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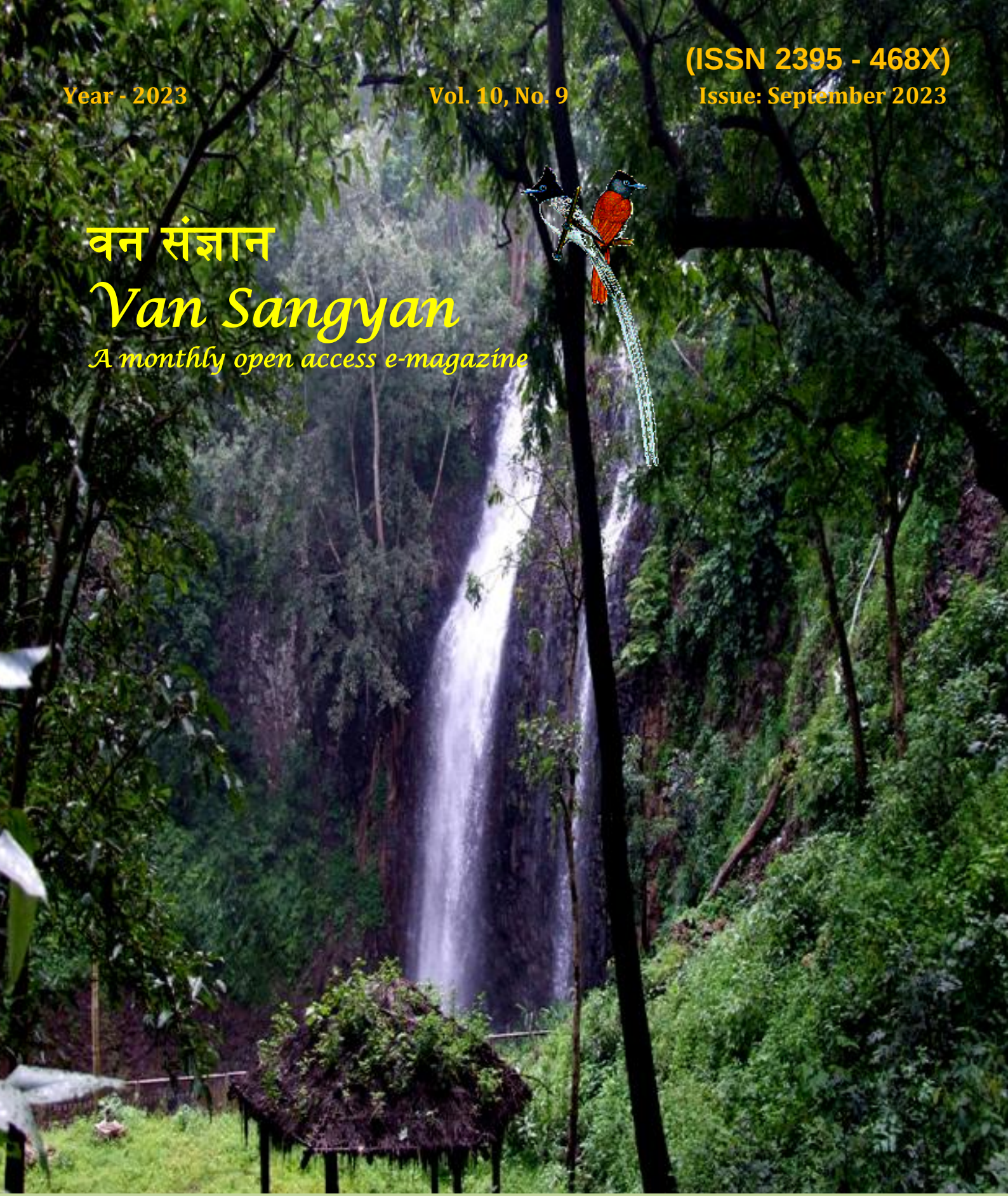

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Van Sangyan

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Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

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The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number. TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

Historically, natural dyes have been employed to color food substrates, leather, and common textile fibers such as cotton, wool, and silk. However, with the emergence of synthetic dyes and their superior fastness properties compared to natural dyes, the latter have experienced a significant decline in usage. In the contemporary context, there is a heightened awareness of the eco-friendliness and sustainability of consumer products. This has led to a renewed interest in natural dyes, resulting in a gradual resurgence in their popularity.

In recent years, there has been a substantial increase in the utilization of natural dyes. This resurgence is attributed to a growing concern among people regarding environmental pollution. Consequently, individuals are inclined to avoid chemically more hazardous synthetic dyes and intermediates. The export market has witnessed a day-by-day escalation in the demand for textiles dyed with natural dyes, reflecting a positive shift towards environmentally conscious choices.

In line with the above this issue of Van Sangyan contains an article on Natural dyes: Opportunities and strategies. There are also useful articles viz., Unlocking ecological histories: Advancements in dendroecology research, Feeding ecology of Sloth Bear (Melursus ursinus) and its role in seed dispersal, From grey to green: Unleashing the potential of urban forestry, Seed biopriming in forestry: Enhancing reforestation and sustainable forest management, Review on Melia dubia -A sustainable raw material for wood industries, Forest engineering and infrastructure development and पवित्र उपवन: भारत में प्रकृति संरक्षण की विरासत.
I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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Natural dyes: Opportunities and strategies

S Vennila[1], P. Radha[2] and K. Kumaran[2]

[1]Agricultural College and Research Institute, Vazhavachanur
[2] Forest College and Research Institute, Mettupalayam
Tamil Nadu Agricultural University, Coimbatore

Introduction

India has a rich biodiversity and it is not only one of the world's twelve megadiversity countries, but also one of the eight major centres of origin and diversification of domesticated taxa. It has approximately 490,000 plant species of which about 17,500 are angiosperms; more than 400 are domesticated crop species and almost an equal number their wild relatives. Thus, India harbours a wealth of useful germplasm resources and there is no doubt that the plant kingdom is a treasure-house of diverse natural products. One such product from nature is the dye. Natural dyes are environment friendly, for example, turmeric, the brightest of naturally occurring yellow dyes is a powerful antiseptic which revitalizes the skin, while indigo gives a cooling sensation (Mahanta and Tiwari, 2005).

After the accidental synthesis of mauveine by Perkin in Germany in 1856 and its subsequent commercialization, coal-tar dyes began to compete with natural dyes. The advent of synthetic dyes caused rapid decline in the use of natural dyes, which were completely replaced by the former within a century (Singh, 2001). However, research has shown that synthetic dyes are suspected to release harmful chemicals that are allergic, carcinogenic and detrimental to human health. Ironically, in 1996 Germany became the first country to ban certain azo dyes.

Presently there is a great demand for the use of natural colours throughout the world due to non-biodegradable and carcinogenic nature associated with synthetic dyes (Chungkrang and Bhuyan, 2020). They are not produce any undesired by-products and at the same time they help in regenerating the environment, therefore natural dyes are the safe dyes. Government of Germany was the first to take initiative to put ban on azo-dyes for manufacturing, dyeing and importing textiles and other consumer goods dyed with these dyes from January 1, 1995 by the act of German Legislation (Consumer Goods Ordinance). Netherlands followed a ban with effect from August 1, 1996 on similar lines. European Union is likely to impose ban on these toxic dyes shortly. India has also banned the use of specific azo-dyes and under notification sufficient legal teeth‖ had been given for taking panel action against those who use these dyes (Singh *et al.*, 2006).

Natural dyes are important since they are better than synthetic dyes in many ways.

Undeniably, the natural dyes are healthier products, purely because they do not comprise chemicals damaging to fitness (Baliarsingh *et al.*, 2013). These dyes are collected from nature and no need to apply manufacturing process to prepare them. These dyes are easily decomposed in nature after using and they do not pollute the environment while destroying them after end use (Alam *et al.*, (2020). The natural dyes are used mainly in coloration of textiles, food, drugs and cosmetics. Small quantities of dyes are also used in coloration of paper, leather, shoe polish, wood, cane, candles and such other

products requiring coloration (Gulrajani, 2001).

Status of natural dyes in India

Presently natural dyes are not in use for mainstream textile processing. Only about 1% of the total textiles produced are dyed by using natural dyes. Traditional dyers and enthusiasts are the main users of natural dyes who work at the cottage level. Some small industries are also using natural dyes and there are a number of companies who are manufacturing and selling natural dyes both as finely ground plant material as well as purified extracts. Sustainability is a complex multidimensional concept concerning the environment, economy, human health, and social impact. It aims to meet the needs of the present generation without compromising the ability of future generations to meet their needs. Many researchers emphasis on using natural dyes in the textile industry can make a valuable contribution to the environmental sustainability in the twenty-first century. Various sustainability issues involved in the present status of usage of natural dyes *viz*., renewable and biodegradable; easy-to-treat effluent; promote vegetation and carbon fixation; Status in Global Organic Textile Standards (GOTS); availability and supply Issues of natural dye; high cost of natural dye and dye products.

Potential source of natural dye

Natural dyes obtained from plants, animals and minerals. Although some fabrics such as silk and wool can be coloured simply by being dipped in the dye, others such as cotton require a mordant. Many natural dyestuff and stains were obtained mainly from plants and dominated as sources of natural dyes, producing different colours like red, yellow, blue, black, brown and a combination of these. Almost all parts of the plants like root, bark, leaf, fruit, wood, seed, flower, etc. produce dyes. It is interesting to note that over 2000 pigments are synthesized by various parts of plants, of which only about 150 have been commercially exploited. Nearly 450 taxa are known to yield dyes in India alone (Chandramouli, 1995). The increasing market demand for dyes and the dwindling number of dye-yielding plants forced the emergence of synthetic dyes like aniline and coal-tar, which threatened total replacement of natural dyes. Even today, some dyes continue to be derived from natural sources; for example, dyes for textile industries are still obtained from *Bixa orellana, Terminalia chebula, Tectona grandis, Hibiscus Sabdariffa,* Eucalyptus, Casuarina, *Anogeissus latifolia, Indigofera tinctoria, Sterculia foetida, Terminalia catappa, Carthamus tinctorius* and *Clitoria ternatea* those for eye shadow from indigo. Tables 1 show some of the important dye-yielding plants used traditionally.

Table 1. Promising natural dye yielding tree species

S. No	Scientific name	Family	Common name	Dye yielding parts	Dye colour
1.	*Ailanthus triphysa*	Simaroubaceae	Malabar Tree of Heaven	Leaves	Black
2.	*Adhatoda vasica*	Acanthaceae	Malabar nut	Leaves	Yellow / Grey
3.	*Clerodendrum bracteatum*	Verbenaceae	Bracted Glory Bower	Leaves	Pale green
4.	*Cordia dichotoma*	Boraginaceae	Sebesten tree	Leaves	Yellow
5.	*Tectona grandis*	Lamiaceae	Teak	Leaves	Yellow

6.	*Indigofera cassioides*	Fabaceae	Neel	Leaves & Flowers	Blue
7.	*Indigofera tinctoria*	Fabaceae	Indigo	Leaves	Blue
8.	*Zizyphus mauritiana*	Rhamnaceae	Indian jujube, Ber	Leaves	Red-pink
9.	*Ficus religiosa*	Moraceae	Pipal	Leaves & Bark	Red & Brown Yellow
10.	*Lawsonia inermis*	Lythraceae	Henna tree	Leaves	Brown
11.	*Toona ciliata*	Meliaceae	Indian mahogany	Leaves, Flowers	Red & Yellow
12.	*Artocarpus heterophyllus*	Moraceae	Jack fruit tree	Wood	Yellow
13.	*Acacia catechu*	Fabaceae	Cutch Tree	Wood	Reddish brown
14.	*Adenanthera pavonina*	Mimosaceae	Red Bead Tree	Wood	Reddish brown
15.	*Caesalpinia sappan*	Caesalpiniaceae	Sappan wood	Wood & pods	Red
16.	*Michelia champaca*	Magnoliaceae	Champa	Wood	Yellow
17.	*Pterocarpus santalinus*	Fabaceae	Red sanders	Wood	Red
18.	*Acacia farnesiana*	Fabaceae	Cassic flower	Bark	Black
19.	*Acacia leucocephala*	Fabaceae	Safed Kikar	Bark & leaves	Red
20.	*Acacia nilotica*	Mimosaceae	Gum arabic tree	Bark and pods	Yellow, dark grey
21.	*Acacia sinuate*	Fabaceae	Ritha	Bark	Brown
22.	*Albizia odoratissima*	Fabaceae	Kala siris	Bark	Brown
23.	*Bauhinia purpurea*	Fabaceae	Orchid tree	Bark	Purple
24.	*Bauhinia variegate*	Fabaceae	Kachnar	Bark	Yellow
25.	*Casuarina equisetifolia*	Casuarinaceae	coast sheoak	Bark	Light reddish
26.	*Ceriopsis tagal*	Rhizophoraceae	Indian mangrove	Bark	Black, Brown or purple with Indigo
27.	*Chloroylon swietenia*	Rutaceae	Indian satin wood	Bark	Yellow
28.	*Lannea coromandelica*	Anacardiaceae	Jingan	Bark	Golden & Pale Brown
29.	*Madhuca indica*	Sapotaceae	Illupai tree	Bark	Reddish yellow
30.	*Mangifera indica*	Anacardiaceae	Mango	Bark	Reddidh yellow
31.	*Berberis vulgari*	Berberidaceae	Barberry	Bark, wood, roots & stem	Yellow
32.	*Cassia fistula*	Fabaceae	Golden shower	Bark and sapwood	Red
33.	*Morinda tinctoria*	Rubiaceae	Ach	Bark	Red

34.	*Myrica esculenta*	Myricaceae	Kay phal	Bark	Yellow
35.	*Emblica officinalis*	Euphorbiaceae	Indian gooseberry	Bark & fruits	Reddish black
36.	*Terminalia arjuna*	Combretaceae	Arjuna tree	Bark	Light brown
37.	*Terminalia tomentosa*	Combretaceae	Asan	Bark & fruit	Brown
38.	*Ventilago denticulata*	Rhamnaceae	Pitti	Bark & Roots	Red, Purple and Chocolate
39.	*Garcinia xanthochymus*	Clusiaceae	Dampel, Tamal	Bark	Yellow
40.	*Pterocarpus marsupium*	Fabaceae	Indian kino tree	Bark	Red
41.	*Rhizophora mucronata*	Rhizophoraceae	Mangrove	Bark	Chocolate
42.	*Saraca Indica*	Leguminosae	Asoka Tree	Bark	Reddish/ purple
43.	*Shorea robusta*	Dipterocarpaceae	Sal	Bark	Red & black
44.	*Mimusops elengi*	Sapotaceae	Bakul	Bark and seed	Brown & yellow
45.	*Syzygium cumini*	Myrtaceae	Jammun	Bark	Red
46.	*Anacardium occidentale*	Anacardiaceae	Cashew	Pericarp	Light red
47.	*Aegle marmelos*	Rutaceae	Bael	Rind of the fruit	Red
48.	*Annona reticulata*	Annonaceae	Custard apple	Fruit, Shoots	Bluish black
49.	*Areca catechu*	Arecaceae	Areca nut palm	Nuts	Red
50.	*Aleurites moluccana*	Euphorbiaceae	Indian walnut	Root	Brown
51.	*Artocarpus lakoocha*	Moraceae	Dahua	Roots	Yellow
52.	*Butea superba*	Fabaceae	Lata Palash	Root	Red
53.	*Berberis nepalensis*	Berberidaceae	Nepal barberry	Root	Yellow
54.	*Geranium nepalense*	Geraniaceae	Bhand, Bhanda	Roots	Red
55.	*Hedyotis puberula*	Rubiaceae	Chay root	Root	Red
56.	*Morinda citrifolia Linn.*	Rubiaceae	Indian Mulberry	Root, bark	Red
57.	*Rheum emodi*	Polygonaceae	Indian Rhubarb /Dolu	Roots	Reddish-brown, greenish yellow to dark yellow
58.	*Rubia cordifolia*	Rubiaceae	Indian madder	Root, Stem	Reddish brown, Light pink/ brown
59.	*Rubia tinctorum*	Rubiaceae	Rose madder	Root, Wood	Red, pink, orange and lilac

60.	*Althaea rosea*	Malvaceae	Hollyhock	Flowers	Red
61.	*Bougainvillea glabra*	Nyctaginaceae	Bougainvillea	Flowers with ivory white bracts	Yellow, green, Orange
62.	*Butea monosperma*	Fabaceae	Palash, Tesu	Flower	Yellow
63.	*Caesalpinia pulcherima*	Fabaceae	Peacock flower	Flowers	Red
64.	*Carthamus tinctorius*	Asteraceae	Safflower	Flowers	Red & yellow
65.	*Cassia auriculata*	Fabaceae	Avaram	Flowers	Yellow
66.	*Chukrasia tabularis*	Meliaceae	Indian mahogany	Flowers & leaves	Red and yellow
67.	*Commelina benghalensis*	Commelinaceae	Benghal day flower	Flower	Blue
68.	*Crocus sativus*	Iridaceae	Saffron, Kesar	Flowers	Yellow
69.	*Delonix regia*	Fabaceae	Flame of the forest	Flowers	Yellow, Olive green, brown
70.	*Delphinium zalil*	Ranunculaceae	Asbarg, Asbar	Flowers	Yellow
71.	*Mesua naga*	Clusiaceae	Nagkesar	Flowers & Bark	Orange, Brown
72.	*Nyctanthes arbor-tristis*	Oleaceae	Parijatha	Flower	Yellow
73.	*Peltophorum pterocarpum*	Fabaceae	Copperpod	Flower	Yellow
74.	*Punica granatum*	Punicaceae	Pomogranate/ Anar	Flower and Rind	Yellow /grey
75.	*Woodfordia fruticosa*	Lythraceae	Dhai	Flowers	Pink to Red
76.	*Bixa orellana*	Bixaceae	Achiote	Pulp (aril) surrounding the seeds	Orange/ yellow
77.	*Cassia tora*	Fabaceae	Sickle pod	Seeds	Blue
78.	*Wrightia tinctoria*	Apocynaceae	Pala indigo	Seeds & leaves	Blue dye
79.	*Berberis aristata*	Berberidaceae	Indian barberry	Plant	Yellow
80.	*Chrozophora tinctoria*	Euphorbiaceae	Dyer's croton	Whole plant	Light green
81.	*Diospyros malabarica*	Ebenaceae	Gab	Fruit	Brown
82.	*Mallotus philippensis*	Euphorbiaceae	Kamala tree	Fruits	Red
83.	*Melastoma melabathricum*	Melastomataceae	Indian rhododendron	Fruit	Purple
84.	*Terminalia bellirica*	Combretaceae	Bahera	Fruit	Yellow & Brown
85.	*Terminalia chebula*	Combretaceae	Kadukai	Fruits	Yellow, dark grey
86.	*Ziziphus jujuba*	Rhamnaceae	Jujube	Fruit	Reddish pink

Natural dye extraction techniques

Extraction of colour materials from natural resources is a complicated process. They need specific technique to extract dye from their original sources. The different techniques for extraction of natural colourants are as follows:

Aqueous extraction

In this method, if the raw material is in dry form, broken into small pieces or powdered by grinding and soaked in water to loosen the cell structure. If the raw material is in wet form then it is chopped into fine pieces or grinded to fine paste. Then boiled and is filtered to remove the non colouring matters from the dye liquor. Both can be used easily to impart colour in different things.

There are some disadvantages associated with aqueous extraction method like time consuming for extracting colour, high temperature requirement, required large volume of water, heat sensitive colouring substances gets reduced at high temperature low dye yield, only water soluble colouring components can be extracted etc.

Acidic or alkaline extraction

Extraction of dye is done under acidic or alkaline medium. For this dilute acidic or alkaline can also be used which helps in hydrolysis of glycosides resulting in better extraction. Acidic method is used in extraction of tesu natural dye from tesu flower. Alkaline medium is used for those colour extraction which contain phenolic groups. Extraction of colour from lac insect, annatto seeds, safflower petals are extracted by this method.

Ultrasonic microwave extraction

In this extraction method, raw material is treated in aqueous solution using microwave or ultrasonic rays, so that the high temperature, less time and faster rate of extraction can be done. Colour from butterfly pea and annatto seeds are extracted by using this method.

Fermentation

In this extraction method, micro-organisms present raw materials are used to carry out the fermentation and thus help the extracting method. Colour from turmeric, indigo, *Anogeissus latifolia* leaves extracted by using this method. Time consuming, bad smell due to microbial action, immediate extraction of colour after harvesting are some disadvantages of this method

Enzymatic Extraction

Commercially available enzymes including cellulase, amylase, and pectinase have been used to loosen the binding material present in natural materials like bark, roots or any hard part of plant.

Solvent extraction

Organic solvents like acetone, petroleum, ether, chloroform and ethanol are used in the extraction of natural dyes. Solvent extraction method is more efficient than aqueous method. The yield of dye is good quality, required low temperature and the quantity of water requirement is also less.

Supercritical fluid extraction

In this extraction method, a fluid having physical properties between gas and fluid is used. It has low surface tension, low viscosity and good diffusivity properties which results

better interaction with the substrate.

Natural dyes Vs synthetic dyes

Natural dyes are the colourants extracted from plants, minerals or animal residues. The dyes derived from plants material represent a more sustainable source of

colourants. These dyes colour natural fibres like cotton, wool and silk to a greater or lesser extent. Apart from textiles, natural especially vegetable dyes are also used to colour wood, mats, basketry, pith, ivory and leather. After invention of synthetic fibres, there started huge production of synthetic textiles. This in turn resulted into a great demand for dyestuff to meet the huge requirement of dyes. No sufficient natural dyes were available to meet the requirement of the dyeing industry. Moreover natural dyes were found to have limited success in coloration of synthetic fibers. In the nineteenth century, the use of natural dyes in India started declining because synthetic dyes were introduced by the British government. The synthetic dyes which are today's conventional dyes are manufactured from petrochemical based intermediates. The drastic reaction conditions like high temperature and pressure, use of toxic solvents and catalysts in the manufacture of these dyes are sometimes objectionable. Natural dyes on the contrary are considered to be eco-friendly and much less hazardous. Today there is great dominance of the synthetic dyes due to all its advantages. However there are certain disadvantages of these established dyes. Because of a huge production of these dyes and their demand to meet present and future needs, there is going to be significant consumption of non-renewable resources such as oil and by products. Also there are work hazard problems and high environmental impacts during production of these dyes. There is danger of allergies to both the workers and the consumers. Moreover the waste disposal is a serious concern because of coloured effluent out of the dyeing industry.

In nut shell, dyeing with synthetic colours is being considered as a representation of an enormous ecological problem. Therefore, today it has become extremely important to both dye manufactures and textile processors to deal with health hazard problems, disposal of effluent and other environmental requirements usually to statutory norms.

Identification of natural dyes

Today natural dyes are used in limited quantities by craftsman in various parts of the world. Although difficult to obtain commercially, dyes are readily obtained from plant sources *viz*., flowers, leaves, barks, seeds, roots, etc. Craftsmen are becoming gradually enthusiastic about this out-dated and time consuming process for one of the reasons that natural dyestuffs procedure offbeat, one-of-a kind colour. There are not two lots identical, each having subtle differences due to impurities peculiar to the particular plant material used. Thus, the very characteristics of natural dyes that made the early dyers despair, appeal to today's craftsman searching for the unique. Since last decade application of natural dyes on cotton, silk, wool, jute is gaining popularity all over the world possibly due to the context of German ban on synthetic azo dyes which are based on carcinogenic or allergic arylamines. Natural dyes derived from flora and fauna are believed to be safe but sometimes the method of application using metallic mordants makes them non ecofriendly to humans and environment. However, natural dyes by virtue of their unique colour/shade and aesthetic characteristics have a potential export

market. Recently, the buyers from EEC countries especially from Germany insist on a certificate for eco-friendliness of the commodities and therefore, testing of natural dyed substrates as per Eco-standard as well as their anthenticity has become imperative.

Literature survey reveals that some work has been reported an extraction and identification of natural dyes from historic and archeological textiles but a systematic approach to extract and identify the range of colours in natural dyes from dyed textiles, is not readily available (Bhattacharyya and Sahasrabudhe, 1997)

- **Thin Layer Chromatography (TLC)** was used by many workers to identify various natural dyes in textiles. The dyes detected were based on insect and vegetable yellow, red and blue colour.
- **High Performance Liquid Chromatography (HPLC)**, which is a very useful tool to identify synthetic as well as natural dyes, was also used.
- **Infra-Red Spectral studies** were carried out to identify natural dyes viz., alizarin, indigo, dibromoindigo, saffron, weld, Persian berries and safflower yellow.
- **Emission and Excitation Spectra:** It is a non-destructive method was devised, for identifying faded dyes on fabrics through examination of their emission and excitation spectra.
- **UV/Visible Spectroscopic studies** to identify natural dyes were carried out to identify madder, cochineal, indigo, etc., using different solvents for extraction.

Future prospects and conclusion

Nowadays, fortunately, there is increasing awareness among people towards natural products. Due to their non-toxic properties, low pollution and less side effects, natural dyes are used in day-to-day food products. Although the Indian subcontinent possesses large plant resources, only little has been exploited so far. More detailed studies and scientific investigations are needed to assess the real potential and availability of natural dye-yielding resources and for propagation of species in great demand on commercial scale. Biotechnological and other modern techniques are required to improve the quality and quantity of dye production.

Due to lack of availability of precise technical knowledge on the extraction and dyeing technique, it has not commercially succeeded like synthetic dyes. Also, low colour value and longer time make the cost of dyeing with natural dyes considerably higher than with synthetic dyes.

Numerous plant species are found to have an important role in the day-to-day life of the ethnic and local people. However, it is a matter of concern that the indigenous knowledge of extraction, processing and practice of using of natural dyes has diminished to a great extent among the new generation of ethnic people due to easy availability of cheap synthetic dyes. It has been observed that the traditional knowledge of dye-making is now confined only among the surviving older people and few practitioners in the tribal communities of Arunachal Pradesh. Unfortunately, no serious attempts have been made to

document and preserve this immense treasure of traditional knowledge of natural dye-making associated with the indigenous people. Lack of a focused conservation strategy could also cause a depletion of this valuable resource. It is time that steps are taken towards documenting these treasures of indigenous knowledge systems. Otherwise, we are bound to lose vital information on the utilization of natural resources around us.

To conclude, there is an urgent need for commercialization of natural dyes can be successful with systematic and scientific approach for identification of resources, extraction, purification, chemical structure elucidation and promotion of use of natural dyes, thereby enhancing the economy of the local people. As a whole, systematic approaches with scientific attitude and conservation of natural resources need to overcome the limitation of natural dyes.

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Unlocking ecological histories: Advancements in dendroecology research

Reghu. Anandu[1]and Mohammed Haffis[2]

[1]ICFRE-Institute of Wood Science and Technology
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Bengaluru
[2]Forest Ecology and Climate Change Division,
ICFRE-Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Dehradun

Dendroecology

Dendroecology is a field of study that examines historical ecological processes using dendrochronology. Tree ring analysis, or dendrochronology, uses historical events and environmental changes to calculate dates. Dendroecology may be utilized to address a variety of ecological issues, including the history of fires, insect outbreaks, forest dynamics, climate change, and the identification of pollutant sources. A potent technique for analysing changes in historical and contemporary forest habitats is dendroecology.Dendroecology research have been carried out in several tropical and temperate locations utilising a variety of tree species and techniques.

Application of dendroecological analysis

Dendroecology can shed light on historical and present biological processes that form forest ecosystems. There are certain applications of dendroecological analysis that can help us understand more about the past and current ecological processes that impact forest ecosystems.

Here are a few examples: A research that reconstructed the history of contamination source identification in soil, groundwater, and tree tissues (Morrison *et al*., 2009) using tree rings and stable isotopes.

A research project that used tree rings to retrace the history of fire and climate in the Sierra Nevada and southwest of the US during the last 1000 years (Rozendaal*et al*.,2011) another investigation that examined individual trees' long-term development patterns in a tropical rainforest and how they related to environmental variables using tree rings (Amoroso *et al.*,2017).

Using tree rings, it is assessed that how mangrove plants responded to changes in salinity caused by seasonality in precipitation and temperature. A research that used tree rings to evaluate a forest development model and predict a pine plantation's wood yield. These are only a few of the many uses of dendroecology in the tropics and elsewhere.

Advancing dendroecological studies in India

Dendroecology study holds great promise in unraveling the climatic history of regions across the globe. In India, while dendroecological research is still in its infancy, significant strides have been made by various national institutes. The Indian Institute of Tropical Meteorology (IITM) in Pune, Birbal Sahni Institute of Paleobotany (BSIP) in Lucknow, and the Indian Institute of Science in Bangalore have spearheaded research initiatives,

primarily focusing on coniferous trees in the Himalayan region and teak and toon trees in the tropical climate. With a particular interest in rainfall variability, dry season ground fires, and reconstructing climate patterns, researchers are now turning their attention to explore new tree species that might yield valuable insights.

Target Species: *Tectona grandis* and beyond:

Tectona grandis, commonly known as teak, has emerged as a target species for tree-ring research due to its reliable annual ring formation. This tropical hardwood species not only presents a feasible avenue for studying climate signals but also offers valuable insights into its growth response to environmental conditions. Additionally, researchers are exploring other tree species, such as *Lagerstroemia microcarpa*, *Cedrela toona*, and *Terminalia bellirica*, to expand the scope of dendroecological studies in India. These species, found in deciduous forests and known to produce annual rings, hold the potential to provide further understanding of climate as well as ecological dynamics. Efforts are underway to explore several other tree species in India that might produce annual rings, which have yet to be discovered by the scientific community. By studying these unknown species, researchers aim to expand the knowledge base of dendrochronology in the Indian context and unlock new insights into climate patterns and environmental changes. This exploration opens up avenues for multidisciplinary collaboration and the possibility of refining existing methodologies while developing novel approaches to extract climate information from tree rings. (Suresh, H.S., 2012)

Challenges in dendroecological analysis

Dendroecological analysis in the tropics is more challenging than in temperate regions due to certain obstacles.

- Among these difficulties are: Due to weak or variable seasonality, complicated phenology, and cambial activity, many tropical tree species lack or have irregular yearly growth rings (Quintilhan *et al*., 2021)
- Due to the lack of shared development signals, synchronisation, and replication, it is difficult to cross-date tree-ring series from various trees or sites. (Groenendijk *et al*., 2014)
- There aren't enough long-lived tree species to give lengthy chronologies for climatic reconstructions or disturbance histories (Quintilhan *et al*., 2021)
- The scarcity of reference material to calibrate and validate tree-ring data, such as climate records, forest inventories, or historical documents. The logistical and methodological restrictions of gathering, processing, and analysing tree rings in distant and varied tropical forests(Quintilhan *et al*., 2021).

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Feeding ecology of Sloth Bear (*Melursus ursinus*) and its role in seed dispersal

R. Ravi Kumara*, P.C. Lohith and T. N. Manohara

Silviculture and Forest Management Division,
Institute of Wood Science & Technology
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Bengaluru, 560003, India.
Email: ravisilkstar5@gmail.com

The Indian bear, often known as the sloth bear (*Melursus ursinus* Shaw, 1791; Family: Ursidae), is a species that can only be found on the Indian subcontinent. There are reports of this species in 174 protected areas in India, including 46 national parks and 128 wildlife sanctuaries. Despite the species' wide distribution, many populations are in decline due to diminishing food sources, degraded and fragmented habitats, and escalating human-animal conflict. The sloth bear is listed as "vulnerable" by the International Union for Conservation of Nature and Natural Resources (IUCN) and is included in Schedule I of the Indian Wildlife Protection Act, 1972, as well as in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Kumar and Paul, 2021). The sloth bear population size for all of India is estimated to be between 6,000 and 11,000. In terms of population richness and habitat availability, the Western Ghats range and Central India are the only strongholds of distribution (Yoganand et al., 2006). Although it is unknown how long sloth bears live in the wild, they have been reported to live up to 40 years in captivity (Ward and Kynaston, 1995).

In addition to being referred to as the "sloth bear," the term "labiated bear" also describes the animal's protruding lower lip and palate, which it uses to suck up insects. It has long, shaggy fur, big sickle-shaped claws, and a mane around its face. It is lankier in comparison to brown bears and Asian black bears (Laurie and Seidensticker, 1977). It has several characteristics with insectivorous animals. In many cases, bears are opportunistic omnivores. As a result, how an animal behaves depends on the availability of food and other essential nutrients in its habitat (Jonkel and Cowan, 1971).Their primary sources of food are insects, particularly termites (*Odontotermes*, *Macrotermes*, *Microcerotermes*, *Hypotermes*, and *Reticulitermes* spp.) and ants. However, termites and other insects may make up more than 80% of the food of bears throughout the rest of the seasonal year, whereas fruits may make up between 70 and 90 percent of the diet during the fruiting season of trees (Seidensticker et al., 2011). Moreover, sloth bears and people compete for certain fruit species in common habitats (Bargali et al., 2004).

Figure 1: Illustrations show the scats of a sloth bear, which contained seeds and insects debris.

Dens are used by sloth bears for both breeding and protection (Akhtar et al., 2008). Dens can be found in lantana shrub thickets, rocky regions on hills and level surfaces, under the roots of trees, hillocks with large rocks, and nullah beds depending on the habitat (Yoganand et al., 2005). Bears often prefer shrubland, Sal woodland, and habitats near water, as well as farms, plantations, and open habitats (Yoganand et al., 2005). However, home ranges might fluctuate seasonally. The presence of termites and the durability of termite mounds most likely contributed to this seasonal transition (Joshi et al., 1997).

Table 1: List of plant species fed by the sloth bear

Common name	Scientific name	Family	References
Golden apple	*Aegle marmelos*	Rutaceae	Bargali et al., 2004;

			Khanal and Thapa, 2014.
Lindley's aporosa	*Aporosa lindleyana*	Phyllanthaceae	Sreekumar and Balakrishnan, 2002.
Jackfruit	*Artocarpus heterophyllus*	Moraceae	Sreekumar and Balakrishnan, 2002.
Wild jack	*Artocarpus hirusta*	Moraceae	Sreekumar and Balakrishnan, 2002.
White bark acacia	*Acacia leucophloea*	Mimosaceae	Philip et al., 2021.
Bel	*Aegle marmelos*	Rutaceae	Philip et al., 2021.
Custard apple	*Annona squamosa*	Annonaceae	Philip et al., 2021.
Axle Wood	*Anogeissus latifolia*	Combretaceae	Philip et al., 2021.
Ground nut	*Arachis hypogaea*	Fabaceae	Bargali et al., 2004.
Spinous kino	*Bridelia retusa*	Phyllanthaceae	Khanal and Thapa, 2014.
Almondette	*Buchanania lanzan*	Anacardiaceae	Bargali et al., 2004.
Mootapalam	*Baccaurea courtallensis*	Phyllanthaceae	Sreekumar and Balakrishnan,2002.
Bamboo	*Bambusa vulgaris*	Poaceae	Philip et al., 2021.
Bidi leaf	*Bauhinia racemosa*	Caesalpiniaceae	Philip et al., 2021.
Silk cotton	*Bombax ceiba*	Malvaceae	Philip et al., 2021.
Salai guggul	*Boswellia serrate*	Burseraceae	Philip et al., 2021.
Flame of the forest	*Butea monosperma*	Fabaceae	Philip et al., 2021.
Golden shower	*Cassia fistula*	Fabaceae	Bargali et al., 2004; Khanal and Thapa, 2014; Sreekumar and Balakrishnan, 2002.
Wild karanda	*Carissa spinarum*	Apocynaceae	Philip et al., 2021.
Bengal currant	*Carissa carandas*	Apocynaceae	Philip et al., 2021.
Amaltas	*Cassia fistula*	Caesalpiniaceae	Philip et al., 2021.
Grey leaved saucerberry	*Cordia sinensis*	Boraginaceae	Philip et al., 2021.
Bird lime	*Cordia myxa*	Boraginaceae	Philip et al., 2021.
Long-leaf cordia	*Cordia sinensis*	Boraginaceae	Philip et al., 2021.
Carray cheddle	*Canthium parviflorum*	Rubiaceae	Kumar and Paul, 2021.
Black currants	*Carissa congesta*	Apocynaceae	Mewada and Dharaiya, 2010.
Coromandel ebony	*Diospyros melanoxylon*	Ebenaceae	Bargali et al., 2004.
Sickle bush ashy	*Dichrostachys*	Mimosaceae	Philip et al., 2021.

babool	*cinerea*		
Solid bamboo	*Dendrocalamus strictus*	Poaceae	Kumar and Paul, 2021.
Warty marble	*Elaeocarpus tuberculatus*	Elaeocarpaceae	Sreekumar and Balakrishnan, 2002.
Ajan	*Ehretia aspera*	Boraginaceae	Philip et al., 2021.
Indian rock fig	*Ficus arnottiana*	Moraceae	Philip et al., 2021.
white fig	*Ficus infectoria*	Moraceae	Philip et al., 2021.
Golden rumph's fig	*Ficus rumphii*	Moraceae	Philip et al., 2021.
Scramberry	*Flacourtia cataphracta*	Salicaceae	Philip et al., 2021.
Governor's plum	*Flacourtia indica*	Salicaceae	Philip et al., 2021.
Ramontchi	*Flacourtia sepiaria*	Salicaceae	Philip et al., 2021.
Cluster fig	*Ficus racemosa*	Moraceae	Bargali et al., 2004.
Sacred fig	*Ficus religiosa*	Moraceae	Bargali et al., 2004.
Drooping fig	*Ficus semicordata*	Moraceae	Khanal and Thapa, 2014.
Banyan	*Ficus benghalensis*	Moraceae	Khanal and Thapa, 2014; Bargali et al., 2004; Philip et al., 2021.
White fig	*Ficus virens*	Moraceae	Bargali et al., 2004.
Gamhar	*Gmelina arborea*	Verbenaceae	Philip et al., 2021.
Falsa	*Grewia asiatica*	Tiliaceae	Philip et al., 2021.
Salvia leaved crossberry	*Grewia damine*	Tiliaceae	Philip et al., 2021.
Donkey berry	*Grewia flavescens*	Tiliaceae	Philip et al., 2021.
Dhaman	*Grewia tiliifolia*	Tiliaceae	Philip et al., 2021.
Balsam	*Impatiens balsamina*	Balsaminaceae	Philip et al., 2021.
Jungle flame	*Ixora coccinea*	Rubiaceae	Sreekumar and Balakrishnan, 2002.
Madras pea pumpkin	*Melothria maderaspatana*	Cucurbitaceae	Philip et al., 2021.
Hoom	*Miliusa tomentosa*	Annonaceae	Mewada and Dharaiya, 2010.
Lantana	*Lantana camara*	Verbenaceae	Sreekumar and Balakrishnan, 2002; Philip et al., 2021.
Mango	*Mangifera indica*	Anacardiaceae	Sreekumar and Balakrishnan, 2002; Philip et al., 2021.

Butter	*Madhuca indica*	Sapotaceae	Bargali et al., 2004.
Date palm	*Phoenix dactylifera*	Arecaceae	Philip et al., 2021.
Manilla tamarind	*Pithecellobium dulce*	Mimosaceae	Philip et al., 2021.
Indian kudzu	*Pueraria tuberosa*	Fabaceae	Philip et al., 2021.
Peach	*Prunus persica*	Rosaceae	Philip et al., 2021.
Dwarf date palm	*Phoenix humilis*	Arecaceae	Sreekumar and Balakrishnan, 2002.
Guava	*Psidium guajava*	Myrtaceae	Bargali et al., 2004.
Jamun	*Syzygium cumini*	Myrtaceae	Bargali et al., 2004; Sreekumar and Balakrishnan, 2002; Philip et al., 2021.
Lac	*Schleichera oleosa*	Sapindaceae	Bargali et al., 2004.
Malaysian ashok	*Saraca indica*	Caesalpiniaceae	Philip et al., 2021.
Marking nut	*Semecarpus anacardium*	Anacardiaceae	Philip et al., 2021.
Wild jujube	*Ziziphus nummularia*	Rhamnaceae	Bargali et al., 2004.
Jackal jujube	*Ziziphus oenopolia*	Rhamnaceae	Sreekumar and Balakrishnan, 2002; Bargali et al., 2004; Philip et al., 2021.
Indian jujube	*Ziziphus mauritiana*	Rhamnaceae	Bargali et al., 2004.
Wild jujube	*Ziziphus rugosa*	Rhamnaceae	Sreekumar and Balakrishnan, 2002.
Corn	*Zeamays*	Poaceae	Bargali et al., 2004.

Role in seed dispersal

Seed dispersal is a key success in plant communities, and frugivory is very important in vertebrate communities (Corlett, 2017). The role of bears in seed dispersal is inevitable (Fredriksson et al., 2006; Steinmetz et al., 2013). They play an important role in seed dispersal and termite control, as both are considered vital for the long-term sustenance of forest ecosystems. The role of sloth bears as seed dispersers is helpful in the population dynamics of fleshy-fruit species in South India. Therefore, bears have a great influence on the species composition of plants in their ecosystem (Harrer and Levi, 2018).

Seed passage through the digestive gut of the sloth bear appeared to increase the germination rate of some species without showing any detrimental effect on the germination behaviors. The seed germination time is significantly different in both unpassed and passed seeds, and maximum seed germination is reported in *Syzygium cumini* followed by *Buchanania lanzan*, *Cassia fistula*, and *Mangifera indica* (Kumar and Paul, 2021). Moreover, the greater use of deciduous forest by sloth bears is probable because sloth bears preferred food plants such as *Cassia*

fistula, *Cordia obliqua*, and *Zizyphus mauritiana* (Ramesh et al., 2009), which were more available there than in the semi-evergreen forest. Sloth bears may thus act as important seed dispersers of the invasive weed lantana, increasing the probability of it spreading to other parts of the reserve. Since its introduction, it has spread across the country and invaded most of the tropical and subtropical parts of India. The role of sloth bears as dispersers of lantana seeds may have serious habitat management implications (Rather et al., 2020).

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From grey to green: Unleashing the potential of urban forestry

Manish Kumar Mankur[1], Susmita Shil[2], Ekta Singh[1], Ankita Bhardwaj[2]

[1]Department of Forestry
Indira Gandhi Krishi Vishwavidyalaya, Raipur (492012), Chhattisgarh, India
[2]Department of Silviculture and Agroforestry
College of Forestry, Kerala Agricultural University, Thrissur (680656), Kerala, India
Email: susmitashilf@gmail.com

Introduction

According to the Society of American Foresters' Dictionary of Forestry (1998 edition), urban forestry is defined as 'the art, science, and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits trees provide to the society. The world is urbanizing very fast as nearly two-thirds of the world's population is expected to live in urban areas by 2025. The rate of urbanization is remarkably high in the developing world. India is also becoming increasingly urbanized. Between 2001 and 2011, the total population in India increased by 17.64%, and according to a survey made by the UN, in 2030, 40.76% of the country's population is expected to live in urban areas. India has the second-largest urban system in the world (Majumdar and Selvan, 2018). Cities occupy less than 3% of the global terrestrial surface but account for 78% of carbon emissions, 60% of residential water use, and 76% of wood used for industrial purposes. According to the latest air quality database, compared to 49% in high-income countries, 97% of cities in "low- and middle- income countries with more than 100,000 inhabitants do not meet WHO air quality guidelines" (WHO, 2018). To take care of all these issues we need to promote urban forestry concept whereverpossible. Urban forestry is the care and management of tree populations in urban settings for the purpose of improving the urban environment. The concept of urban forestry, which advocates the role of trees as a critical part of the urban structure, was developed to address the issue of impact on forestry by urbanization. The urban forestry comprises all green elements under urban influence. Changes in structure of society have accelerated the urbanization. Urbanization is considered as the main driver for eco system change (Konijnendijk, 2003). As of 2010, 50.6 % of the world's population lives in cities (UNDP, 2010). In the tropics and sub tropics, the urban population is expected to grow to 4 billion by 2025, and major cities are expected to grow substantially in surface area (Avijit, 2002). Developing countries are urbanizing rapidly thus emitting more greenhouse gases (GHG). Urbanization generally has adverse effects on eco system like destruction in habitat and watershed, change in forest structure, etc. The urban forest isan integrative, combining various urban green structure components into a wholeaiming to connect various sectors, agendas, and programmes while building longer-term policies and plans for urban tree resources. It is multidisciplinary and attempting to be interdisciplinary in which experts from

both the social and natural disciplines are involved.Participatory, geared towards creating partnerships amongst all stakeholders, and focused on various benefits, highlighting the advantages and services that urban forests can offer in terms of the economy, the environment, and society at large.The goal of urban forestry is establishing a welcoming and secure environment to address community needs and demands by maintaining or improving urban forest cover and focus on enhancing residents' and guests' wellbeing**, r**educe risks to people's lives and property**, i**ncrease management activity coordination with other neighbourhoods, departments, or offices, set attainable long-term aims and goals.

In comparison to American, Australian, and European cities, the bulk of Indian cities except for Chandigarh and Canhinagar have an extremely low per-capita availability of urban forests. However, the city of New Delhi, which serves as India's capital, has significant urban forestation programmes. Green space currently makes up 20% of Delhi's land area. Initiatives related to urban forestry are now under the control of the parks and garden society. In Delhi, two biodiversity parks, nine city woods, and nine more are now under construction or in the planning stages. Dehli's roads can be recognised by the kind of trees that have been planted next to them, such as Vigyan Path and Toona ciliate. In the state of Gujarat, the planting of trees is encouraged by linking it to religious rituals from a variety of worldviews.Each planet, constellation, and sign of the zodiac has a favourite tree in the Hindu sacred scripture known as the Puranas. It is thought that planting these trees will increase luck and human life. Six hectares of land in Gandhinagar city have trees planted in recognition of these religious convictions. It is a special area created for nourishing the trees with life and love so that the forest would be healthy and prosperous (Chaudhry and Tewari, 2011).

Importance of urban forestry

Urban forestry increases tree outside forest areawhich enhance improvement of air quality by reducing the pollutant from the atmosphere as well as by carbon sequestration (Singh *et al*., 2022).The development of green infrastructure could be a key component of cities adaptation to future scenarios of global warming. It can also significantly improve the environmental quality in the vicinity of urban areas.Cities with more impermeable surfaces have higher runoff, and the aquatic environment suffers because of stormwater being dumped into nearby rivers.The United States Department of Agriculture estimates that trees planted over open, impermeable surfaces like parking lots might reduce stormwater runoff by up to 20%, and that branches and stems can catch and reduce 15% of the total rainfall. A huge tree has the capacity to store up to 332 gallons of water. In addition, urban green spaces support a wide range of flora, including squirrels, monkeys, birds, and insects. Street trees also create pathways for wildlife such as small mammals, birds, butterflies, moths, beetles, and other insects to move between the urban forest and adjacent rural vegetation and some of these creatures are so well-adapted to the urban environments that they are more abundant in cities than in surrounding natural vegetation

(Mullaney *et al*., 2015). Urban forestry has been demonstrated to support psychological recovery, stress reduction, and to enhance focus and productivity (Shin *et al*., 2010).

Paradoxically, unlike conventional forestry and fruit trees, urban street trees usually do not have a market value (Pandit *et al*., 2012) and therefore, they are viewed more as liabilities than assets. Therefore, urban greenery needs to be given a monetary worth to catch the attention of city planners and managers. Trees are truly natural capital assets for cities(Willis and Petrokofsky, 2017) as they offer countless advantages and ecosystem services that are vital to the wellbeing of city residents.Street trees of cities support healthy urban communities and boost property values (Mullaney *et al*., 2015) such as home values (Luttik, 2000) and businesses revenues, reduce cooling-related energy costs, moderate ambient air temperatures, reduce carbon emissions, and improve water and air quality.A single tree can cut annual heating costs by 1.3% and cooling costs by 7%, for instance, and a 10% increase in tree cover is reported to lower total heating and cooling energy use by 5–10% . The street stretches with trees had afternoon temperatures lower by 5.6 ^{0}C and road surface temperature lower by 27.5^{0}C than exposed road surfaces in Bangaluru (Vailshery *et al*., 2013).

Constraints in urban forestry

The implementation of urban forestry programmes on a larger scale can be very expensive and inadequately placed trees or trees of the wrong species might pose a threat to city dwellers, either directly (via falling limbs or the complete collapse of the tree) or indirectly. In addition, tree roots can result in the breaking of roadways, pavements, and occasionally water pipes and urban trees have the potential to weaken the structural integrity of buildings by embedding their roots into the ground and by falling branches or whole trees.Damage to trees may result from intentional destruction, careless disregard, harvesting of tree products, or browsing cattle. Incorrect and neglected staking leads to bark damage.Lack of policies, insufficient funding, public support, coordination and cooperation, inadequate research on the ecological, socioeconomic, and management aspects of forestry practises in urban areas are all factors that limiting the promotion of urban forestry.

Management of urban forestry

- The evaluation of the resource, including its background, present condition, and potential problems, is the first stage in creating an urban forest management plan. Depending on the management goals (such as productivity, protection, or recreation), which might vary both within and between cities (and even nations), the type and extent of data will change.
- Determining the scope, the needs, and the priorities- Information obtained from the forest inventory and other sources, such as urban plans and social impact surveys, can be used to pinpoint prospective problems, future management requirements, planting locations, tree-related dangers, and the potential for the creation of goods and ecosystem services.

- The extent, duration, and kind of management plans for urban forests might vary, depending on whether they are local, city, national, or regional. Their development needs sufficient baseline data, expert advice, time, money, and the cooperation of numerous stakeholders.
- Carrying out the management plan's recommended activities in a timely, effective, and efficient way is the responsibility of those in charge of implementation. Work should be done on creating detailed work plans with defined roles and actions.
- To ensure the sustainability of urban forests, a long-term monitoring programme is necessary. This allows for the evaluation of the effects of management interventions and the achievement (or lack thereof) of management objectives.

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Seed biopriming in forestry: Enhancing reforestation and sustainable forest management

Varsha Giri*, Prakash and Naveen Kumar Bohra

ICFRE-Arid Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Jodhpur, Rajasthan (342 005), India
Email: vgiri7151@gmail.com

Abstract

Seed biopriming, a technique widely used in agriculture, is gaining recognition for its potential applications in forestry. By applying beneficial microorganisms to tree seeds, seed biopriming offers promising benefits in terms of seedling establishment, disease management, and overall forest ecosystem resilience. As we strive for sustainable forestry practices, seed biopriming emerges as a valuable tool to support reforestation initiatives, combat disease pressures, and promote the restoration of degraded areas, ensuring the health and vitality of our forests for future generations. This review explores the application of seed biopriming in forestry, highlighting its potential advantages and environmental implications.

Keywords: Seed biopriming, forestry, reforestation, restoration, resilience

Introduction

Seed biopriming is a technique that involves treating seeds with beneficial microorganisms before planting. These microorganisms can help to improve seed germination, seedling growth, and resistance to diseases. Seed biopriming is an environmentally friendly alternative to the use of chemical pesticides and fungicides. While the primary focus of seed biopriming is on enhancing seed performance and plant health, it is essential to evaluate its environmental impact as well.

Following are the various beneficial impacts of seed biopriming in forestry.

Improved seedling establishment

In reforestation efforts, seedling establishment is a critical factor for successful forest regeneration. Seed biopriming can enhance the germination rate, seedling vigor, and root development of tree species. The application of beneficial microorganisms such as mycorrhizal fungi can improve nutrient uptake, particularly phosphorus, aiding seedling growth in nutrient-deficient soils. Additionally, biopriming can enhance seedling resistance to abiotic stresses, such as drought and salinity, increasing survival rates during early growth stages.

Disease suppression

Diseases caused by fungal pathogens pose a significant challenge to reforestation and forest health. Seed biopriming offers a sustainable approach to disease management by introducing antagonistic microorganisms that can suppress the growth of pathogens. This reduces the incidence of seedling diseases and decreases the reliance on chemical fungicides. By promoting healthy seedling establishment, biopriming contributes to the overall resilience of forest ecosystems.

Promotion of mycorrhizal associations

Mycorrhizal fungi play a crucial role in nutrient cycling and tree growth in forest ecosystems. Seed biopriming can facilitate the establishment of mycorrhizal associations by introducing compatible fungal species to the seeds. This symbiotic relationship enhances nutrient uptake, improves soil structure, and contributes to long-term forest productivity. By promoting mycorrhizal associations, biopriming supports sustainable forest management practices and ecosystem health.

Restoration of degraded soils

Forested areas affected by degradation, such as mining sites or areas impacted by deforestation, often face challenges in terms of soil quality and nutrient availability. Seed biopriming can aid in soil restoration efforts by introducing beneficial microorganisms that enhance soil fertility and nutrient cycling. The application of bio primed seeds can kick-start the recovery process, facilitating reforestation and the establishment of healthy forest ecosystems.

Conservation of genetic diversity

Seed biopriming can contribute to the conservation of genetic diversity in reforestation efforts. By improving seedling vigor and survival rates, biopriming ensures a broader representation of the genetic pool of tree species. This helps maintain the genetic diversity necessary for healthy and resilient forests, allowing ecosystems to adapt to changing environmental conditions and potential threats.

Conclusion

Seed biopriming holds significant potential in forestry, contributing to successful reforestation efforts and sustainable forest management. By improving seedling establishment, suppressing diseases, promoting mycorrhizal associations, restoring degraded soils, and conserving genetic diversity, biopriming enhances the resilience and long-term productivity of forest ecosystems. Overall, seed biopriming is a promising technique for improving the germination, survival, and resistance of tree seedlings. It is an environmentally friendly alternative to the use of chemical pesticides and fungicides, and it has the potential to increase forest productivity and resilience to pests and diseases.

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Review on *Melia dubia* -A sustainable raw material for wood industries

Kanica Upadhyay

Department of Forest Products & Utilization
College of Horticulture & Forestry
Jhalawar

Introduction

Melia dubia is a native, fast-growing tree species that has gained economic importance in the markets due to its suitability to replace expensive exotic industrial trees. *Melia dubia* belongs to family Meliaceae and grows up to 40 feet within two years of planting. It has high potential for approximately 40 tons yield of biomass per acre per year of a 10-year plantation. It can be used in manufacture of variety of wood products such as pencil, pulp, packaging, and plywood industries. It has been widely cultivated by farmers in southern states and has also gained the popularity among the farmers of central and northern part due to its characteristics like fast growth, straightness of stem without major branches, less shade effect and insensitivity to pests and insect attacks. In India, it mostly grows in tropical moist deciduous forests and is found in Kerala, Karnataka, Sikkim, Himalayas, North Bengal, Upper Assam, Khasi Hills, Hills of Orissa, Deccan and Western Ghats. The species grows well in wet areas with annual rainfall above 1000 mm, but can also be grown in 650-1000 mm. It is a light demander tree, but performs well in moderate shade with an optimal temperature of 30-35°C. It grows on a wide variety of soils but prefers well-drained red, red loam, alluvial and black loam types with pH ranging from 5.5 to 7.5 with a soil depth of 1.5 m. Economic profitability is Rs 24,000-137,500 per acre per year in different parts of the country. Under the scenario of shifting farmer's momentum towards secure income generating commodities like agroforestry, *Melia dubia* proves to be very beneficial for them in terms of monetary and other livelihood opportunities (Chavan *et al.*, 2021).

Seedlings of *Melia dubia*

Propagation of *Melia dubia* is done by seeds and clonal propagation. Forest College and Research Institute (FC&RI), Mettuapalayam and ICAR Central Agroforestry Research Institute (CAFRI), Jhansi, Uttar Pradesh has standardized the propagation technique through seeds and clonal propagation. The introduction of the Mini clonal technique has enhanced the production of quality planting material, as it offers advantages such as high productivity, success, efficiency, uniformity, low nutrients and in minimal space. In general, 5,000 plants can be produced per year from 1 m2 of area. Planting can be done in plain pits (45 × 45 × 45 cm) in June-July as soon as monsoon sets in (Chavan *et al.*, 2021). Just before the monsoon season, the pits should be filled with standard potting mix (5 kg FYM + 100-150 g neem cake + 50 g DAP). Weekly watering and application of fertilizer once every three months increases plant growth. It is recommended to apply the whole mixture (N:P: K – 19:19:19) 25-50 g per tree in the first two years and 100 g tree-1 from the 3rd year onwards. Watering with fungicides (e.g. Bavistin @ 1 g ml $^{-1}$) and insecticides (e.g. chlorpyriphos 40 EC @ 2 ml $^{-1}$) protects young plants from soil-borne fungal diseases and pests such as termites and rootworms. A straight and clear trunk and the desired size is achieved by judicious pruning practices. Side branch pruning is recommended when the seedling reaches a height of 2–3 m. In high density plantings (>500–5000 trees ha^{-1}), mechanical pruning is encouraged in the 2nd, 4th, 6th and 8th year of planting by removing the tree, to promote the growth and health of side trees. It has also been observed that high density plantations are preferred to accommodate more seedlings for plywood and timber. But 200 to 500 trees per hectare give the desired size and quality of wood.

Status and role of *Melia dubia* in the timber industry:

The current supply of raw materials for wood industries like pulpwood, plywood, furniture, and biomass energy in the country is far behind the demand. Shortage of timber supply will lead to downfall in

domestic and international markets in term of industrial requirement. In addition, the available forest resources are scarce & thus, will lead to increasing economic pressure on forest which will further lead to exploitation of forest resources.The use of fast growing, elite trees with short rotation ageallows early harvest and so it helps to improve yield. However, considering the acute shortage of suitable raw material, the industries must focus on establishment of plantation of such species to achieve maximum yield within a short rotation period. *Melia dubia* can be considered the promising species looking such factors. In addition to the commercial industrial importance, this species helps in environmental amelioration by checking gas emission into the atmosphere as the trees are naturally endowed to absorb maximum CO_2. (Warrier, 2014)

The wood of *Melia dubia* is used commercially in the pulp and plywood industries (Parthiban et al., 2009). The wood is also used in the manufacture of packaging cases, matchsticks, photo frames, pencils, small furniture, interior windows and panels, cigar boxes, construction purposes, ceiling planks of agricultural implements and in packing boxes, etc. Melia dubia is a cash earning tree for growers. Agricultural expert working on *Melia dubia*also reported that farmers can get a return of Rs 12 lakh per acre after eight years. At the same time, they can sow other fruits, vegetables, medicinal plants, or fodder between these trees, since the distance between them is at least 10 feet. Its peeling properties also help to obtain the best veneers for the plywood industry (Kiran *et al.*, 2022).

Marimuthu *et al.*, (2015) reported that wood is preferentially used in packaging boxes, cigar boxes, ceiling boards, construction purposes, agricultural implements, pencils, match boxes, splints, ship supports, musical instruments, tea boxes and plywood. It is good firewood with a calorific value of 5,043 - 5,176 cal./kg. A study was conducted to evaluate the growth and yield of *Melia dubia* using an RBD design with 10 treatments. Significant differences were observed in growth attributes such as tree height (m), girth at breast height (GBH) (cm) and stand volume (m3 ha-1 tree-1 or ha-1) and biomass (kg tree-1 or t ha -1), during Sorghum Sudan Grass (SSG) intercropping (July 2019) and final SSG forage harvest (November 2019), between forest pasture (T1 to T5) and salt plantation (T6 to T10) systems, the increase in growth and yield characteristics in the SSG intercrop period differed significantly. At the end of the SSG harvest experiment, the *M. dubia* (4 × 2 m) SSG system was higher in production per tree, biomass, and volume and biomass gain. Conversely, growth and yield variables per hectare were recorded for a single plantation of *M. dubia* (3 × 2 m). They concluded that SSG intercropping in *M. dubia* plantations could increase the growth and yield of *M. dubia* (Prajapati et al., 2020). Currently, its papermaking potential is becoming the subject of interest for researchers. The research related to *Melia dubia* has attracted many scientists for its applicability and future thrust in various aspects.

Conclusion

The information available and various research trials as well as projects on *Melia*

dubia (Malabar Neem) have shown its versatility & suitability as a sustainable raw material for plywood, panel & paper manufacturing. Increased pressure on commercial timber like Teak & Shisham can only be decreased by introducing such fast-growing species for wood industries. Southern part of India is motivating the farmers to introduce *Melia dubia* as an agroforestry model and utilise it to produce MDF, Particle Boards and other timber products. In last few years, various plywood manufacturers in South India have started using *Melia dubia* as core and face veneer purpose in plywood manufacture, although the adoption is taking time but this wood species is beneficial for the farmers & wood industrialist in every extent.

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Forest engineering and infrastructure development

Varsha Giri* and Raju Singh Bhati

ICFRE-Arid Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Jodhpur, Rajasthan (342 005), India
Email: vgiri7151@gmail.com

Abstract

Forest engineering, an important aspect in forestry, is the application of engineering principles to the design, construction, and maintenance of infrastructure in forests. This includes forest roads, bridges, trails, buildings, and other structures. Forest engineers must consider a variety of factors when designing and constructing forest infrastructure, including the environmental impacts, the cost-effectiveness, and the safety of the structures. It plays a vital role in the development of infrastructure within forested areas, encompassing the design and construction of forest roads, bridges, and trails. This field aims to strike a balance between meeting human access and resource utilization needs while minimizing environmental impacts and ensuring cost-effective solutions. By considering the ecological footprint of these projects, forest engineers aim to harmonize human activities with the preservation of forest ecosystems. This abstract explores the significance of forest engineering in infrastructure development, highlighting the integration of environmental considerations and cost-effective approaches.

Keywords: Forest engineering, environmental impact, ecological footprint, forest ecosystems

Introduction

Forest engineering plays a crucial role in the design and construction of infrastructure within forested areas. This discipline focuses on developing sustainable solutions for forest roads, bridges, and trails while considering the environmental impact and cost-effectiveness of these projects. By balancing the needs of human access and resource utilization with the preservation of forest ecosystems, forest engineering strives to create harmonious coexistence between human activities and nature.

Forest infrastructure is essential for a variety of purposes, including:

Forest management

Forest roads and trails are essential for the transportation of timber, equipment, and personnel in forests. They are also used for fire suppression, wildlife management, and recreation.

Sustainable development

Forest infrastructure can help to promote sustainable development by providing access to forests for economic activities, such as timber harvesting and ecotourism.

Environmental protection

Forest infrastructure can also help to protect the environment by providing access to forests for monitoring and research.

Forest engineering is a complex and challenging field, but it is also a rewarding one. Following are the various measures where forest engineering works in the field

of sustainable forestry and environment protection:

Forest Roads

Forest roads are essential for accessing remote areas within forests for various purposes such as timber extraction, forest management, and recreational activities. However, the construction and maintenance of forest roads can have significant environmental impacts. Forest engineers must carefully plan road networks to minimize their ecological footprint. This includes considerations such as minimizing soil erosion, protecting water quality through proper drainage systems, and mitigating wildlife disturbances through wildlife crossings and buffers.

Bridges

Bridges in forested areas serve as vital infrastructure for crossing rivers, streams, and other natural obstacles. Forest engineers face the challenge of constructing bridges that are structurally sound while minimizing their impact on aquatic ecosystems and preserving natural water flows. Innovative designs, such as clear-span bridges, can reduce the need for piers and minimize disturbance to the streambed and aquatic habitats. Additionally, the use of sustainable materials and construction techniques can further enhance the environmental performance of forest bridges.

Trails

Trails provide opportunities for recreational activities, such as hiking, biking, and wildlife observation, while allowing visitors to experience the beauty of forested landscapes. Forest engineers must consider the principles of sustainable trail design to minimize erosion, protect sensitive habitats, and maintain the aesthetic value of the surrounding environment. Techniques such as proper trail alignment, erosion control measures, and the use of durable and low-impact trail materials can help preserve the ecological integrity of the forest while ensuring visitor safety and enjoyment.

Environmental Impact Assessment

One of the most important considerations in forest engineering is the environmental impact of infrastructure. Forest engineering projects require thorough environmental impact assessments to identify potential risks and develop mitigation measures. These assessments involve evaluating the potential impacts on soil, water quality, biodiversity, and cultural heritage. Forest engineers work in collaboration with ecologists, hydrologists, and other experts to ensure that the infrastructure development plans adhere to environmental regulations and best practices.

Cost-effective solutions

While considering environmental impact, forest engineers must also find cost-effective solutions for infrastructure development. This involves optimizing designs, construction methods, and materials to achieve the desired objectives without unnecessary expenses. Implementing sustainable practices, such as using locally sourced materials, incorporating recycled materials, and employing efficient construction techniques, can help reduce costs while minimizing environmental impact.

Conclusion

Forest engineering and infrastructure development are essential for accessing forest resources, managing forests

sustainably, and providing recreational opportunities. By considering the environmental impact and cost-effective solutions, forest engineers can ensure that these projects coexist with the natural environment. Through innovative designs, comprehensive environmental assessments, and sustainable practices, responsible forest infrastructure development can be achieved, benefiting both society and the environment.

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पवित्र उपवनः भारत में प्रकृति संरक्षण की विरासत

[1]अंकित पाल, [1*]दिनेश गुप्ता, [1]संजीव कुमार, [2]चंद्रकान्त तिवारी, [3]एच. एस. नेगी, [1]रोहित, अमरजीत ठाकुर, [4]पंकज शर्मा

[1]वन संवर्धन एवं कृषि वानिकी विभाग

बाँदा कृषि एवं प्रौद्योगिक विश्वविद्यालय, बाँदा, उ.प्र.

[2]वन जीव विज्ञान एवं वृक्ष सुधार विभाग

बाँदा कृषि एवं प्रौद्योगिक विश्वविद्यालय, बाँदा, उ.प्र.

[3]पादप रोग विज्ञान विभाग, बाँदा कृषि एवं प्रौद्योगिक विश्वविद्यालय, बाँदा, उ.प्र.

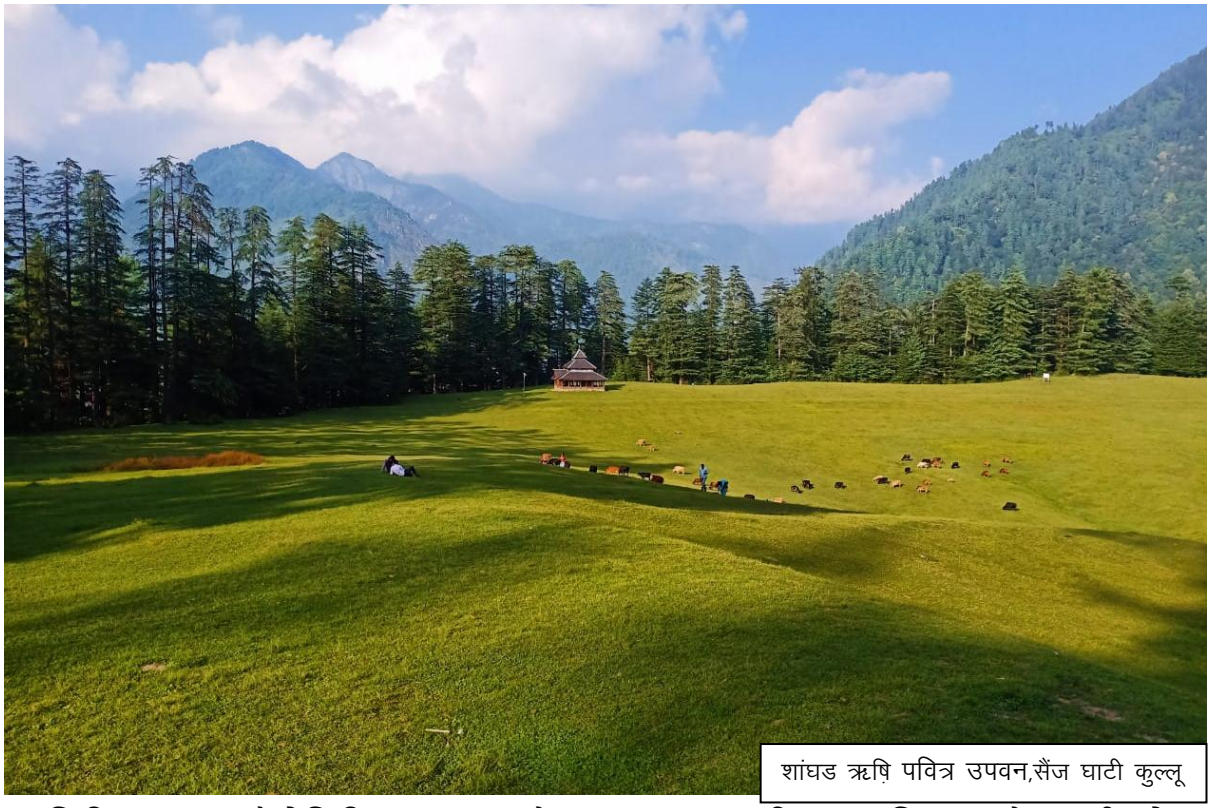
[4]हिमाचल प्रदेश जैव विविधता बोर्ड, हि.प्र.

*E mail: guptadinesh07@gmail.com

परिचय

प्रकृति संरक्षण की प्रथा भारत में एक बहुत ही प्राचीन परंपरा है और प्रकृति संरक्षण की ऐसी ही एक आदिम प्रथा पवित्र उपवन हैं। भारत, जापान, थाईलैंड, चीन, इंडोनेशिया, फिनलैंड, ब्रिटेन, जर्मनी, इटली, ब्राजील, घाना, तुर्की आदि देशों सहित पूरे विश्व में पवित्र उपवन स्थित हैं और वे सभी विभिन्न सांस्कृतिक रीति-रिवाजों और विधियों द्वारा संरक्षित हैं। परन्तु ये उपवन सबसे अधिक अफ्रीकी और एशियाई महाद्वीप में केंद्रित हैं। पवित्र उपवन संभवतः पूरे भारत में बिखरे हुए हैं और धार्मिक विश्वासों, प्रतिबंधों और उनसे जुड़ी वर्जनाओं के माध्यम से पूरी तरह से या लगभग पूरी तरह से मानवीय हस्तक्षेप से मुक्त हैं। पवित्र उपवन अपने मूल्यों के कारण प्राचीन काल से ही भारतीय जैव विविधता की एक समृद्ध धार्मिक, सामाजिक और सांस्कृतिक विरासत को संरक्षित रखते हुए मनुष्य और प्रकृति के बीच एक सेतु का कार्य करते है। आमतौर पर, पवित्र उपवन वन भूमि पर पेड़ों के समूह हैं जो स्थानीय समुदाय द्वारा धार्मिक आस्था के साथ संरक्षित होते हैं। यूनेस्को (1996) के अनुसार ऐसे विशिष्ट क्षेत्र व पादप समूह, जो लोगों की आस्था और उनके प्राकृतिक लगाव के कारण संरक्षित किये जाते हैं, पवित्र उपवन कहलाते हैं। ये क्षेत्र स्थानीय लोक संस्कृति से जुड़े होते हैं। ये पवित्र उपवन आकार में पेड़ों के समूह या एक पेड़ से लेकर 100 हेक्टेयर तक के क्षेत्र में फैले हो सकते हैं। पवित्र उपवनों के वनस्पति की संरचना वनों के चरमोत्कर्ष गठन से मेल खाती है जो लंबे समय तक कम से कम मानवीय हस्तक्षेप के कारण होती है। मौजूदा संस्थानों को मजबूत करके और उन्हें कानूनी दर्जा देकर पवित्र उपवनों जो कि पारिस्थितिक सेवाओं के भंडार हैं का बेहतर प्रबंधन और रख-रखाव किया जा सकता है। पवित्र उपवन जलवायु परिवर्तन पर अध्ययन के लिए परीक्षण के आधार के रूप में काम कर सकते हैं क्योंकि वे अपरिवर्तित रहते हैं और लंबे समय से संरक्षित हैं। भारत में जैव विविधता अधिनियम 2002, वन्यजीव (संरक्षण अधिनियम) 1972, और भारतीय वन अधिनियम 1927 के प्रावधानों में इन विशिष्ट

जैव विविधता हॉटस्पॉट के संरक्षण के लिए कानूनी सुरक्षा प्रदान की जा सकती है। वर्तमान में आधुनिकीकरण, औद्योगिकीकरण, बढते अतिक्रमण और वन संसाधनों का दुरुपयोंग तेजी से इन पवित्र उपवनों के अस्तित्व पर खतरा डाल रहें हैं। पवित्र उपवनों के मूल्यों के बारे में लोगों को जागरुक करते हुये इस प्राकृतिक खजाने को संरक्षित किया जाना चाहिए जिसके लिए वर्तमान में नये कानूनों का निर्माण व उनका अनुपालन आवश्यक है।



शांघड ऋषि पवित्र उपवन,सैंज घाटी कुल्लू

पवित्र उपवनों का विस्तार और स्थिति

भारत में पवित्र उपवन सभी राज्यों में पाए जाते हैं। क्षेत्र और भाषा के अनुसार इन्हें विभिन्न स्थानीय नामों से जाना जाता है जैसे, हिमाचल प्रदेश में देव वन, उत्तर प्रदेश और आंध्र प्रदेश में पवित्रवन, सिक्किम में पांडम, कर्नाटक में देवारा कडु, गुजरात में साबरकांठा, छत्तीसगढ़ में मातागुडी, मध्य प्रदेश में शरण/देवकोट, ओडिशा में जहेरा, गोवा में देवराई/पॅन, पश्चिम बंगाल में गरमथन/हरिथान, तमिलनाडु में स्वामी शोला इत्यादि। देश में पवित्र उपवनों की सटीक संख्या और क्षेत्रों के बारे में बहुत कम साक्ष्य हैं क्योंकि इनके बारे में कोई व्यापक अध्ययन नहीं किया गया है। वर्ष 2021 में पर्यावरण सूचना प्रणाली (पर्यावरण वन और जलवायु परिवर्तन मंत्रालय) द्वारा प्रकाशित एक रिपोर्ट के अनुसार लगभग 10359 पवित्र उपवनों का दस्तावेजीकरण किया गया है, लेकिन वास्तविक संख्या इससे कहीं अधिक होगी। इस रिपोर्ट के अनुसार महाराष्ट्र (2820) के बाद कर्नाटक (1476) में सबसे अधिक और सिक्किम में केवल 16 पवित्र उपवन विद्यमान हैं। हालांकि, एक अन्य अनुमान के अनुसार देश में उपवनों की संख्या 1,00,000 से

1,50,000 तक हो सकती है। पवित्र उपवनों का आकार एक पेड़ के क्षेत्र से लेकर 100 हेक्टेयर से अधिक क्षेत्र तक हो सकता है।

पवित्र उपवनों का प्रबंधन

पवित्र उपवनों के सफल प्रबंधन का एक लंबा इतिहास है जो स्थानीय समुदायों या स्थानीय संस्थानों द्वारा किया गया है। चूँकि ये उपवन सामान्य संपत्ति संसाधन (सी.पी.आर.) की श्रेणी में आते हैं, इसलिए इनके स्वामित्व (उपवनों के मालिक कौन हैं) और कानूनी स्थिति को जानना आवश्यक है। यह पवित्र उपवनों की स्थिति को प्रत्यक्ष और अप्रत्यक्ष रूप से प्रभावित करने वाले प्रमुख और द्वितीयक तत्वों की अंत–र्दृष्टि प्रदान करता है। स्वामित्व के आधार पर, पवित्र उपवनों का प्रबंधन ग्राम परिषद् (पंचायत /ग्राम सभा / स्थानीय प्रबंधन समितियां), ट्रस्ट, वन विभाग व व्यक्तिगत परिवार द्वारा किया जाता है। पवित्र उपवनों में किसी प्रकार के हस्तक्षेप की अनुमति, नियमों और विनियमों का निर्धारण (आचार संहिता), उल्लंघन के लिए दंड जैसे विषयों के संबंध में निर्णय प्रबंधन समितियों द्वारा लिया जाता हैं।

पवित्र उपवन से जुडी कुछ सामान्य मान्यताएं एवं प्रतिबंध:

- उपवन में किसी पेड को काटना एवं किसी भी प्रकार का नुकसान पहुचाना वर्जित है।
- उपवन में स्थित देवी-देवता के मंदिर में जाने से पहले जूते, चप्पल और चमडे से बना कोई भी सामान ले जाना वर्जित है।
- ऐसा माना जाता है कि यदि कोई भी व्यक्ति उपवन में वृक्ष और जीवों को हानि पहुचाता है तो संबंधित देवी देवता नाराज हो जाते है और बीमार कर देते है।

अध्ययन व विश्लेषण के आधार पर पवित्र उपवनों को मूल रुप से निम्नलिखित तीन श्रेणियों में वर्गीकृत किया गया है

- पारंपरिक पवित्र उपवन
- मन्दिर या देवस्थान के आसपास स्थित पवित्र उपवन
- अत्येष्टि स्थल के आसपास स्थित पवित्र उपवन

देवस्थान के आसपास पवित्र उपवन माता हडिम्बा, मनाली (हि.प्र.), शांघड ऋषि पवित्र उपवन, कुल्लू (हि.प्र.), माता वैष्णों देवी कटरा (जम्मू), कामतानाथ चित्रकूट (उ.प्र.), मध्य प्रदेष के जनपद सतना में 40 किमी की दूरी पर स्थिति मां शारदा मन्दिर उपवन, चिल्कीगढ़ कनक दुर्गा पवित्र उपवन (पश्चिम बंगाल), उनाकोटी (त्रिपुरा), ख्लावकुर सियाम किमींग, री-भोई (मेघालय) स्थानीय समुदायों द्वारा प्रबंधन के कुछ उत्कृष्ट उदाहरण हैं।

जैव विविधता संरक्षण में पवित्र उपवनों की भूमिका

समाज में पवित्र उपवनों की महत्वता अधिक है। अनुवांषिक विविधता एवं वन्य जीवों की प्रजातियों के भण्डार गृह के रूप में तथा समृद्ध और औषधीय पौधों एवं दुलर्भ, संकट ग्रस्त, स्थानीय, गंम्भीर रुप से लुप्तप्राय पौधों के संरक्षण हेतु पवित्र उपवनों का हमारे समाज में एक अद्वितीय स्थान है।

पवित्र उपवन क्षेत्र की सूक्ष्म जलवायु, मिट्टी, पोषक तत्व, जल तथा लोगों की धार्मिक और सांस्कृतिक विरासत को संरक्षण प्रदान करने के

अतिरिक्त हमें अमूल पारिस्थितिक सेवायें जैसे कि कार्बन, मिट्टी व पानी का संरक्षण तथा ऑक्सीजन भी प्रदान करते है। प्रकृति और प्राकृतिक संसाधनों के संरक्षण के लिए अंतर्राष्ट्रीय संघ **(IUCN)** के अन्तर्गत विभिन्न श्रेणियों में सूचीबद्ध पौधों की पहचान उदाहरण के लिए दुलर्भ, स्थानीय, और गंभीर रुप से लुप्तप्राय पौधों एवं वन जीवों की प्रजातियां भी इन पवित्र उपवनों में पाई जाती हैं।

निष्कर्ष

भारत में बहुत अधिक संख्या में पवित्र उपवन हैं जो उनसे जुड़े विभिन्न मिथकों और धार्मिक मान्यताओं के कारण जैव विविधता संरक्षण में महत्वपूर्ण भूमिका निभाते हैं। जिससे कि राज्य स्तर पर इन उपवनों के सर्वेक्षण एवं दस्तावेजीकरण के लिए एक पहल अत्यंत आवश्यक है। इनकी स्थिति में सुधार के लिए पवित्र उपवनों के अंदर और आसपास रहने वाले स्थानीय लोगों को विश्वास में लेने की आवश्यकता है, ताकि दीर्घकालिक संरक्षण लक्ष्यों को प्राप्त किया जा सके। पवित्र उपवनों को उच्च स्तर की कानूनी सुरक्षा की भी आवश्यकता है जैसे कि वन्यजीव संरक्षण अधिनियम, 1972 के तहत् सामुदायिक रिजर्व घोषित करना या जैव विविधता अधिनियम, 2002 की धारा 35 के तहत जैव विविधता विरासत स्थलों के रूप में अधिसूचित करना, इत्यादि। पारिस्थितिक सेवाओं के भुगतान (पीईएस) की नई अवधारणा से पवित्र उपवनों का प्रबंधन करने वाले समुदायों व स्थानीय संस्थानों को वित्तीय सहायता प्रदान की जा सकती है। चूंकि पवित्र उपवन अछूते वन हैं और लंबी अवधि से संरक्षित किए गए हैं, इसलिए जलवायु परिवर्तन अध्ययन के लिए प्रतिनिधि स्थलों के रूप में भी इनकों उपयोग में लाया जा सकता है। पवित्र उपवनों के धार्मिक, सामाजिक, सास्कृतिक, प्राकृतिक, वैज्ञानिक व जैविक महत्व को देखते हुये इनका संरक्षण किया जाना अति आवश्यक है।

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P.O. RFRC, Mandla Road
Jabalpur – 482021, M.P. India
Phone: 91-761-2840484
Fax: 91-761-2840484
E-mail: vansangyan_tfri@icfre.gov.in, vansangyan@gmail.com
Visit us at: http://tfri.icfre.org or http://tfri.icfre.gov.in

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