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# Van Sangyan

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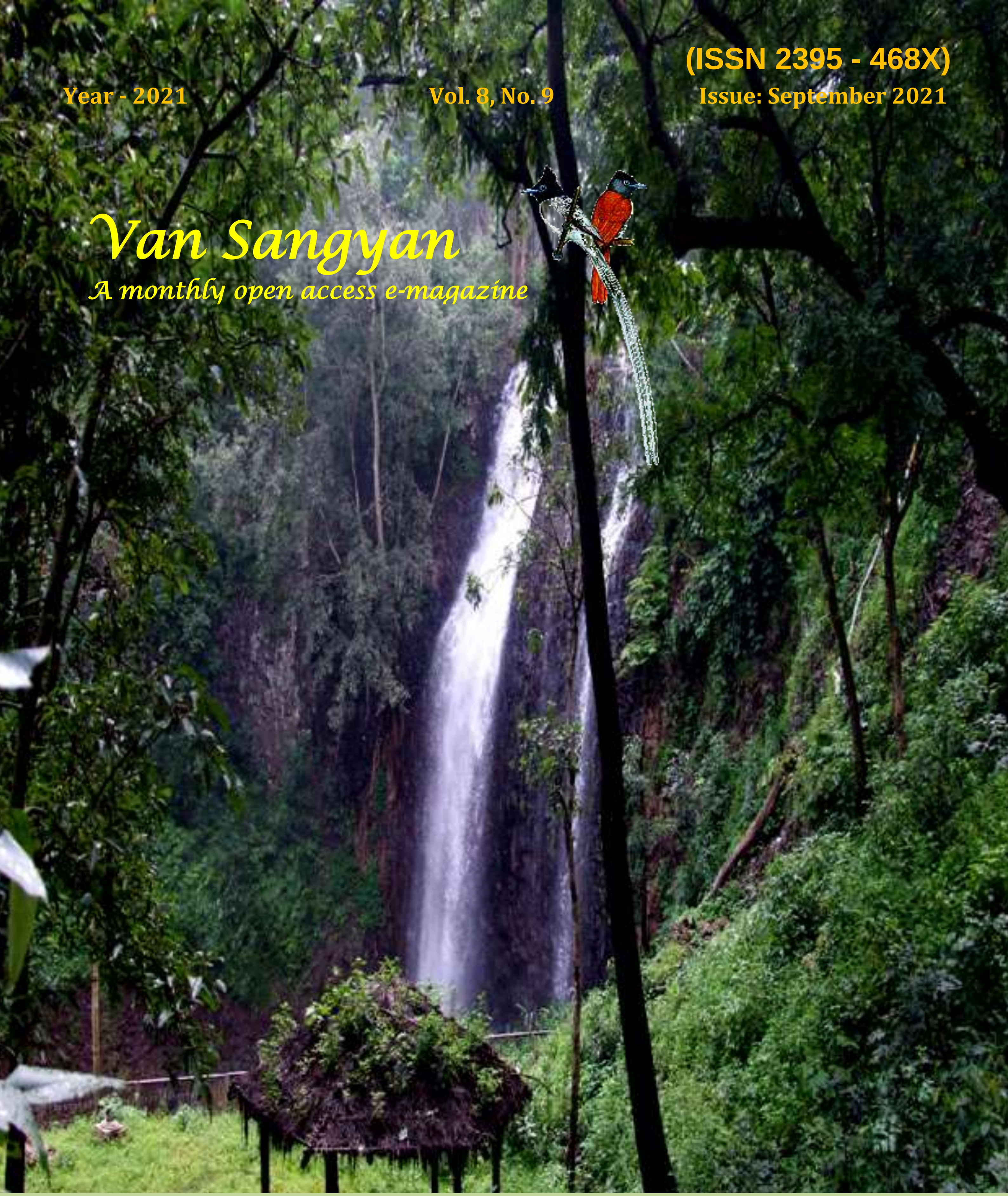

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**Van Sangyan**



**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:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
Tropical Forest Research Institute,
PO-RFRC, Mandla Road,
Jabalpur (M.P.) - 482021.

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
**Photo credit:** Dr. N. Roychoudhury and Dr. Rajesh Kumar Mishra, TFRI, Jabalpur (M.P.)

## From the Editor's desk

*Biochar is defined as "a solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment and can be analogous to charcoal naturally found in fire-prone ecosystems. Biochar has been tested as a soil amendment in many agricultural systems; however, there has been considerably less work on biochar in forest systems. In addition to a long residence time that results in C sequestration, biochar can improve soil properties by enhancing cation exchange capacity (CEC), increasing water holding capacity, increasing soil pH as a liming agent, and reducing soil bulk density and physical resistance to water and gas flow within the soil matrix . All of these properties are thought to play a role in enhancing plant growth in biochar-amended soils .*

*Production of biochar, coupled with new national and international policies that promote large-scale biomass utilization could potentially lead to changes in how forest soils and stands are sustainably managed. Bioenergy coupled with biochar as a co-product is a promising alternative for green energy. Removal of forest residues can improve stand health and reduce the risk of wildfire, but residues also may serve as essential habitat for wood decay fungi and other organisms provide cover for wildlife, reduce soil erosion, and play an important role in soil nutrient dynamics and hydrology. Therefore, how much biomass is left or removed should take into account multiple management objectives and should be determined on a site-specific basis.*

*Although biochar application in forest ecosystems may be logistically more challenging than in agricultural systems, forest sites are prime candidates for soil improvement from biochar additions.Biochar has the potential to reduce fire risks by removing highly flammable excess woody residues from forest sites, and improve soil water and nutrient retention, and to enhance vegetation growth through improved soil physical or chemical properties. In addition, since charcoal is a major component of the fire-adapted ecosystems as a result of wildfires or prescribed burns, application of biochar is expected to mimic many of the soil properties associated with wildfire-generated charcoal and thus better emulate natural disturbance processes*

*Biochar may be useful for restoring or revitalizing degraded forest soils and help with carbon sequestration, nutrient leaching losses, and reducing greenhouse gas emissions. However, biochar is not currently widely used on forested lands across North America. This chapter provides an overview of several biochar experiments conducted in North America and discusses the feasibility of using in-woods mobile pyrolysis systems to convert excess forest biomass into biochar. Biochar may be applied to forest sites in order to positively influence soil properties (nutrient leaching, water holding capacity), but its biggest benefit may be in facilitating reforestation of degraded or contaminated sites, and in sequestering carbon in soils. The majority of data on biochar applications on forest sites focus on seedling responses and short-term impacts on nutrients, soil physical properties and microbial changes. Long-term field research is necessary to determine water use, carbon sequestration, nutrient use, and greenhouse gas emissions, and the subsequent alteration of forest growth and stand dynamics.*

*In line with the above this issue of Van Sangyan contains an article on Biochar and its application in forestry. There are also useful articles viz. Guggul–A critically endangered medicinal plant of dry lands, Semal or silk cotton tree Bombax ceiba Linn., Poplar defoliator, Clostera cupreata and its control measures and Storm water and its management.*

*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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# Biochar and its application in forestry

**C.N. Hari Prasath, A. Balasubramanian, S. Radhakrishnan and M. Sivaprakash**

Department of Silviculture and NRM,
Forest College and Research Institute, TNAU, Mettupalayam – 641 301
E-mail: prasathforestry@gmail.com

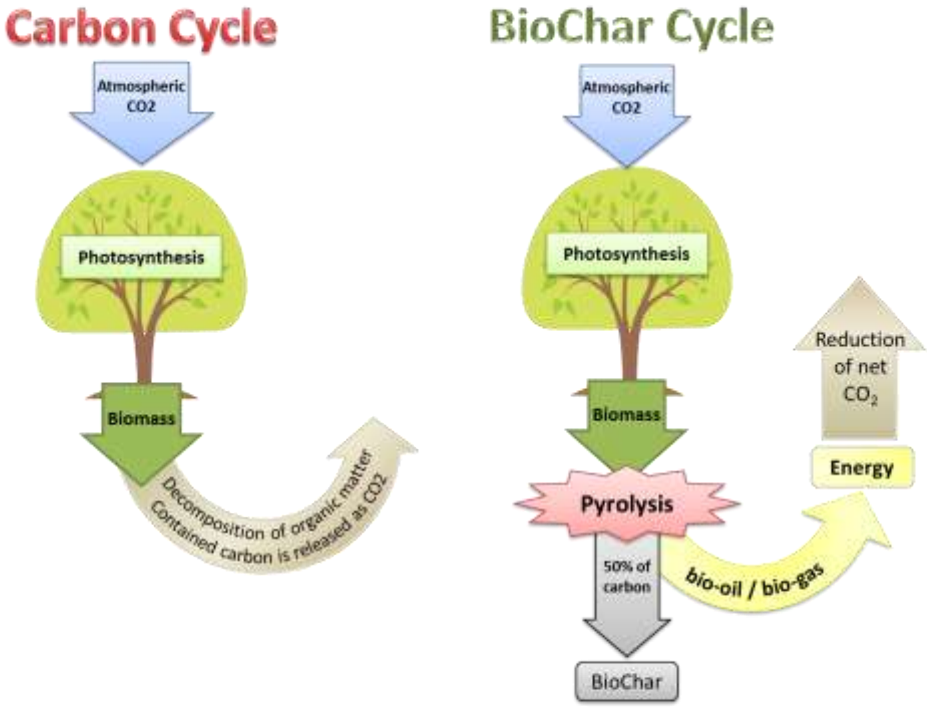
Biochar is a charcoal-like substance that's made by burning organic material from agricultural and forestry wastes (Also called biomass) in a controlled process called pyrolysis. Biochar is a stable form of a carbon-rich compound, which is produced by the thermal decomposition of organic material under a limited supply of oxygen and at low temperatures typically between 300°C and 700°C. An important defining feature of biochar is the presence of fused aromatic ring structure, which is characterized by rings of six carbon atoms linked together. The range of carbon form in biochar depends on various factors including the charring conditions and the process of formation. The chemical composition of the biomass feedstock has a direct impact upon the physical nature of the biochar.

**Feedstocks for biochar production**

Biochar can be produced from a diverse range of feedstocks like forestry wastes and agricultural residues, animal wastes or municipal wastes etc. Biochar feedstock can be categorized into primarily produced biomass and waste biomass. Different types of perennial grasses, crop residues, wood chips, bagasses, algae etc., are included in the first category. The second category consists of waste biomass produced from various sources like agriculture, forestry, food processing, municipal and household etc. Poultry wastes such as chicken litter, domestic and industrial waste such as sewage sludges and paper mill sludge are also used to produce biochar. Organic components present in the feedstock undergo a series of decomposition reactions during the conversion process.

**Techniques for biochar production**

Biochar can be produced by dry carbonization, pyrolysis or gasification of biomass and hydrothermal carbonization (HTC) of biomass under pressure. Different parameters like temperature, heating rate, biomass and vapor residence time distinguish one technique from the other. These technologies involve the heating of biomass material with little or no oxygen environment which drive off the volatile gasses and leave the carbon behind. One of the advantages of these processes is the reduction of the harmful feedstock properties by terminating microorganisms and degrading organic pollutants.




**Pyrolysis**

It is the most widely used technique to produce high carbon content products like biochar. During pyrolysis, the thermo-chemical decomposition of organic matter takes place at high-temperature in an oxygen-free environment. Depending on the heating rate and residence time, pyrolysis can be slow pyrolysis or fast pyrolysis. Fast pyrolysis favors higher yield of bio-oil while in case of slow pyrolysis, a high amount of biochar is generated. Slow pyrolysis is the conventional carbonization method used in char production purposes for centuries.

**Gasification**

In gasification, biomass is exposed to a relatively high temperature along with an oxidative environment and therefore, partially combusted. Gasification is the thermo-chemical conversion of biomass at high temperatures under a controlled amount of oxidizing agent that converts biomass into a gaseous mixture consisting of carbon monoxide, hydrogen, carbon dioxide and traces of methane. Biochar is a co-product of the gasification process.

**Hydrothermal carbonization**

Hydrothermal carbonization (HTC) is a thermo-chemical process in which organic matter is converted into carbon-rich products under a high-pressure environment. In case of HTC, damp biomass is preferred as the reaction takes place in an aqueous condition. About 30 to 60 % char yield is reported during HTC reaction.

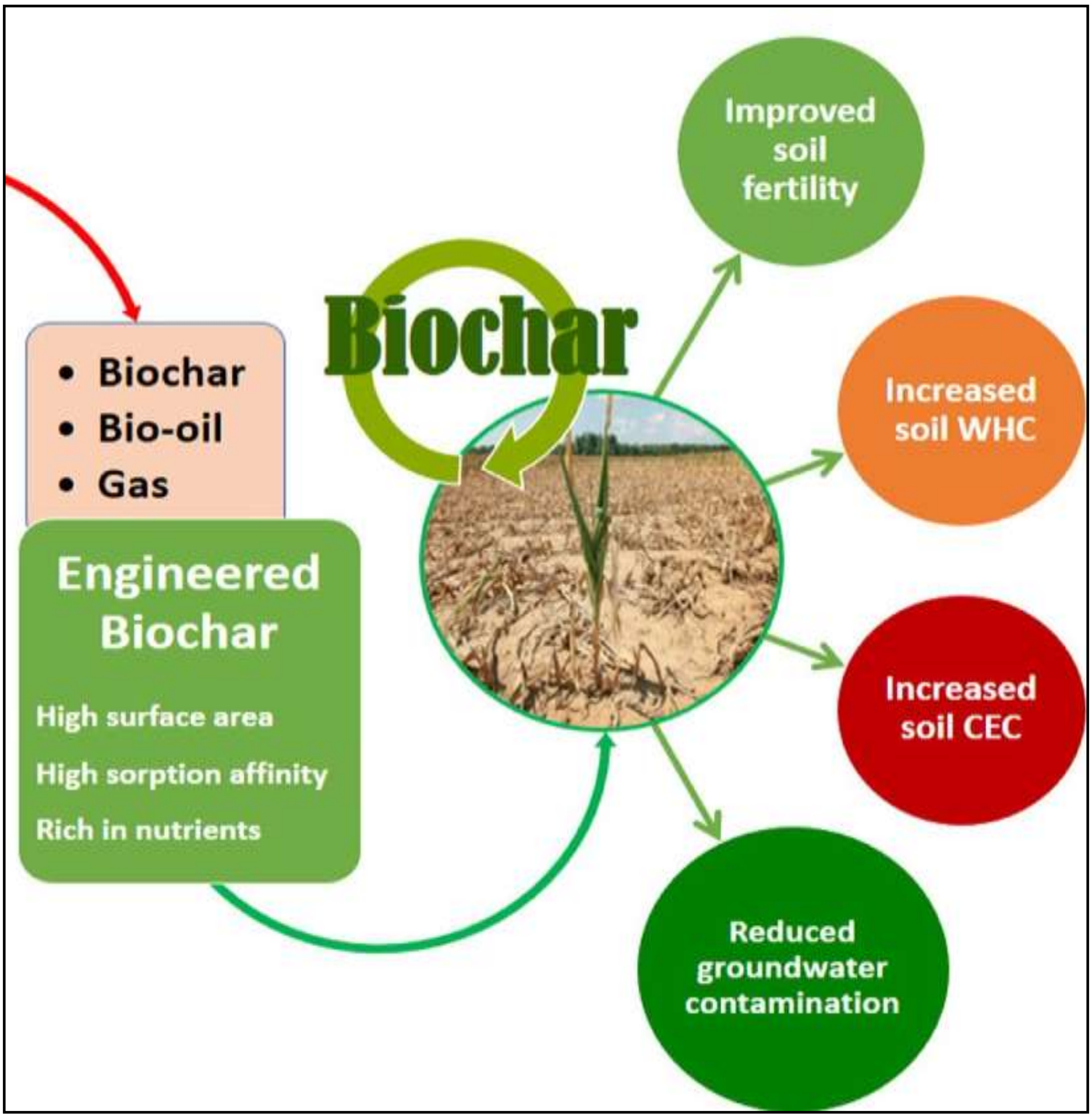
**Biochar application in forest ecosystem**

**Soil Improvement**

Biochar application to forests generally increases soil porosity, soil moisture retention, and aggregate stability while reducing soil bulk density. In addition, it typically enhances soil chemical properties including pH, organic carbon stock, cation exchange capacity, and the concentration of available phosphorous and potassium. Further, biochar application alters microbial community structure in forest soils, while the increase of soil microbial biomass is only a short-term effect of biochar application. Biochar effects on GHG emissions have been shown to be variable as reflected in significantly decreasing soil $N_2O$ emissions, increasing soil $CH_4$ uptake, and complex (Negative, positive, or negligible) changes of soil $CO_2$ emissions. Moreover, all of the aforementioned effects are biochar-, soil-, and plant-specific.

**Climate change mitigation**

Negative emission strategy includes obtaining energy from biomass and storage of carbon in soil through application of biochar. The global potential of carbon sequestration of biochar lies between 0.3-2 Gt $CO_2$ $yr^{-1}$. This soil carbon pool and its dynamics directly influence the global carbon cycle. These changes lead to an urgent need for developing a strategy of net negative emissions. It is reported that biochar has potential for delivering negative emissions and comparing the biophysical, energy and cost impacts, it has advantages over other negative emission technologies. During conversion of biomass to biochar, about 50 % of the carbon present in biomass is converted and trapped in the new stable form and thereby reduces $CO_2$ emission from the soil due to decomposition.




**Application of biochar**

**Plant improvement**

Application of biochar increased plant diameter than the control. The height of the sapling was also affected due to the application of biochar and varied significantly among species. Various factors including inherent differences in the soil, biochar type and differences in responses among plant species influenced these inconsistencies. An average of 41 % increase in biomass was reported from a recent meta-analysis of tree responses to biochar. The biochar can improve the initial seedling growth of tree species. However, the effects were less significant in temperate forests than in tropical or boreal forests. Biochar helped in changing the growth pattern with 5-8 % increment in tree height and increases both above- and belowground long-term carbon sequestration

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# Guggul–A critically endangered medicinal plant of dry lands

**CB Harisha*, SB Chavan, DD Nangareand RY Karde**

ICAR-National institute of Abiotic Stress Management
Pune
*Email: harisha.cb@gmail.com

Dry lands are characterized as water scares regions, where total consumption of water exceeds the annual rainfall. These regions are known to for high temperature, high rates of water loss through evaporation and transpiration and high level of climate uncertainty. It is extensively distributed over 40 % of the global land area, supports more than two billion peoples and almost 50 % of total livestock. Dry lands consist of several economic plant species evolved strategy to cope with drought and high temperature. Among many species suitable for water scares condition, a member of burserace family is important to consider. Among them *Commiphora mukul*, *Bursera penicillata*, *Boswellia spp*. etc are having commercial importance in terms of resin and oil yield. There are 185 species of genus *Commiphora* are present (Hough *et al*., 1952). Out of this only four species are produced in India i.e. *Commiphoramukul*, *Commiphoraberryi*, *Commiphorawightii* and *Commiphoraagallocha*. From this four species *Commiphoramukul* and *commiphorawightii* gives the good yield of guggul.

Guggal drug is made from the sap (gum resin) of the *Commiphoramukul* tree. It is also known as Indian bdellium and also by many local names: Bengali, Gujarati - Guggul, Hindi – Guggulu, Myrrh; Kannada - Guggulu; Marathi - Guggala; Malayalam - Gulgulu, Guggalu; Tamil – Maishakshi, Gukkal; Telugu – Guggal. Guggul is the gum resin that comes by tapping of matures stem of tree, which belongs to the same genus as myrrh and has some similarcomponents and actions. Guggul resin contains steroids, diterpenoids, alipathic esters, and carbohydrates. According to Ayurveda, there are five type of Guggulu namely; Krishnan (black), Pita (Yellow), Nila (blue), Kapisha (light brown) and Rakta (blood red).

**Origin and distribution**

The species is native to southern Pakistan and western India.Guggal is a xerophyte and grow naturally in arid and rocking zones of India. In India it is being cultivated in arid and semi-arid climate and it is tolerant of poor soils. The crop is found wildly in Rajasthan, Tamil Nadu, Assam, Gujarat, Maharashtra and Karnataka. In India Major guggulu producing centres are Kutch forest division in Gujarat and Jodhpur forest division in Rajasthan.

Since time immemorial the plant is being exploited by faulty and indiscriminate method of gum tapping due to which the crop is categorized in IUCN'S Red list as critically endangered. Importantly, decline in natural guggal tree population, prolonged pre-tapping period of resin and high demand in market leading to explore the possible ways of plant conservation and good agricultural practices including agro techniques, harvesting, post harvesting processing etc. According to estimation the annual demand of guggulu is nearly 1000 tones, while the consumption of this drug is nearly 2300 tones used in various preparations of Indian system of medicine. The oleo gum resin of guggulu is being imported from Pakistan annually. Therefore it is rational to conservation and cultivation of this endangered species with the study of good harvesting and post harvesting methods.

**Plant part used**

Oleo Gum resin obtained from the guggul tree by tapping the matured stem and it contains essential oil and steroid compounds. It is pale yellow, brown or dull-green in colour with a bitter aromatic taste when fresh it is viscid and golden coloured and balsamic odour. The genuine guggulusamples contain approximately 1% of essential oil and 1.0 -1.5 % of guggulsterones ($Z$ and $E$).

**Medicinal uses**

This resin or gum obtained from tree used in many Ayurvedicmedicine since for centuries.In modern ages guggul gum resin is used for

1. Largely used as incense and as a fixative in perfumery and in medicine.
2. In indigenous medicine, it is used as an astringent, antiseptic, anti-arthritic, anti-obesity, stomachic, carminative, and digestive.
3. Platelet stickiness appears to be reduced by guggul, which is desirable for decreasing the risk of coronary artery disease.
4. It may also promote fibrinolysis (dissolving the fibrin in blood clots) and act as an antioxidant.
5. Inhalation of the guggal fumes is recommended in hay fever and chronic bronchitis.
6. It is an ingredient of ointment of ulcers.
7. Highly effective in the treatment of obesity, arthritis and ulcers
8. Lower the blood cholesterol - modern medicine
9. Ethyl acetate extract of guggal has been named guggulipid.

**Botanical description**

Guggul is a small tree or shrub up to 3-4 m height, branches are crooked, knotty, aromatic and end in sharp spines.Bark is papery, peels in flankers from the older parts of the stem.Plants are dimorphic. Flowers appear in groups of 2 or 3 usually red. The fruit is ovoid up to 1 cm long drupe and generally contain under developed embryo.

**Guggul plant stem and fruits**

**Soil and climate**

Plants are found growing naturally in arid tracts of Western India over sandy to silt-loam soils. It can also be grown on shallow rocky soils with minimum soil management. The plant has a wider adoptability and is found growing in arid region. Plant architecture having small leathery leaves and thick bark covered with white waxy coat over the stem helps it to withstand the desert conditions.It prefers a warm dry climate and ideal temperature ranges between 27-40$^{0}$C with relative humidity of 76%.

**Propagation**

Guggul can be propagated both sexually and asexually, but sexual propagation by means of seed is not viable method due to its slow and erratic germination. Among the asexual methods of reproduction, air layering and stem cuttings are the most commercially adopted methods.

**Seeds**

Even though plant produce profuse fruits and seed set propagation by seeds is not the common practice, because of the seed germination is slow and is also very poor (5%) due to the presence of a hard seed coat. Even then to achieve good germination, the seeds are mechanically scarified with sand paper and are kept under running water for 24 hours. Seedlings may be raised in polythene bags during *kharif* and after hardening the seedlings transplanted.

**Vegetative method**

Stem cuttings of about 15-20 cm long and 10 mm thick semi-hardwood-cuttings are taken and treated with IBA or NAA 2000 ppm growth regulator solutions. Cuttings are planted in a nursery beds (June-July) or polythene bags. The cuttings sprout in 20-25 days, and will be ready for planting in the main field after 10 to 12 months during the next rainy season. The percentage of rooting in stem cuttings is around 80 - 94 %. Air layering of cuttings of about 15 cm long and 10 mm thick shoots are girdled and smeared with NAA1000ppm + IBA 1000 ppm gives better rooting in layers.

**Planting and care**

CSIR-CIMAP (Central Institute of Medicinal and Aromatic Plants), Lucknow, has developed a good oleo-gum-resin yielding cultivar called "Marusudha". For planting in main field land is levelled and ploughed during rainy season by 2-3times and laid out into plots of convenient sizes. Square pits of 0.5 m$^3$ are dug at a spacing of 3 x3 m.The pits are filled with farm yard manure and top soil and mixed with neem leaves to prevent any damage to the plants due to termite attack. Seedlings of 10-12 months old are transplanted during monsoon season. CSIR-CIMAP has released improved variety of guggal is Marusudha can be used for commercial plantations.As the plants grow they are trained properly by cutting the side branches and to attain main stem more girth to achieve easy and sufficient tapping area on plant. It is found that guggal stems pruned in May contain maximum amount of guggal sterons (0.06%).

**Two year old guggal plant in shallow rocky basaltic soil condition at ICAR-NIASM, Baramati**

**Harvesting and processing**

Tapping is controlled wounding of plant to secrete the gum from cut portion. In guggal plant tapping starts from 8 to 10 years after planting. The tappable plants or stage can be identified by few maturity indices like main stem or primary branches attaining diameter of 5-7.5cm girth and the gum which is present in the Balsam canals in the phloem flows out when shallow incision is made on the bark.

The sharp end of the chisel is dipped in the guggal solution and cut of 10cm long and 1.5cm deep incision is made on stem carefully.Incisions are made at 30cm distance on man stem and branches. Ideal tapping period is during cool and dry months December –March. Incision should not be deeper than bark. It is done by sharp knife. The knife should be dipped in an activator like guggal gum pest. About 3-4 longitudinal incisions given on the main strem and primary branches of plant and upon tapping the yellowish white fragrant latex oozes out through the incision and slowly solidifies into vermicular pieces often forming big lump.The tapped resin may be collected at an interval of 10-15 days depending on weather conditions. The yield of gum-resin from each plant is about 700-900 g per plant. If the incision is too deep, the plant either dies or yields little resin in the following years.While making the incision a small quantity of guggal gum mixed with water may be applied to the incised place using the prick-chisel.

**Grading of guggal gum**

1. Best grade of guggal: collected from the thick branches of tree. These lumps of guggul are translucent
2. Second grade guggal: is usually mixed with bark, sand and is dull colored guggul.
3. Third grade guggal: is usually collected from the ground which is mixed with sand stones and other foreign matter.
4. Final grading: is done after getting cleaned material.
5. Interior grades: are improved by sprinkling castor oil over the heaps of the guggul which impart a shining appearance.

**Adulterants**

The oleo gum - resin of *Commiphora mukul* is commonly adulterated with resin of *C. agallocha*, *C. stocksiana*, *C. berryi*, *C. pubesence*, *C. opobalasamum*, *C. stocksiana*, and the similar looking oleu – gum-resin of other trees.

**Factors affecting gum yield and quality**

- Plants tapped in the month of September produced the highest gum due to good sap flow in the plant, while it was the lowest in plants tapped during May due to dry weather leads to evaporation of water from the gum.

- The gum yield at different seasons showed positive correlation with soil moisture level. Tapping in the month of May yields lower gum due to very low soil moisture whereas, tapping in the month of September yields higher gum due to good soil moisture.
- The highest gum yield can be obtained by tapping at the collar region of the main branch, while tapping on twigs yields lowest gum.

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# Semal or silk cotton tree *Bombax ceiba Linn.*

**Shalini Toppo**

Department of Forestry
College of Agriculture
Indira Gandhi Krishi Vishwavidyalaya
Raipur (C.G.)

## Introduction

*Bombax ceiba* L. of the family *Bombacaceae* is an important medicinal plant of tropical and subtropical India commonly known as Semal or Silk Cotton Tree. It is the tall deciduous tree, with straight buttressed trunk and broad spreading branches. Almost every part of this plant is used as medicine, and its roots and flowers are used for curing the maximum number of ailments. Medicinal usages of *Bombax ceiba* has been reported in many traditional systems of medicine such as Ayurveda, Siddha and Unani medicine since ancient times. Besides having immense medicinal potential, it has also been used for other commercial and industrial purposes.

## Habitat and distribution

*Bombax ceiba* is widely found in temperate Asia, tropical Asia, Africa and Australia. In India, it can be found at altitudes upto1500 m. In peninsular India, the tree is very commonly seen in the dry and moist deciduous forests and also near rivers. This tree is a great light-demander and fast growing tree. *Bombax ceiba* grows best on deep sandy loams or other well-drained soils, especially in valleys, in the regions that are receiving 50 to 460 cm annual rainfall well distributed throughout the year.

## Common name

It is known by different names such as Red Silk Cotton tree, Indian Kapok tree (English), Shalmali (Sanskrit), Semal (Hindi), Shimul (Bengali), Mullilavu (Malyalam), Kondaburuga (Telgu) in different languages.

## Botanical classification

| | |
|---|---|
| Kingdom: | Plantae |
| Division: | Magnioliophyta |
| Class: | Magniolipsida |
| Order: | Malvales |
| Family: | Bombacaceae |
| Genus: | *Bombax* |
| Species: | *ceiba* |

## Morphology

Semal is a lofty, deciduous tree up to 40 m tall with horizontally spreading branches and young stems covered with hard prickles. Bark is grey brown or silver grey colored with hard sharp conicles prickles. Leaves are large, spreading, glabrous, leaflets lanceolate, 3-7 and margin entire. Flowers are red numerous, appearing when the tree is bare of leaves, stamens many arranged in five bundles of 9-12 each and an inner bundle of 15. The fruits are brown capsule-like upto 15 mm long, filled with numerous black seeds. Seeds are smooth, black or grey embedded in long white wool, which are irregular obovoid in shape, smooth and oily with dense silky hair. Gum is light brown to opaque or dark brown called as semul gum.


**Uses**

*B. ceiba*, one of the important plant species is used in various indigenous systems of medicine in India, China and Southeast Asian countries. Almost every part of the plant is used as medicine and its roots and flowers are used for curing maximum number of ailments. Its young roots are roasted in the fire and eaten like roasted sweet potato while some tribes eat even raw roots during famine or otherwise also. The roots of *B. ceiba* are cooling, sweet, stimulant, tonic and demulcent and are used in dysentery. The gum has the property of cooling, aphrodisiac, astringent, and demulcent. The bark has the property of demulcent and emetic, and it also has the power of healing. Leaves are used for skin eruptions. Flowers are used as an astringent and are good for skin troubles, splenomegaly and hemorrhoids. Seeds are said to be useful in treating gonorrhea and chronic cystitis.

*B. ceiba* is also used for various commercial purposes. It is an important multipurpose tree used for agroforestry, providing food, fodder, fuel and fiber. Due to high protein content in the leaves, the plant is the most preferred fodder species. It is widely used in silvipastoral system of agroforestry, to meet the feed requirements of livestock during the fodder deficit period in winter. Wood of this plant is strong, elastic and durable which is best suited for ship, boat and catamaran building. It is most widely used in match industry and for planking ceilings, canoes, shingles, toys, scabbards, coffins, well curbs, brush-handles and artifact production. Oil isolated from its seeds is comparable to true Kapok plant and can be used as an edible oil substitute for cottonseed oil, for soap making and as an illuminant. Floss isolated from its fruits is an excellent material for making padded surgical dressings, insulating material for refrigerators, soundproof covers and walls and as being vermin-proof; it is most suitable for making cushions, pillows and upholstery. The plant is best matchwood resource and useful for reclamation of wastelands and mine spoils. So it can also be used to improve the barren soil and gain the economic benefits.

**Conclusion**

*Bombax ceiba* is a very valuable tree; its each and every part is useful for various purposes. It is considered as one of the most valuable trees as ethnomedicinal and commercial purpose. This article may develop awareness among people regarding importance and valuable uses of this tree. It is one of the most important tree species that has economic and ecological importance and should be conserved for ecological perspectives.

# Poplar defoliator, *Clostera cupreata* and its control measures

**N. Roychoudhury and Rajesh Kumar Mishra**

Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Jabalpur -482 021, Madhya Pradesh
E-mail : choudhury_nr@yahoo.com, mishrark@icfre.org

**Abstract**

The present article describes the pest profile of *Clostera cupreata* Butler (Lepidoptera: Notodontidae), a major defoliator of poplar, *Populus* species (family Salicaceae). The management aspects of this insect pest are mentioned.

**Key words:** *Populus*, defoliator, *Clostera cupreata*, control measures

**Introduction**

The genus *Populus* (family Salicaceae) are commonly known as poplar or cottonwood, consists of a group of about 35 species which are indigenous to the temperate regions of the world and several species and their clones/hybrids have been introduced and adapted for large scale plantations in a wide range of climatic conditions in many countries (Singh, 1979; Tewari, 1993). In India, apart from an indigenous species, *P. ciliata* and two naturalized species, *P. alba* and *P. nigra*, several species and their numerous clones have been introduced and planted in plains of Haryana, Punjab and Tarai region of Uttarakhand.

**Overview of insect pests**

Like any other plantation species, *Populus* species are also prone to insect ravages and as many as 119 insect species belonging to the Order-Coleoptera (28 species), Diptera (2 species), Hemiptera (21species), Hymenoptera (19 species), Lepidoptera (48 species) and Thysanoptera (1 species) are associated with *Populus* species (Browne, 1968).

Most of the exotic poplars, especially *Populus deltoides* have been suffering multiple insect injuries since their introduction in India (Ahmad and Faisal, 2012). Infestation by different insect species to poplar has been reported from time to time by many workers (Pruthi and Batra, 1960; Chatterjee and Thapa, 1964; Seth, 1969; Lohani, 1976; Singh et al., 1983; Singh and Singh, 1986; Tewari, 1993). According to Thakur (2000), 112 insect species have been recorded from various species of *Populus*. All of them are indigenous insect fauna, comprising chiefly defoliators (58 species), stem and shoot borers (23 species), sapsuckers (27 species) and termites (4 species). According to Ahmad and Faisal (2012), as many as 133 insect species so far have been recorded by different workers at various locations infesting different poplar species in India. However, among the defoliators, *Cloetera cupreata*, which was reported originally from *Salix tetrasperma* has adapted on *Populus* as new host and is now a key defoliator pest in most exotic poplar in nurseries and plantations. The pest profile and control measures of this insect are described as hereunder.

**Pest profile**

***Clostera cupreata* Butler (Lepidoptera: Notodontidae)**

*Clostera cupreata* (syn. *Pygaera cupreata*) is commonly known as poplar defoliator and widely distributed in northern India, viz. Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The female moth lays 200-300 eggs on the leaf surface (Thakur, 2000). Young larvae are light brown with greenish mid-dorsal portion. Head light brown, speckled with dark brown spots. Two reddish tuft of hairs on each mid-dorsal margin of 1st abdominal segment and 8th abdominal segment are present. The matured larvae are 25-28 mm long. There are five larval instars. The total larval period is about 11-12 days. Pupation takes place in thin hairy yellowish-brown cocoon either between the two leaves fastened together with silk or in leaf folds. The pupal period is 4-6 days. The diagnostic features of moth are pale reddish brown, head, abdomen and hindwings pale, wing expense 25-30 mm, forewing pale reddish brown with two pale oblique antemedian lines, the first line angled to medial nervate, the second curved to near the inner margin, a medial outwardly curved line joining a straight postmedial line at inner margin, and hindwing paler than forewing (Fig. 1). Male moth with a characteristic anal tuft arising on the dorsal side of the anal segment (Hampson, 1892). The duration of the life cycle lasts for about 19-20 days and there are 8-9 generations in a year.

The larva of this moth is also reported to be a defoliator of *Salix alba*, *S. babylonica* and *S. tetrasperma* (Beeson, 1941; Browne, 1968).

*C. cupreata* has been an important pest of poplar plantations in the Tarai Region of Uttarakhand since 1966 and in Punjab State since 1986 (Seth, 1969; Lohani, 1976; Chaturvedi, 1981; Singh et al., 1983). Epidemics in poplar typically develop three years after plantation establishment (Thakur, 2000). Large scale defoliation by *C. cupreata* is known to decrease significantly the growth increment of poplar trees (Gao et al., 1985). Severe and repeated defoliation in young plants results in mortality (Singh and Singh, 1986).

**Fig.1. Adult moth of *Clostera cupreata***

**Control measures**

Ahmad (1993) has suggested for selection of *C. cupreata* resistant clones of poplar for plantations. Introduction of egg parasitoid, *Trichogramma achae*, *T. chilionis* and *T. perkensi* in poplar plantation can minimize the population of *C. cupreata* (Thakur, 2000). Singh et al. (1983) have recorded population suppression of *C. cupreta* by aerial spraying of Carbaryl (Sevin) insecticide. Foliar spray of insecticides, such as 0.04% Endosulfan, 0.04% Fenithrothion, 0.05% Monocrotophos and 0.05% Quinolphos are found very effective against this poplar defoliator (Thakur, 2000). According to Sangha et al. (2017), foliar spraying of insecticides viz. Quinalphos, Profenofos and Carbaryl @ 0.1% concentration kept the population of *C. cupreata* under check up to 21 days.

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# Storm water and its management

**Rekha Agarwal**

Government Science College
(Department of Higher Education, Madhya Pradesh)
Old Robertson College, Estd.-1836
Jabalpur (MP)- 482 001

Stormwater is water that comes from precipitation and ice/snow melt – it either soaks into exposed soil or remains on top of impervious surfaces, like pavement or rooftops. It occurs when the rate of precipitation is greater than it can infiltrate, or soak, into the soil. Runoff also occurs when the soil is saturated. Runoff remains on the surface and flows into streams, rivers, and eventually large bodies such as lakes or the ocean. Stormwater will eventually evaporate off of a level surface, but most often it flows as runoff to another location. While runoff is flowing to a storm drain or nearby water body, it picks up pollutants along its path. This runoff can cause stream impairment, flooding, pollution, fish & wildlife habitat loss, soil erosion, and reduced groundwater levels.

Runoff, the product of rainstorms or snowstorms, flows over the ground and into drains, sewers, or waterways. The more permeable (or absorbent) the surface, the less runoff there will be. Porous natural landscapes, such as meadows and forests, will readily soak up as much as 90 percent of the rain or snowmelt they receive. In contrast, streets, parking lots, rooftops, and other hard, impervious (non-absorbent) surfaces essentially repel stormwater, preventing it from soaking into the land and forcing it to flow whichever way gravity takes it. The average city block can generate more than five times as much runoff as a forested area of equal size.

When rainfall hits an impervious surface, it meets whatever pollutants reside on that

surface. That could include road salt, sediment, or trash; oil, heavy metals, or toxic chemicals from cars and trucks; pesticides or fertilizers from lawns and gardens; and even viruses or bacteria from animal waste. These contaminants turn pristine rainfall into dirty runoff. How exactly does that happen? Point the blame at our stormwater management systems and impervious surfaces.

Water that drains from bathrooms, kitchens, and other sources with plumbing gets channelled via sewers to sewage treatment plants and is then discharged into public waterways. However, most storm drains funnel rainfall directly into waterways without treatment, bringing with it whatever it carries in a raw state, including trash, toxins, pathogens, excess sediment and nutrients, and thermal pollution (hot water that causes a sudden upswing in ambient water temperatures).

Stormwater runoff is generated from rain and snowmelt that flows over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. Runoff can pick up and deposit harmful pollutants like trash, chemicals, and dirt/sediment into streams, lakes, and groundwater. Construction sites, lawns, improperly stored hazardous wastes, and illegal dumping are all potential sources of stormwater pollutants.

Rainwater harvesting offers a small-scale best management practice to reduce stormwater runoff and the problems associated with it. By harvesting the rainfall and storing it, you can slowly release the water back into the soil, either through irrigation or direct application. The water then moves into groundwater table, providing a steady supply of water to local streams and rivers.

Green roofs are covered with vegetation to enable rainfall infiltration and evapo-transpiration of stored water. A green roof can also reduce the effects of atmospheric pollution, reduce energy costs, decrease the heat island effect and create an attractive environment.

Just an inch of rainfall on one mile of a narrow, two-lane road can produce 55,000 gallons of stormwater runoff. When funnelled through a storm drain, the sudden entry of so much rainfall can damage and erode delicate banks of waterways, resulting in land and habitat loss and changing a waterway's basic morphology.

Stormwater runoff contributes to the frequency and severity of small-scale urban floods. Although localized flood events are not as damaging as catastrophic ones, they can create a greater overall economic burden because of their repetitive nature.

Stormwater runoff impacts the water we drink, the seafood we eat, and the recreational areas we visit. It introduces disease-causing pathogens into water supply sources that treatment facilities can't always filter out and it can

contaminate fish and shellfish, which in turn can sicken us. Rainfall runoff also inundates beach water with bacteria at levels that violate public health standards and sicken an estimated 3.5 million people a year nationwide, causing rashes, hepatitis, and gastrointestinal illness.

Green infrastructure prevents runoff by capturing rain where it falls, allowing it to filter into the earth (where it can replenish groundwater supplies), return to the atmosphere through evapo-transpiration (when water evaporates directly from the land or plants), or be reused for another purpose, such as landscaping.

Green infrastructure improves water quality by decreasing the amount of stormwater that reaches waterways and by removing contaminants from the water that does. Soil and plants help capture and remove pollutants from stormwater in a variety of ways, including adsorption (when pollutants stick to soil or plants), filtration (when particulate matter gets trapped), plant uptake (when vegetation absorbs nutrients from the ground), and the decomposition of organic matter. These processes break down or capture many of the common pollutants found in runoff, from heavy metals to oil to bacteria.

Mitigating stormwater has become a prime directive of cities and states as they look to reduce the impact on aging and undersized sewage systems or simply want to drive sustainable city planning and the construction of green buildings.The harvesting of stormwater from industrial zones prior to its entry into natural waterways is likely to reduce the subsequent impact of point source discharge on surface waters by reducing pollutant loads. If suitably designed, a stormwater harvesting system will also provide urban stream health benefits by mitigating frequent flows to streams and serve as a public amenity. Stormwater harvesting and storage can be achieved in a number of ways including biofiltration, porous pavement, rain garden, and groundwater recharge. To protect water resources, communities can employ management practices to control stormwater and prevent pollution at its source.


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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**