced are of poor quality, that the colours are expensive and difficult to use, and that there is not enough land to grow them (B. Glover, 1995, U Sewekow, 1988, U Sewekow, 1995, D J Hill, 1997). Therefore, they say that natural dyes are not a suitable commercial alternative to synthetic dyes, and therefore they have no future in the textile industry. But this is to miss the point regarding natural colouring, as no one suggests that natural colouring could completely replace synthetic colouring. Natural dyes have environmental and health issues that cannot be ignored. Nevertheless, synthetic colouring itself can pose significant industrial hazards, and its manufacturing is protected by strict COSHH (Control of Substances Hazardous to Health) regulations that are not needed for the production and processing of natural colorants.

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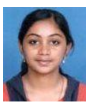

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doi: 10.32622/ijrat.83202012