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Plant Based Natural Dyes in Assam: A Systematic Review

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Abstract : In the history of natural dyeing, India has a rich heritage of using vibrant colouring fabrics, paintings with the locally available colouring materials. These colorants were made from plants, animal extracts or minerals. During the medieval and early colonial periods indigoid blue, khoyar from acacia bark, range of reds from madder, burgundy from lac insects were mostly used in which the colour "last as long as the cloth itself". Among the various types of natural colorant materials, plant extracted dye is widely used, some of which has also medicinal properties. In India, there are more than 500 varieties of plants that can be used for dyeing and printing. In Assam also, there are large number of dye yielding plant available in the forest as well as domestic areas. In this article, the author studied the different dye yielding plants of Assam and establishes more than 50 numbers of mostly used plants which are grouped according to the particular colour they produced. Though, natural colour has certain inherent drawbacks for large scale production, use of natural materials increases the value of a product and contributes to sustainable and eco-friendly environment.

Keywords: *Colorant, Natural Dye, madder, dye-yielding, drawbacks.*

1. INTRODUCTION

Natural dyes are used as 'colorant' and it seems to be the principal colouring matters of dyeing textile substrate from ancient times to the late 19th century. The colorants are the substances that have an affinity to the substrate to which it is being applied. Natural dyes are not only used in textile substances but also in food industry (Annatto, Curcumin and cochineal), leather items, cosmetics (lipstics, hair colouration), dye-sensitized solar cells, histological staining, pH indication & pharmaceuticals (Saffron, Rhubarb) and several other fields [33, 54]. In the ancient period plants and insects have been used as the main source of natural dyes. Natural dyes and pigments are also obtained from the minerals of the earth. Colouring matters derived from different organs of plant , such as roots, bark, leaf, fruit are known as vegetable class of dyes, lac, cochinel, kermes are the animal dyes which are obtained from animal and colorants obtained from various inorganic metal ores and metal salts are known as mineral dyes [39, 52]. However, though there are abundant numbers of natural colorants in the form of plants, animals or minerals, only few of these yield colorants which can be extracted and used commercially viable.

A drastic decline in the usage of natural dyes occurred after the introduction of synthetic dyes by Henry Perkin in the year 1856 [25]. By the development of synthetic dyes, due to its versatile application properties and number of advantages it becomes very popular and people adopted these dyes for dyeing and printing purposes. Thus, synthetic dyes led to an almost complete replacement of natural dyes. The replacement of natural dyes by the synthetic dyes have also certain other reasons, such as wide range of colour, reproducibility in easier way, and easily available varieties of colours with low cost. Due to such plentiful advantages of synthetic dyes many dyeing and printing units were established throughout the world and achieved mass production with speedy processes and accurate result as per requirement.

The production of synthetic dyes involves reaction which is conducted at high temperature and pressure using primarily from petroleum derivatives. About 80% synthetic dyes are constituted of aromatic azo type. Researches have shown that synthetic dyes are suspected to release harmful chemicals that are allergic, carcinogenic and detrimental to human health. Some of the synthetic dyes contain toxic or carcinogenic amines or other such chemical groups which have environmental impact and distress to the human skin. These dyeing plants, which uses chemicals, does not maintain proper effluent treatment plant and disposed their wastage into the cultivatable land or in river etc. thus leads to environmental and water pollution.

In the present era, ecological consideration, safe environment is becoming an important factor in the selection of consumer goods all over the world. Moreover, Government is very serious about the environmental pollution and waste disposal problems. As a result most of the developed countries close their dying and printing industries so as to overcome the environmental pollution problem. Germany was the first to take initiative to put ban on production and use of numerous specific azo dyes. Netherlands, India and some other countries also followed the ban of such dyes [22].

Indian Government also serious about this matter and framed rules & regulations for control of such dyeing & printing plants. In 1970s and 80s, the farmers created agitation against a dyeing and printing plant at Sanganer, Rajasthan, who disposed the effluents of chemical dyes in the agricultural land and leads to uncultivable and unpotable water. Same condition was happening in Tirupur in Tamilnadu, where the farmers created agitation, which led to shutdown of about 70% of chemical dyeing units in 2011[39]. On the other hand, natural dyes are biodegradable and do not cause any health hazards and hence they can be easily used without much environment concerns. So, natural dyes provide a reasonable solution to these problems. Of course, natural dyes have certain inherent drawbacks and technical problems in terms of commercial application to textile substrate. Some of the common downsides are:

- adaptation of traditional dyeing processes on modern equipment [63]
- supply of dye-houses with the required amount of plant material [63]
- standardization of extraction and dyeing of the plant material [13]
- selection of plant material and processes that yield products with acceptable fastness properties [13]
- Reproducibility of shades [52]
- Difficult to standardize the recipe and methods [52]
- Lack of availability of standardized methods and precise technical know-how on extraction and dyeing techniques.[14,52]
- The aqueous extract of natural dyes causes fungi growth if not used within 24-48 hours.[52]
- Use of metallic mordant or metal salts such as copper, cobalt, chromium etc.in some of the dyes, which are not eco-friendly. [14]
- Lack of proper knowledge about the natural sources for producing the different colour & shade.

Despite such some of the disadvantages of natural dyes, use of natural materials and natural methods is considered to be a choice that increases the value of a product and contributes to sustainable life in environmental, economic and sociologic senses [26]. Nowadays, most of the commercial dyers and textile export houses have started re-looking to the maximum possibilities of using natural dyes for dyeing and printing of different textiles for targeting niche market [4].

2. OBJECTIVES

It is observed and proved that most of the synthetic dyes are non-biodegradable, carcinogenic and generate water pollution as well as waste disposal problems. On the other hand, natural dyes are biodegradable, eco-friendly, no health hazards and it has the antimicrobial, medicinal properties. Thus, natural dyes will provide a reasonable alternative to synthetic dyes in view of its eco-friendliness, environ-friendliness, no effluent generation, mild dyeing condition, medicinal benefits, ancient heritage and aesthetic approach [10, 14, 46]. In fact natural dyes also have some drawbacks in terms of commercial application. Despite such common disadvantages for application of natural dyes on textiles in large scale sector, it is widely used in decentralized sector in every corner of India. Similarly, in the Assam and North Eastern region of India, it is seen that the coloration of textiles, especially on eri silk, is mostly confined in handloom sectors and small scale exporters and sale with high valued products. They dyed the textiles with traditional techniques and do not have standardized methods and precise technical know-how.

In Assam, it is perceived that plants are the major sources of natural colorants. But, most of the local dyer does not have the comprehensive knowledge about the different local plants which can produce a particular colour or shade. Moreover, it is revealed from the different published research paper that most of the research is carried out about the class of natural dyes, extraction methods, dyeing principles, fastness properties, medicinal uses etc. There is less research paper found in relation to the name of the groups of colour yielding plants for producing a particular colour. Thus, the author tries to give a systematic study as per the literature published (delimited to the referenced papers) about the different colour yielding plants available in Assam and summarize the group of colour yielding plants for producing a particular colour or shade along with their fastness properties.

3. METHODOLOGY

A three stage procedure is followed so as to obtain the accurate conclusions for the literature review process. In the first stage, the authors have searched the papers in the internet, books and journals from two different sources, one is the downloaded soft copy from the internet through search engine and the other is hardcopy from the nearby libraries and friends. The downloaded materials (research papers) are related to the name of the plants, sources, extraction, application, advantages & disadvantages of natural dyes.

In the second stage, a systematic review was carried out for all the downloaded and collected articles. After applying inclusion/exclusion criteria some of the papers are rejected which are not relevant to the reviewing topics and the papers which have the relevant materials to the investigated topic are selected for reviewing. Then, they are grouped together as per the nature of similar content.

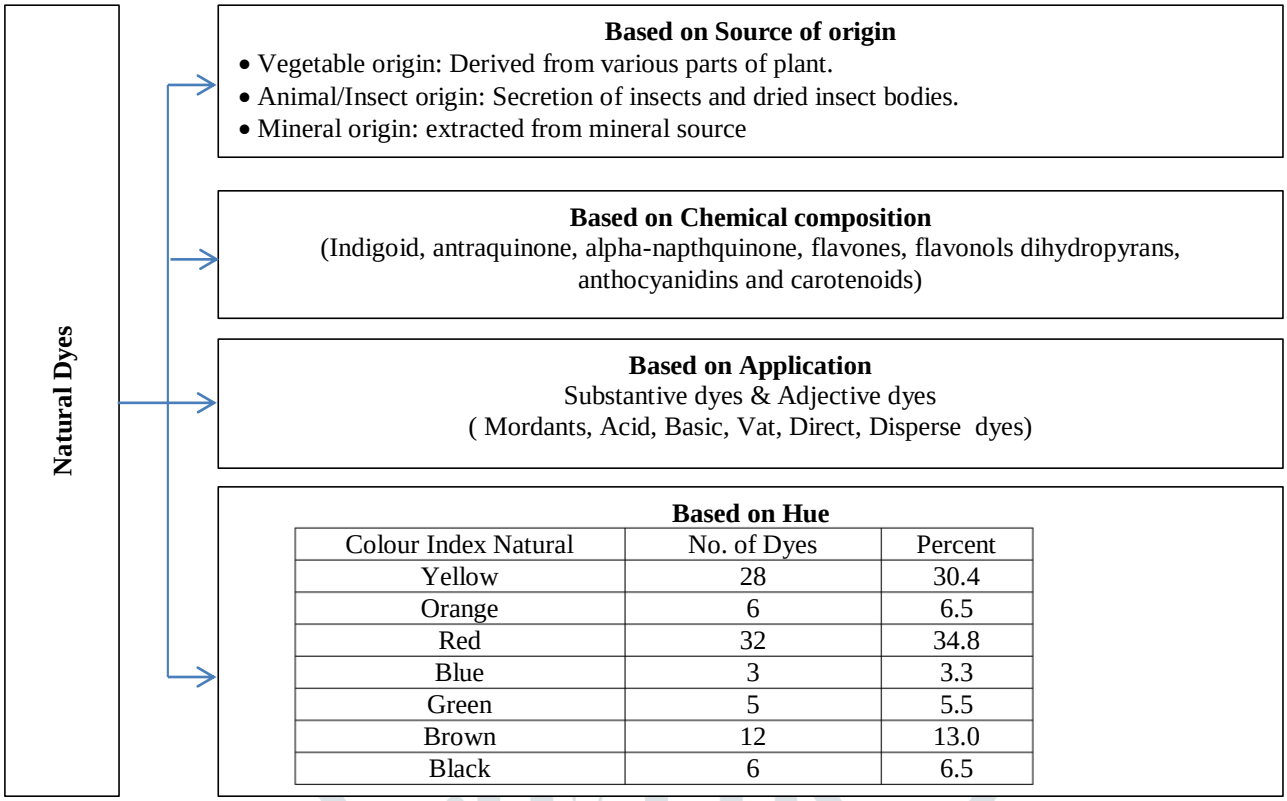
In the third stage, grouped papers are analyzed and synthesized according to the certain specific areas and finally summarized. Lastly, the author's conclusions are drawn based on the reviewed literatures.

4. SUMMARY OF LITERATURE REVIEW AND DISCUSSION

The development of natural dyes took place at the same time after the technique of weaving had been discovered in about 5000BC [NPTEL]. The earliest written record of the use of natural dyes was found in China dated 2600 BC (www.quilthistory.com Quilt History - The earliest dyes). In India, the Ajanta paintings, dated as far back as 1st century AD, where colourful garments worn by men and women perceived the use of natural dyeing and paintings.

4.1 Classification of Natural dyes

Natural dyes are mainly obtained from the renewable resources of nature such as plant leaves, roots, bark, flowers, fruits, and animals, although some minerals are also available in the earth for painting and dyeing. These colorants cover a wide range of chemical classes including indigoid, antraquinone, alpha-napthquinone, flavones, flavonols dihydropyrans, anthocyanidins and carotenoids [70]. Natural colorants can be classified in different groups based on their source of origin, chemical composition, application and on the basis of colour / hue [4, 8 28,25]. The classification of natural dyes can be represented as below in fig.1.0.



Colour Index Natural	No. of Dyes	Percent
Yellow	28	30.4
Orange	6	6.5
Red	32	34.8
Blue	3	3.3
Green	5	5.5
Brown	12	13.0
Black	6	6.5

Figure 1.0 Classification of Natural Dyes

Silk and wool fibres are mostly dyed with natural fibres as they have the strong affinity towards natural dye. On the other hand cellulosic fibres, cotton, jute, linen have poor affinity for natural dyes and thus mordanting technique with exhaustion method of dyeing is successfully used [28].

4.2 Plant based natural colour source

The plant based natural source of colour cannot be applied directly to the textile substrate. They have to be extracted properly and converted to applicable state. K.H. Prabhu et al enlisted a list of natural dyes source and their applications, where the plants species, common name, part used, colour application are incorporated [25]. Similarly, S.B. Gokhale et al also enlisted a list of commonly dye yielding plants in India, where the author mentioned the botanical name & family, parts used, colouring components, uses and mordants combination with the dyes for producing different colours [48]. Both the above mentioned papers give a brief idea about the list of colour yielding plants available in India. But, all the species are not available in the Northeast region of India. Moreover, the local peoples are practising the extraction and dyeing procedure with their traditional methods from the available local plants in their nearby areas. A survey was conducted by A.V. Singh in the Nagaon district, Assam in 2014-15 [3]. In the study, the surveyor found that the processes of dyeing techniques are followed from generation to generation through verbal transformation. The surveyor recorded the information on dye yielding plants, methods of dye preparation through discussions from the volunteer respondents and mentioned in his paper.

After reviewing the referenced papers [1-67], the author revealed that there are number of information available in respect to the various class of natural dye yielding plants, their extraction methods, dyeing procedures and advantages and drawbacks of natural dyes. But, there is some shortage of direct information regarding the different group of plants available for producing a particular colour. Thus, the author tries to make a list of available dye yielding plants, predominantly in the Assam, India for producing a particular colour or shade. The summary of dye yielding plants in colour wise is prepared and tabulated as below in Table 1.

Table 1 List of colour wise dye yielding plants in Assam, India

Colour	Plants Name	Botanical Name	Parts used / Dyeing Hints
Blue	Croton joufra Roxb / Gosmahudi (Mishing)	Euphorbiaceae	Fresh Leaf paste- 100%
	Indgofera ttinctoria L. / Sibu (Karbi)	Papilionaceae	Leaves & Twigs paste mixed with slake lime
	Piper betle L. / Pan (Assamese)	Piperaceae	Leaves & roots paste mixed with slake lime
Light Blue	Aparajita (Butterfly pea)	Clitoria ternatea	Flowers-90.0%, Water-10.0% and lemon ½ crashed
Dark Blue	Sibu (Karbi) Indigo	Baphicacanthus cusia (Nees) Bremek	Dry leaves and stem powder mixed with hot water

Dark Blue	Assam Indigo (Rom)	Strobilanthes cusia	Fresh Leaves boiled in water and dyed with vat dyeing process.
Light pista green	Henna	Lawsonia intermis	First pre-mordanted with 10% Myrobolan , then dyed with Henna
Pista green	Henna	Lawsonia intermis	First pre-mordanted with 10% $Al_2(SO_4)_3$, then dyed with Henna
Light green	Henna	Lawsonia intermis	First premordanted with 10% Myrobolan + 10% $Al_2(SO_4)_3$ and dyed with Henna
Shabby green	Henna	Lawsonia intermis	First premordanted with 10% Myrobolan + 10% Fe_3SO_4 and dyed with Henna
Brown	Kattha	Acacia sundra	Pre-mordanted with Alum or Harda, dyed with kattha at 80^0 C.
	Annatto Power	Bixa orellan	Premordanted with Alum or Harda , dyed with annatto dye at 80^0C
	Machmai (Assamese)	Trema orientalis Blume	Stem bark boiled in water
	Eucalyptus	Eucalyptus tereticornis	Grinded leaves with water and Onion Ash mordanting
Light Brown	Eucalyptus Camaldulensis	Myrtaceae	Crashed leaves with onion ash mordant
Light Reddish Brown	Dab(coconut) shell dye +Lac dye (stick lac)	Arecaceae + Kerria lacca	2% Green dab (coconut) husk dye + 2% Lac dye (on Cotton fibre) with 0.1% $K_2Cr_2O_7$
Medium Reddish Brown	Banana stem dye + Lac dye (stick lac)	Musa spp. + Kerria lacca	2% banana stem dye + Lac dye (on Cotton fibre) with 0.1% $K_2Cr_2O_7$
Dark Brown	Eucalyptus Camaldulensis	Myrtaceae	Crashed leaves with Soap nut mordant
	Mesaki Jati Koroi (Assamese)	Sarcochlamys pulcherrima Gaud.	Leaves & stem bark boiled in water
	Radha sura (Assamese) / Gulmohar	Delonix regia Raf.	Flower petal with reproductive organ
	Dab(coconut) shell dye +Lac dye (stick lac)	Arecaceae +Kerria lacca	2% Green dab (coconut) husk dye + 2% Lac dye (on silk fibre) with 0.5% Potash Alum
	Tea	Camellia sinensis	Premordanted with Fe_3SO_4 , dyed with tea at boil.
	Tamul (Assamese) / Betel Nut	Areca Catechu	Grinding the young betel husk and post mordant with Lime water
Pastel Brown	Betel Nut	Areca Catechu	Crashed young betel nut husk, then post mordant with Alum
Yellowish Brown	Eucalyptus	Eucalyptus tereticornis	Grinded leaves with water and mordanting with Harda
Blackish Brown	Khoyar (Assamese)	Acacia catechu wild	Dry stem bark mixed with slakes lime with boiled in water
Coffee Colour	Terminalia (Haritaki) + Pomegranate	Terminalia chebula/Myrobalan (Haritaki) + Punica Granatum (Pomegranate)	Xilikha -30.0%, Pomegranate-40.0%, Alum-20.0% and Ferous Sulphate-10.0%.
Deep Chocolate	Catechu brown dye + Lac dye	Acacia catechu +Kerria lacca	% Blended catechu brown dye + 2%Lac dye with 0.5% Potash Alum
Ghee (Cream)	Rose	Rosa rubiginosa	Rose-80.0%, Eating Soda-05.0% and Water-15.0%.
Light Pink	Tamarind	Tamarindus indica	Tamarind Peels-100.0%.
Light Pink	Lac	Kerria lacca	First premordanted with 10% Myrobolan and dyed with Lac
Dark Pink	Lac	Kerria lacca	First premordanted with 10% $Al_2(SO_4)_3$ and dyed with Lac
Pinkish Red	Lac	Kerria lacca	First premordanted with 10% Myrobolan + 10% $Al_2(SO_4)_3$ and dyed with Lac
Maroon	Palash + Myobalan	Butea Monosperma + Terminalia chebula	Palash flower-20.0%, Myobalan-30.0%, Alum-10.0% and Water-40.0%.
	Rongapuroi (Assamese) /Malabar Spinach	Basella alba L.	Ripe fruit mixed with alum
Yellow	Marigold	Tagetes	First mordant with aluminium acetate for cellulosic or with alum for protein fibre, then dyed with extracted marigold dyes
	Keli kadam (Assamese)	Adina cordifolia Benth & Hook.f	Chips of heart wood boiled in water
	Bael or Bel (Assamese) / Wood Apple	Aegle marmelos Correa ex Roxb.	Crushed fruit shell boiled in water
	Ingtat arong (Karbi) /	Artocarpus lakoocha	Chips heart wood boiled in water

	Mnkey fruit	Roxb.	
	Kurial (Deori) / Kanchan / Butterfly tree	Bauhina purpurea L.	Stem bark boiled with slakes lime
	Kath halodi (Assamese) / Daru haldhi	Berberies aristata DC	Stem boiled in water
	Haludi (Assamese) / Turmeric	Curcuma domestica Valeton	Rhizome boiled in water with slakes lime
	Radha sura (Assamese) / Gulmohar	Delonix regia Raf.	Flower mixed with turmeric
	Togor (Assamese)	Ervatamia divaricate (Linn.) Alston	Fruit pulp around the seeds boiled in water
	Kuji thkera (Assamese)	Garcinia morella Desr.	Gum from ripe fruit mixed with alum
	Tepor-tenga (Assamese)	Garcinia xanthochymus Hk.f.	Stem bark & fruit gum grinded & boiled in water
	Kopah (Assamese) / Cotton	Gossypium herbaceum L.	Fresh flowers paste
	Chubaiata (Assamese)	Mussaenda frondos L.	Leaves boiled in water
	Naga Tenga (Assamese)	Myrica esculenta Buch. Ham	Stem Bark boiled with slake lime
	Noga bhomloti (Assamese)	Symplocos cochnichinesis Moore	Leaves & Stem Bark boiled withwater
	Tam tingali (Assamese)	Symplocos oxyphylla Wall	Stem bark boiled in water
	Sagoon (Assamese) / Teak	Tectona grandis L.f. (Verbenaceae)	Stem bark boiled in water
	Rongalong (Assamese)	Trifolium prtense L.	Flowers boiled with alum
Golden	Xilikha (Haritaki) + Pomegranate (Dalim)	Terminalia chebula/Myrobalan (Haritaki) + Punica Granatum (Pomegranate)	Xilikha -30.0%, Pomegranate-40.0%, Alum-20.0% and water-10.0%.
Light Yellow	Palash	Butea Monosperma	Butea (Palash)-50.0%, Alum-05.0% and Water-45.0%
Reddish Yellow	Dhaiphool (Assamese)	Woodforrdia fruiticosa Kurz	Flowers paste with little water
Black	Aam, Madhuri, Silikha and Jamun (Assamese)	Mangifera indica L./ Piium guajava L. /Terminalia chebula Retz./ Syzygium cuminii	Dried stem bark of all four plants powered and boiled
	Arsontita (Bodo)	Rauvolfia tetraphylla L.	Fruit juice mixed with alum
	Jamun (Assamese)	Syzygium cuminii L. Skells	Stem bark boiled in water with slake line
	Silikha (Assamese)	Terminalia catappa L.	Fruit with alum boiled in water
Red Black	Bakam (Assamese)	Caesalpinia sappan L.	Stem bark and heart wood decoction in water with iron
Bluish Black	Jetuka (Assamese)	Lawsonia inermis L.	Leaves crashed with leaves of Indigofera tinctoria for paste
Orange	Joroth (Assamese) / Red Beri	Bixa orelllana L.	Dry Seed powder mixed with slake lime
	Gongari (Deori)	Mallotus philippenis	Ripe fruits crushed and boiled in water
	Sewali (Assamese)	Nyctanthes arbor-tristis L.	Fresh flower paste boiled in water with alum addition
	Bonbogori (Assamese)	Pterospermum lanceaefolium Roxb	Stem bark, leaves, gum grinded and boiled in water
Orange Red	Ushahul (Bodo)	Impatiens balsamina L.	Stem, leaves and flower paste and boiled in water
Red	Godhuli gopal (Assamese)	Mirabilisjalapa L.	Flower paste boiled in water
	Achu goch (Assamese)	Morinda angustifolia Roxb	Stem chips or root treated with slake lime
	Rongapotia goch (Assamese)	Poinsettia pulcherrima Graham	Flower boiled with alum
Brick Red	Jatikoroi (Assamese)	Albizia odoratissima Benth	Fresh stem bark boiled in water
Deep Red	Banana stem dye +	Musa spp. + Kerria	2% waste banana stem dye + 2% Lac dye (On silk fibre) with

	Lac dye	lacca	0.5% Potash Alum

The summary report in reference to colour yielding plants for a particular colour, as prepared in the Table-1, is after reviewing the papers mentioned in the referenced section. But, during preparation of the table most of the included information is included from the A. K. Samanta et al [1], A. Kar et al [2], S. Chakravarty [55], K. Chandra Rath et al [24], S. Khatun et al [56], W. S. Laitonjam et al [67], G. Tripathi et al [20], K.C. Rath et al [24]. After thorough study the data of the above table and the different research articles mentioned in the reference section, the following inferences can be drawn.

- A dyeing plant can produce variety of shades of same colour based on the use or non-using of mordant in the dyeing process.
- A dyeing plant can produce variety of shades of same colour based on the amount of mordant used in the dyeing process.
- Yellow and brown colour yielding plants are mostly available in the northeast region in comparison to other colour.
- To produce secondary or tertiary colour two or more than two colour yielding plants with compatible nature can be mixed at the time of dyeing just like synthetic dyes.
- Same dyeing recipe produces different hue when dyed with cotton or silk fibre.
- Cotton or silk fibre shows different hue even when they are dyed from the same dyeing recipe and condition.
- Majority of the natural dye process involves the use of natural or metallic mordant [6]. Post-mordanted dyed sample shows better colour fastness than pre-mordanted procedure [66].
- Instead of artificial mordant enzymatic dyeing method to prevent environmental pollution. The enzymatic method at low temperature on silk shows higher dye absorption, colour strength and good colour fastness with low pollution to environment [53].

4.3 Natural dye market and Brands

From the information available in the internet, it is observed that there are number of companies in India and abroad producing natural dyes and marketing, mostly in small pacing for home-use or for small scale dyeing. The Natural Dyes Market size is estimated to reach US$4.5 billion by 2027 and it is projected to grow at a Compound Annual Growth Rate (CAGR**)** of 8.6% from 2022-to 2027 [68]. As natural dyes has the UV protection, anti-microbial, anti-bacterial, anti-insect etc. properties, a number of brands in the fashion and textile industry has emerges and available in the market under various trade names.

5. CONCLUSIONS

In today's world, the consumers are very much interested in using the naturally dyed garments due to its non-toxic, non-carcinogenic nature and as a whole due to its number of beneficial properties. The demand of naturally dyed product is increased day-by-day and it will be augmented in the near future too. There are plentiful dye yielding plants in Assam and the people of Assam are practising natural dyeing of textiles since early days. Earlier, dyeing with natural dyes in Assam was restricted to the various tribes with their traditional dyeing technique from locally available products. For the last few decades numbers of research works have been carried out on natural dyes by the researchers from educational institutions, research organisations, social organisations etc. As a result, some information on natural dyes and its application processes are available in the form of books, journal, leaflets etc.

Through this review, the author attempts to provide certain specific information about the natural colour yielding plants available in the state of Assam. However, the practice of natural dyeing is performed by the local entrepreneur in small sector and supplied to the local, national and international market. But, this is just a small contribution towards the world's huge demand of naturally dyed product. Thus, there is tremendous scope for production of natural dyed & printed products in large scale and export to the international market. Thus, it is very much essential to establish and documented the scientific procedure of natural dyeing technique for each and every class of natural dye. To do so, an integrated effort from the researchers, people of academic institutions, Non-government Organisations, Industry people must exercise experimental & research project for proper documentation of dyeing, printing process.

REFERENCES

[1] A. K. Samanta, Sunanda Mitra Roy (2017). "Dyeing of cotton yarns with Latkan wood, Hena, Lac & Turmeric" in books: Handloom Textiles & Natural Dyes.Edited By-Ashish Mitra, Visva-Bharati, Department of Silpa-Sadana, WB, pp:188-193.

[2] A. Kar & SK Borthakur. (2008). Dye yielding plants of Assam for dyeing handloom textile products. Indian Journal of Traditional Knowledge, 7(1):166-171.

[3] A. Victor Singh (2017). Study on Dye Yielding Plants of The Karbis of Nagaon, Assam. International Journal of Advanced Research, 5(7):382-385.

[4] A. K. Samanta and A. Konar (2011). "Dyeing of Textiles with Natural Dyes" in books: Natural Dyes, Edited by E. Perrin Akçakoca Kumbasar, 29-56. DOI:10.5772/1817

[5] A. Kamboj and Surabhi Mahajan. (2018). Development of silk Kurtis with tie and dye technique using natural dyes. Asian Journal of Home Science, 13(1): 175-179.

[6] A. Kumar Samanta and Adwaita Konar.(2011). Dyeing of Textiles with Natural Dyes, Natural Dyes, Dr. Emriye Akcakoca Kumbasar (Ed.), ISBN: 978-953-307-783-3, InTech, Available from: http://www.intechopen.com/books/natural-dyes/dyeing-of-textiles-with-natural-dyes. pp:29-56.

[7] A. N. Banerjee , OP Kotnala & Sankar Roy Maulik. (2017). Dyeing of Eri silk with natural dyes in presence of natural mordants. Indian Journal of Traditional Knowledge, 17(2):396-399.

[8] A.Tamilarasi (2021). Classification and types of natural dyes: A brief review. International Journal of Creative Research Thoughts (IJCRT), 9(11): c527-c532.

[9] Ado A , Yahaya H. , Kwalli A. A. , & Abdul kadir R. S. (2014). Dyeing of textiles with eco-friendly natural dyes: A review. International Journal of Environmental Monitoring and Protection; 1(5): 76-81.

[10] A. Mukherjee (2017). "Innovative dyeing and printing with natural dyes" in books: Handloom Textiles & Natural Dyes. Edited By-Ashish Mitra, Visva-Bharati, Department of Silpa-Sadana, WB, pp:188-193.

[11] B. Patel and p. Kanade (2019). Top Dyeing of Silk using natural dyes. Asian Dyer, June-July 2019, pp:63-66.

[12] B. Sutradhar , D. Deb , K. Majumdar & B.K. Datta (2015). Short Communication: Traditional dye yielding plants of Tripura, Northeast India. 16 (2): 121-127.

[13] Borland V.S. (2000). Natural resources: animal and vegetable fibers for the 21st century. American. Textile. Industry, 29(6): 66–70.

[14] D. Pargai, S. Jahan and M. Gahlot (2020). "Functional Properties of Natural Dyed Textiles" in Chemistry and Technology of Natural and Synthetic Dyes and Pigments. DOI: http://dx.doi.org/10.5772/intechopen.88933.

[15] D. N. V. Satyanarayana & K. Ramesh Chandra (2013). Dyeing Of Cotton Cloth with Natural Dye Extracted From Pomegranate Peel and its Fastness. International Journal Of Engineering Sciences & Research Technology, 2(10):2664-2669.

[16] Ekta Grover, Anshu Sharma, Bhawana Rawat, Susan Paul & Shahnaz Jahan. (2005). Article in International Dyer, November 2005: pp.9-16.

[17] E. Catharine. (2016). Applications of Cross Dyeing with Natural Dyes. Textile Society of America Symposium Proceedings. 953. pp.108-116.

[18] G. Tripathi, M. K. Yadav, P. Padhyay & S. Mishra (2015). Natural dyes with future aspects in dyeing of Textiles: A research article. International Journal of PharmTech Research, 8(1):096-100.

[19] Gajendra CV, Kumaran K and Uma D (2019). Eucalyptus bark as a novel source for dyeing silk fabric. International Journal of Chemical Studies, 7(3): 818-823.

[20] G. Tripathi , Mukesh Kumar Yadav,Yogesh Kumar Tiwari. (2017). Cotton fabric dyeing process Eucalyptus camaldulensis leave's from natural dye. International Journal of ChemTech Research, 10(9) : 79-82.

[21] Hana Křížová (2015). "Natural dyes: their past, present, future and sustainability" in book: Recent Developments in Fibrous Material Science (pp.59-71)

[22] J. Arora, P. Agarwal, G. Gupta (2017). Rainbow of Natural Dyes on Textiles Using Plants Extracts: Sustainable and Eco-Friendly Processes. Green and Sustainable Chemistry, 7, 35-47. https://doi.org/10.4236/gsc.2017.71003.

[23] K Elsahida, A M Fauzi, I Sailah & I Z Siregar (2019). Sustainability of the use of natural dyes in the textile industry. IOP Conference series: Earth and Environmental Science. 399 012065. doi:10.1088/1755-1315/399/1/012065.

[24] K. Chandra Rath, Biswanath Sethi. (2017). Cytotoxic Effect of Silk Dyeing Industry Effluents on the Mitotic Cells of Allium cepa. European Journal of Zoological Research, 5 (2):10-16.

[25] K. H. Prabhu and Aniket S Bhute (2012). Plant based natural dyes and mordants: A Review. Scholars Research Library. J. Nat. Prod. Plant Resour, 2(6):649-664.

[26] S. D. Doğan & M. Akan (2018). A Research on Colours and Fastness Values of Different Materials Dyed with Some Natural Dyes. International Journal of Materials Science and Applications. 7(3): 69-74. doi: 10.11648/j.ijmsa.20180703.11.

[27] K. Terangpi (2021). Importance of the Indigenous Plant Knowledge: Study of Selected Plant Species Culturally Used by the Karbi Community of Karbi Anglong District, North-East India. Agrobiodiversity & Agroecology, 01(01): 65-78. Doi: https://doi.org/10.33002/aa010104

[28] L. Chungkrang and Smita Bhuyan (2020). Natural Dye Sources and its Applications in Textiles: A Brief Review. International Journal of Current Microbiology and Applied Sciences, 9(10):261-269.

[29] Lokesh P and Kumara Swamy M (2013). Extraction of natural dyes from Spathodea campanulata and its application on silk fabrics and cotton. Pelagia Research Library, 4(1):111-115.

[30] M. Gias Uddin (2015). Study on the color levelness of silk fabric dyed with vegetable dyes. Uddin. Sustain Chem Process (2015) 3:10 DOI 10.1186/s40508-015-0038-1.

[31] M. L. Gulrajani (2001). Present Status of Natural Dyes. Indian Journal of Fibre & Textile Research, Vol.26: pp. 191-201.

[32] M. Gogoi & Anumoni Gogoi (2017). Traditional Natural Colour of Assam. International Journal of scientific research and management, 5(1):5026-5035.

[33] M. Yusuf, Mohd Shabbir & Faqeer Mohammad (2017). Natural Colorants: Historical, Processing and Sustainable Prospects. Published with open access at Springerlink.com. DOI 10.1007/s13659-017-0119-9.

[34] N. Gogoi & B. Kalita. (1999). Dyeing of silk with natural dye(Part-I). Colourage, January-1999, pp.23-26.

[35] N. S. Mat Hussin, A. R. Ismail, S. W. Hasbullah & N. Abdul Kadi (2020). Properties Of Textiles Dyed With Young Adonidia Merillii (Betel Nut) Fruit Husk. International Journal Of Scientific & Technology Research, 9(3): 1917-1922.

[36] Netra Lal Bhandari, Kabita Bist, Jyoti Ghimire , Santosh Chaudhary , Durga Prasad Pandey, Rameshwar Adhikari (2020). Feasibility Study of the Euphorbia Pulcherrima Plant Extract As Natural Dye With Different Mordants For Fabric Dyeing. Journal of Institute of Science and Technology, 25(1): 30-36.

[37] P. Kampeerapappun, K. Wongwandee & S. Janon. (2020). Dyeing properties and color fastness of eri silk yarn dyed with soaked red kidney bean water. Journal of Metals, Materials and Minerals, 30(4): 51-59.

[38] P. Kanti Das and A Kumar Mondal (2012). The Dye Yielding Plants Used In Traditional Art Of 'Patchitra' In Pingla And Mat Crafts In Sabang With Prospecting Proper Medicinal Value In The Paschim Medinipur District, West Bengal, India. International Journal of Life Science Biotechnology and Pharma Research, 1(2): 158-171.

[39] P.Tolat Balaram (2017). "Eco-friendly dyes of India" in books: Handloom Textiles & Natural Dyes.Edited By-Ashish Mitra, Visva-Bharati, Department of Silpa-Sadana, WB, pp:182-187.

[40] Patel, N. (2011). Natural Dye Based Sindoor. *Life Sciences Leaflets*, *11*, 355 to 362.

[41] Pubalina Samanta, Deepali Singhee and Ashis Kumar Samanta (2018). Fundamentals of Natural Dyeing of Textiles: Pros and Cons. Current Trends in Fashion Technology & Textile Engineering, 2(4): 69-76.

[42] R. Chakrabarti and A. Vignesh . Natural Dyes: Application, Identification and Standardization. Available online in www.fibre2fashion.com. (Accessed on July.24, 2022).

[43] R. Siva. (2007). Status on natural dyes and dye-yielding plants in India. Current Science, 92(7):916-925.

[44] R. Kanchana, Apurva Fernandes, Bhargavi Bhat, Saurabhi Budkule, Santeshwari Dessai & Reshma Mohan (2013). Dyeing Of Textiles With Natural Dyes - An Eco-Friendly Approach. International Journal of ChemTech Research, 5(5), pp 2102-2109.

[45] R. Siva (2007). Status of natural dyes and ye-yielding plants in India. Current Science, 92(7): 916-925.

[46] R. Jihad [2014]. Dyeing of Silk Using Natural Dyes Extracted From Local Plants. International Journal of Scientific & Engineering Research, 5(11): 809-818.

[47] S. Khatun, G.R.M. A. M. Khan, L. Rahman. K. Hossain, D. Talukdar & M. Khatun. (2012). Extraction Of Natural (Dab Shell And Latkan) Dyes Blended It With Synthetic (Reactive Red And Methyel Orange) Dyes And Observe Their Dyeing Effects On Silk And Cotton Fibre. IOSR Journal of Applied Chemistry (IOSR-JAC), 2(6): 45-47.

[48] S. B. Gokhale, A. U. Tatiya, S. R. Bakliwal & R. A. Fursule (2004). Natural Dye Yielding Plants in India. Natural Product Radiance, 3(4): 228-234.

[49] S. Bhuyan and N. Gogoi (2013). Value addition of Eri silk yarns with Datura stramonium–A natural colourant. J. Acad. Indus. Res. Vol. 1(9):530-532.

[50] S. Dolanbay Dogan & Meral Akan (2018). A Research on Colours and Fastness Values of Different Materials Dyed with Some Natural Dyes. International Journal of Materials Science and Applications, 7(3): 69-74.

[51] S. Jyotsna Gogoi, N. Gogoi and B. Baishya Kalita (2019). Tea Leaves; A herbal dye on ERI silk. Journal of Pharmacognosy and Phytochemistry, 8(6):442-446.

[52] S. Roy Moulik (2017). "Natural Dye – an overview" in books: Handloom Textiles & Natural Dyes.Edited By-Ashish Mitra, Visva-Bharati, Department of Silpa-Sadana, WB, pp:170-175.

[53] S. Salimpour Abkenar (2021). Traditional Dyeing of Silk with Natural Dyes by EcoFriendly Method. International Scholarly and Scientific Research & Innovation 15(6): 133-136.

[54] Salauddin Sk M, Mia R, Haque MA, Shamim AM 92021). Review on Extraction and Application of Natural Dyes. Texti le & Leather Review. 2021. https://doi.org/10.31881/TLR.2021.09

[55] Sangeeta Chakravarty and Rani Hazarika Kakaty. (2015). An Analytical Study on Traditional Techniques of Dyeing Textiles with Natural Dyes in Assam, India. Global Journal of Arts, Humanities and Social Sciences. (Published by European Centre for Research Training and Development UK), 3(10) : 1-7.

[56] Seatara Khatun, G.R.M. Astaq Mohal Khan, Md. Lutfor Rahman, Md. Jahidul Islam, Md. Farid Ahmed, Md. Ruhul Amin, Md. Saifullahhel Ali Azom. (2016). Extraction of natural dyes and their utilization on silk and cotton fibres. Int. J. Bus. Soc. Sci. Res., 5(1): 67-70.

[57] Seatara Khatun, G.R.M. Astaq Mohal Khan, Md. Lutfor Rahman, Md. Jahidul Islam, Md. Farid Ahmed, Md. Ruhul Amin, Md. Saifullahhel Ali Azom (2016). Extraction of natural dyes and their utilization on silk and cotton fibres. Int. J. Bus. Soc. Sci. Res. 5(1): 67-70.

[58] ST-Natural Dyes 5.2.3\Them Doc\ Paper: A future vision for natural dyeing in India\Ver 3 final, Uzramma. This theme paper is available in https://kalpavriksh.org/wp-content/uploads/2019/05/Natural-Dyeing-paper-December-2001.pdf (Accessed on Sept.18, 2023)

[59] Sujata Saxena and A. S. M. Raja (2014). "Natural Dyes: Sources, Chemistry, Application and Sustainability Issues" in Roadmap to Sustainable Textiles and Clothing. Textile Science and Clothing Technology, DOI: 10.1007/978-981-287-065-0_2, pp:37-80.

[60] T. Karthik and D. Gopalakrishnan (2014). Environmental Analysis of Textile Value Chain: An Overview. Textile Science and Clothing Technology, DOI: 10.1007/978-981-287-110-7_6, pp:153-188.

[61] Teklemedhin TB & Gopalakrishnan LH (2018). Environmental Friendly Dyeing of Silk Fabric with Natural Dye Extracted from Cassia singueana Plant. Journal of Textile Science & Engineering, S3:001 doi: 10.4172/2165-8064.S3-001, pp: 01-06.

[62] Teli M. D, Paul. R, Pardeshi P.D (2000). Natural dyes: Classification, chemistry and extraction methods. Part I: Chemical classes, extraction methods and future prospects.

[63] Uddin MDT, Akhtarul Islam S, Mahmoud Rukanuzzaman MD (2009). Journal of Hazardous Material, 164 (1): 53-60.

[64] V. Kumar Gupta (2020). "Fundamentals of Natural Dyes and Its Application on Textile Substrates" in books: Chemistry and Technology of Natural and Synthetic Dyes and Pigments. DOI: http://dx.doi.org/10.5772/intechopen.88933.

[65] V. Narayana Swamy, K. N. Ninge Gowda & R. Sudhaka (2014). Eco-Friendly Natural Dye for Cotton and Silk Fabrics. Life Science Leaflets, Vol. 51, pp: 90-99.

[66] V. Narayana Swamy (2020). Analysis and Study of Effect of Natural Dye From Bombax malabarica on Silk Fabric. Clothing and Textiles Research Journal, 38(1): 49-58.

[67] W. S. Laitonjam, L. Potsangbam, S. D. Wangkheirakpam. (2014). Comparative study of the natural dyes derived from two indigenous plants of north-eastern India on silk and cotton fabrics. International Journal of Natural Products Research, 4(1) : 15-18.

[68] https://www.industryarc.com/Research/Global-Natural-Dyes-Market-Research-511877. Accessed on Sept.28, 2023.

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