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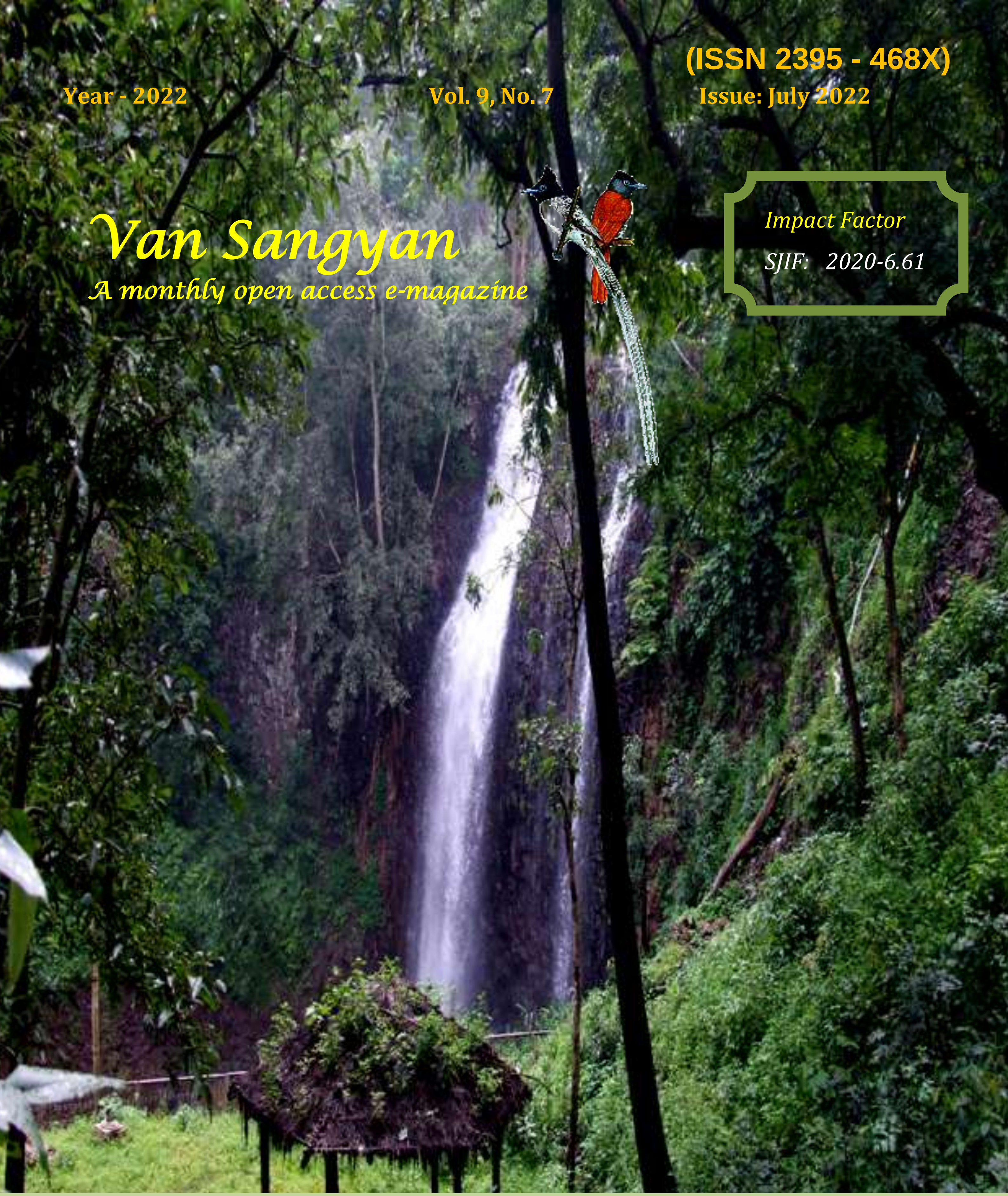

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Van Sangyan

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

From the Editor's desk

During the past three decades, agroforestry has become recognized the world over as an integrated approach to sustainable land use because of its production and environmental benefits. Its recent recognition as a greenhouse gas–mitigation strategy under the Kyoto Protocol has earned it added attention as a strategy for biological carbon (C) sequestration. The perceived potential is based on the premise that the greater efficiency of integrated systems in resource (nutrients, light, and water) capture and utilization than single-species systems will result in greater net C sequestration. Available estimates of C-sequestration potential of agroforestry systems are derived by combining information on the aboveground, time-averaged C stocks and the soil C values; but they are generally not rigorous. Methodological difficulties in estimating C stock of biomass and the extent of soil C storage under varying conditions are compounded by the lack of reliable estimates of area under agroforestry.

Agroforestry, the practice of introducing trees in farming has played a significant role in enhancing land productivity and improving livelihoods in both developed and developing countries. Although carbon sequestration through afforestation and reforestation of degraded natural forests has long been considered useful in climate change mitigation, agroforestry offers some distinct advantages. The planting of trees along with crops improves soil fertility, controls and prevents soil erosion, controls water logging, checks acidification and eutrophication of streams and rivers, increases local biodiversity, decreases pressure on natural forests for fuel and provides fodder for livestock. It also has the ability to enhance the resilience of the system for coping with the adverse impacts of climate change.

The effectiveness of agroforestry systems in storing carbon depends on both environmental and socio-economic factors; in humid tropics, agroforestry systems have the potential to sequester over 70 Mg/ha in the top 20 cm of the soil.The carbon storage capacity in agroforestry varies across species and geography. Further, the amount of carbon in any agroforestry system depends on the structure and function of different components within the systems put into practice.
The fact that agroforestry systems can function as both source and sink of carbon has been presented in literature. There is also clear evidence to suggest that the type of agroforestry system greatly influences the source or sink role of the trees. For example, agrisilvicultural systems where trees and crops are grown together are net sinks while agro silvipastoral systems are possibly sources of GHGs. Practices like tillage, controlled burning, manuring, application of chemical fertilizers and frequent soil disturbance can lead to significant emissions of GHGs. According to the IPCC agroforestry systems offer important opportunities of creating synergies between both adaptation and mitigation actions with a technical mitigation potential of 1.1-2.2 PgC in terrestrial ecosystems over the next 50 years. Additionally, 630 Mha of unproductive croplands and grasslands could be converted to agroforestry representing a carbon sequestration potential of 391,000 MgC/yr by 2010 and 586,000 MgC/yr by 2040. The carbon in the aboveground and belowground biomass in an agroforestry system is generally much higher than the equivalent land use without trees (i.e. crop land without any trees).

In line with the above this issue of Van Sangyan contains an article on Carbon sequestration potential through agroforestry. There are also useful articles viz. Agroforestry for carbon sequestration, Chirata: a useful medicinal plant in India, Possible solutions of plastics through insects, Entomophagy, Atmospheric ozone – Its beneficial and harmful effects, Impact of solar ultraviolet radiation on our environment and Occurrence of larval parasitoid, Apanteles expulsus in teak leaf skeletonizer, Eutectona machaeralis

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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Carbon sequestration potential through agroforestry

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Abstract

Agroforestry is the practice of growing perennial trees and agricultural crops in interacting combinations is recognized worldwide as an integrated approach to sustainable land-use. Agroforestry systems (AFSs) are believed to have a higher potential to sequester carbon (C) because of their perceived ability for greater capture and utilization of growth resources (light, nutrients, and water) than single-species crop or pasture systems. The estimates of C stored in AFSs range from 0.29 to 15.21 Mg ha^{-1} yr^{-1} above ground, and 30 to 300 Mg C ha^{-1} up to 1-m depth in the soil. The extent of C sequestered in AFSs depends to a great extent on environmental conditions and system management. Carbon sequestration is basically the progression of transforming carbon in the air (carbon dioxide or CO2) stored in the soil carbon. Carbon dioxide is taken up with plants through the process of photosynthesis and built-in into living plant material. Agroforestry provides a sole opportunity to combine the double objectives of climate change adaptation and mitigation. It is an attractive alternative for sequestering carbon on agroforestry lands since it can sequester chief amounts of carbon still as leaving the bulk of the land in the production. It is most important option for carbon storage potential in its manifold plant species and soil, high applicability and indirect effects such as decreasing pressure on natural forest or soil erosion. The responsibility of agroforestry practices in climate change mitigation and adaptation is required to realize the potential next to overcoming various components of current and future international climate mitigation policies.

Introduction

Carbon (C) is found in all living organisms and is the main building block for life on earth. It is present in the soil organic matter, plants and animals, geologic deposits, atmosphere as carbon dioxide (CO_2) and dissolved in sea water. There is a growing interest in the role of diverse types of land use systems in stabilizing the atmospheric CO_2 concentration and reducing the CO_2 emissions or on increasing the carbon sink of agroforestry systems. Agroforestry has been recognized as a means to reduce CO_2 emissions as well as enhancing carbon sinks. Although the pristine natural ecosystems represent the largest vegetation and soil C sinks, a considerable extent of this has already been lost especially in the less developed and developing countries of the world. It is unlikely that these degraded and deforested sites will be returned to natural forest cover. Agroforestry systems (AFS) spread over one billion ha in diverse eco-regions around the world have a special relevance in this respect. These woody perennial based land use systems have relatively high capacities for capturing and storing atmospheric CO_2 in vegetation, soils and biomass products. Management of agricultural systems to sequester C has been received as a partial solution to climate change (Morgan et al., 2010). Establishing and maintaining perennial vegetation to enhance C sequestration is less costly compared to most other techniques, and these practices have minimal environmental and health risks. Perennial vegetation is more efficient than annual vegetation as it allocates a higher percentage of C to below-ground and often extends the growing season (Morgan et al., 2010), so enhancing C sequestration potential of agricultural systems even further (Jose, 2009). Agroforestry for carbon sequestration is attractive because (Makundi and Sathaye, 2004): (a) it sequesters carbon in vegetation and in soils depending on the pre-conversion soil C, (b) the more intensive use of the land for agricultural fabrication reduces the need for slash-and-burn or shifting cultivation, (c) the wood products produced under agroforestry serve as alternative for similar products unsustainably harvested from the natural forest, (d) to the extent that agroforestry increases the income of farmers, it reduces the incentive for further extraction from the natural forest for income augmentation, and finally, (e) agroforestry practices may have dual mitigation benefits as fodder species with high nutritive value can help to intensify diets of methane-producing ruminants while they can also sequester carbon (Thornton and Herrero, 2010). Agroforestry provides a unique opportunity to combine the twin objectives of climate change adaptation and mitigation strategies. Although agroforestry systems are not primarily designed for carbon sequestration, there are many recent studies that substantiate the evidence that agroforestry systems be capable of play a major role in storing carbon in aboveground biomass (Verchot et al., 2007) and in soil (Nair et al., 2009) and in belowground biomass (Nair et al., 2009). Agro-forestry have carbon storage potential in its numerous plant species and soil, high applicability in agricultural land, and indirect effects such as decreasing pressure on natural forest or soil erosion (Montagnini and Nair, 2004). The utilization of the environment by species includes three main components: space, resources, and time. Any species utilizing the same exact combination of these resources as another will be in direct competition which could lead to a reduction in C sequestration. The tree components in agroforestry systems can be important sinks of atmospheric carbon due to their fast growth and high productivity. Thus, promoting agroforestry can be one of the options to deal with problems related to land use and CO_2 induced global warming. The amount of carbon sequestered motivation largely depends on the agroforestry system, its structure and function which to a great extent, are determined by environmental and socio-economic factors. Also tree species and system management can influence carbon storage in agroforestry systems (Albrecht and Kandji, 2003). In this paper, we present a review of carbon sequestration potential of agroforestry systems, this necessitate for more studies estimating the potential of agroforestry systems, specify the multiple benefits of these systems and the potential to provide synergy between climate change mitigation and adaptation by way of decreasing the susceptibility of communities to climate risks and climate change in the long period.

Benefits of agroforestry systems

Agroforestry has the potential to offer both economic and environmental reimbursement. Some of the major benefits of maintaining agroforestry systems are discussed below.

Enhanced soil fertility

Soil fertility is good-looking and maintaining for vital in the food security, falling poverty, preserving environment and for sustainability (Pandey, 2007). Agroforestry land use systems like agro-horticulture, agro-pastoral system, agri-silvipastoral system, etc., are proficient ways of restoring soil organic matter (Pandey, 2007). Jama et al., (2006) reported that yield is higher with improved crop rotation than with continuous cropping. The leaf litter from agroforestry practices, forms humus after decomposition and improves various soil properties (ICAR, 2006). Agroforestry systems can also control runoff and soil erosion, thereby dipping losses of water and nutrients, soil material and organic matter. It can make sure development of soil toxicities, both soil acidification and salinization and trees can be employed in the reclamation of polluted soils.

Enhanced income

The varied component of agroforestry provides multiple harvests at different times of the year. It increases food production, improves supply of fodder for fish and livestock, increases supply of fuel wood, improves soil fertility and water supply, habitats, etc. Therefore it reduces the risk of crop failure and ensures alternate income for the farmers (Pandey, 2007).

Decreased vulnerability

Agroforestry improves the resilience of farming systems besides buffering against different risks, both biophysically (hydraulic lift, soil fertility) and financially by diversification and income risk (Verchot et al., 2007). On the other hand the advantage for include dropping seasonal labour peaks, earn income throughout the year and ensure remuneration over the small, middle and lengthy term (FAO, 2005).

Aesthetic worth

Agroforestry practices can enhance the soil, water, air, animal and human being resources in the country. It was may use only 5% of the farming land area, yet account for over 50 percent of the biodiversity, improving wildlife habitat and harbouring birds and beneficial insects which feed on crop pests. Tree biodiversity adds variety to the landscape and improves aesthetics values. Other advantages include-utilization of solar energy more efficiently than monocultural systems, reduced insect pests and associated diseases, increased nitrogen inputs because of nitrogen fixing trees and shrubs. It was also moderate microclimates and shelter given by trees improves yields of nearby crops and livestock.

Measurement of carbon sequestration in agroforestry systems

Aboveground (Vegetation)

Aboveground measurements of C stock (implication, C sequestration) are direct derivatives of aboveground biomass (AGB) measurements/estimates, assuming that 50% of the biomass is made. The AGB is often derived by summing up the amount of harvested and standing biomass, and the measurements are relatively straight-forward compared to those of the belowground section. Estimation of tree biomass by wholetree harvesting is an old approach: it consists of cutting down sample trees, separating various parts (stem, leaves, inflorescence, etc.), digging out and washing the roots, determining their dry weights from each part, and adding them up to get the total biomass. After dividing up the harvested representative trees into their several components (branches, dead branches, branchlets, leaves, roots and fine roots), and determining their dry weight, the C content in each is measured. Using the data, allometric equations are developed as regression models with the measured variables such as diameter at breast height (DBH), total tree height or commercial bole height, and sometimes wood density, as the independent variables and total dry weight as the dependent variable. The destructive technique of determining tree biomass, though comparatively accurate, is tremendously time and labour intensive, especially for large trees. It is often use to validate other, fewer invasive and costly methods, such as the estimation of C stock using non-destructive in-situ measurements and remote sensing. In the allometric equations developed based on bio-physical properties of trees and validated by occasional measurements of destructive sampling are widely used in forestry for estimating standing volumes of forests. With increasing understanding about the role of forests in sequestering C, diverse allometric equations have been developed for different forest types (Basuki et al., 2009 and Fernandez-Nunez et al., 2010).

Belowground (Soils)

The determination of belowground organic C dynamics in AFS is critical for understanding the impact of the system on C sequestration, but it is difficult than that for aboveground C. Organic C occurs in soils in a number of different forms including living root and hyphal biomass, microbial biomass, and as soil organic matter (SOM) in labile and more recalcitrant forms. The most common method of estimating the amount of C sequestered in soils is based on soil analysis, whereby the C content in a sample of soil is determined (mass per unit mass of soil, such as g C per 100 g soil) and expressed usually in mega grams (Mg = 106 g or tons) per hectare. Soil organic C (SOC) is often measured on a whole soil basis. The WalkleyBlack method that used to be employed extensively in the past, and is perhaps used even now in some places, is no longer recommended because of concerns about the accuracy of determination. Currently, several studies measure SOC by quantifying the amount of CO_2 produced through heating in a furnace. Other studies measure the change in weight of the sample after heating. However, the temperature used can differ; it needs to be standardized for accurate comparison of different studies. The existence of carbonates and charcoal in the soil can also skew results (Kimble et al., 2001). These measurements of C on a whole soil basis provide information about total concentrations, but other analytical procedures are needed to determine details of the form and recalcitrance of the stored C as well as where it is stored. In order to gain a better understanding of such details of C sequestration in soils, attention has focused on the study of soil aggregates (Nair et al., 2010).

Carbon sequestration by trees:

The carbon sequestration potential (CSP) of various trees in AFS in different parts of the country is presented in Table 1. The CSP of trees varies with species, structure, age and spatial distribution. For the most common tree density in the range of 312–800 trees/ha (usually preferred by the farmers in planted AFS), the CSP varied in the range of 0.25 to 19.14 Mg C/ha/yr. Nair et al. (2010) have also reported world scenario of carbon stored in AFSs ranged from 0.29 to 15.21 Mg C/ha/yr in above ground, and 30–300 Mg C/ha up to a depth of 1 m in the soil (the age varied from 4 to 35 years). Thus the trees in agroforestry not only improving livelihood of small and marginal farmers, but also helping in mitigating global warming by enhancing carbon sequestration potential of Indian agriculture (Ajit et al. 2013). “National Innovations on Climate Resilient Agriculture” (NICRA) is assessing the carbon sequestration potential of selected AFS in the country. The research under the NICRA scheme indicated that in agroforestry, the tree has a capacity for biomass production at least as great as that of natural vegetation.

Carbon sequestration potential (CSP) of trees in India

Region	Agroforestry system	Tree species	No. of tree/ha	Age (year)	CSP (Mg C/ha/yr)	References
Himalaya	Block plantation	*Eucalyptus tereticornis*	2500	3.5	4.40	Dhyani et al. (1996)
			2777	2.5	5.90	
		Tectona grandis	570	10	3.74	Negi et al. (1995)
			500	20	2.25	
			494	30	2.87	
			100	19	2.47	
		Cedrus deodara	100	19	2.47	Wani et al. (2014)
		Acacia/Dalbergia/Prosopis		6	1.13-3.08	Kaur et al. (2002)
	Agrihortipasture	*Malus domestica*			1.15	AICRPAF (2006)
		Prunus persica etc.			1.08	
Indogangatic	Agrisilviculture	*Leucaena leucocephala*	10666	6	10.48	Mittal and Singh (1989)
		Populus deltoides	400	7	1.98	
	Block plantation	*Acacia nilotica*	1250	7	2.81	Kaur et al. (2002)
		Dalbergia sissoo	1250	7	5.37	
		Prosopis juliflora	1250	7	6.50	

Arid and semi-arid	Block plantation	*Albizia procera*	312	10	1.79	Rai et al. (2000)
		Albizia amara	312	10	1.00	
		Dalbergia sissoo	2500	9	11.47	
		Albizia lebbeck	625	9	0.62	
		Melia azaderach	312	10	0.49	
Tropical	Home garden	Mixed tree species	667	7	1.60	Saha et al. (2009)
	Block plantation	Eucalyptus spp.		7-10	3.71	Ajit et al. (2014)
		Acacia mangium	5000	6.5	12.59	Kaushal R et al. (2014)

Source: Modified from Newaj et al. (2014)

Carbon sequestration through agroforestry

In this paper clearly indicates that, (i) Long rotation agroforestry systems such as windbreak, shelterbelts, woodlots, boundary plantation, agrihorticulture, silvipasture, home gardens, and multi-storeyed systems have large potential in carbon storage in biomass. (ii) Short rotation systems (agrisilviculture) have high potential for soil carbon sequestration. (iii) Fast growing hardwoods (Eucalyptus, Poplar, Melia, Casuarina, Leucaena etc.) and tropical bamboos have large potential for biomass than slow growing species. (iv) Both types (Long and short rotation AFS) have similar soil carbon sequestration potential. AFS provide the climate change mitigation mechanism through: (i) CO_2 assimilation, providing biological and economic gains. (ii) Improvement in production environment further enhances CO_2 assimilation. (iii) C sequestration can be rewarded if mechanism is developed as recommended by the National Agroforestry Policy 2014. Therefore, the evidences are clear to suggest that agroforesry is desirable, both for its beneficial effects on climate change adaptation and mitigation, and for sustaining farm income. The combination of trees with crop gives not only timber, fuel, fodder and food but also reduces CO2 from the atmosphere at acceptable level. The carbon sequestration potential of agroforestry system is higher than any other land use system except forest, however CSP of agroforestry system varies according to tree species, age of system, crop/variety, type of agroclimate, etc. Agroclimatic zones in India represents different agroforestry systems and their aboveground and belowground (soil) CSP varies between 0.25 to 19.14 Mg C/ha/yr and 0.003 to 3.98 Mg C/ ha/yr, respectively. Besides the potential of agroforestry systems to accumulate and sequester C, these systems provide the unique opportunity to increase the tree cover to a level of 33% in India.

Conclusion

Agroforestry is a carbon farming strategy to help control the amount of greenhouse gas that accumulates in the atmosphere. Croplands can store carbon in the soil but some CO_2 goes back into the atmosphere when plants are cultivated and harvested each season. Trees on the other hand store carbon in the trunks and roots (biomass). Tree biomasses are reservoirs of carbon that can limit the amount of emissions cropland cultivation emits. The potential to sequester carbon in agricultural lands can increase when trees are also present in the field. One study estimates that the potential for carbon sequestration in agroforestry from arable lands in Europe can go up to 7.29 t C ha^{-1} a^{-1}. Maximizing the carbon farming potential of agroforestry can reward farmers with genuine carbon credits sold to organizations looking to offset their emissions.

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Agroforestry for carbon sequestration

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Carbon is both a component of living organisms and an element present in carbon dioxide. The soil has a high carbon demand and the sources required to compensate the carbon deficiency are releasing more carbon into the atmosphere as carbon dioxide. Although carbon stored in the soil is utilized in plant and soil development, carbon dioxide emitted as a result of agricultural activities accounts for a significant portion of GHG emissions (GHG). If the released carbon can be fixed in the soil through crops, it reduces the quantity of carbon necessary and can be an excellent GHG mitigation approach. Among the different carbon sequestration approaches, agroforestry stands out as the most promising and can serve as a longterm carbon sink.

Agroforestry is an efficient sequester because of its dual benefits as the crop aids in acting cover crop and the tree component help in providing the shade, the litter dropped acts as a manure to the soil, the trees with their huge roots prevents the soil from erosion loss, the land use system prevents shifting cultivation. In India area under agroforestry counts to 25.32 m ha or 8.2% of total geographical area.

Measurement of Carbon Sequestration in Agroforestry System

Carbon stocks in plant parts of trees are taken as the direct measure of carbon sequestrated. The tree is divided into above ground biomass (AGB) and below ground biomass (BGB). This is an old method where the tree is chopped and divided into various parts and the carbon content of the parts are taken as data required. Using the data, allometric equations are developed as regression models with the measured variables such as diameter at breast height (DBH), total tree height or commercial bole height, and sometimes wood density, as the independent variables and total dry weight as the dependent variable. Below ground biomass estimation counts to soil organic carbon estimation which is usually done through Walkley and Black method.

Though is method being accurate, obtaining destructive sampling is often time consuming. With the improved technology this method is replaced by remote sensing and GIS techniques which access the area and volume of the trees and develop allometric equations and estimate the amount of carbon sequestrated by plant parts. The system's physiology is that the tree absorbs ambient gases during respiration and produces biomass; the dead components, such as leaves and roots, breakdown inside the soil and are added to the soil as organic matter. Carbon being the predominant component of the decomposed organic matter it aids in sequesting carbon efficiently.

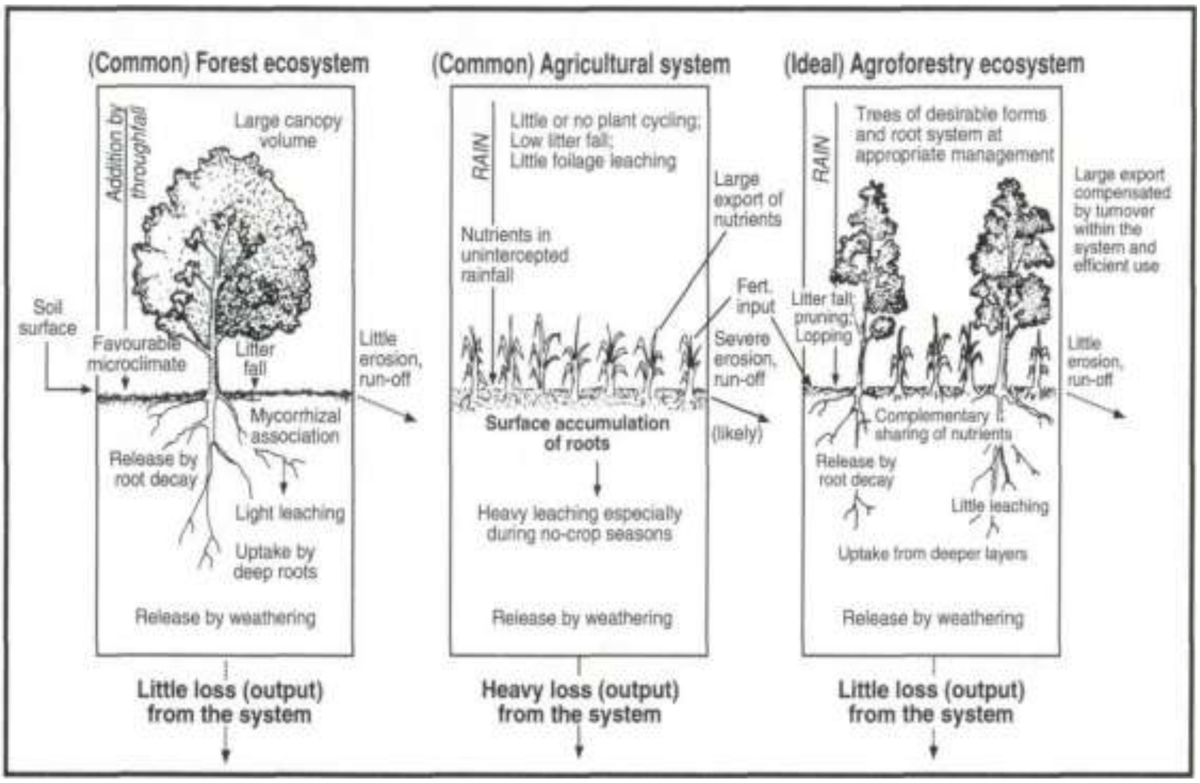

Table 1: Trees Involved in Agroforestry Systems in India and their Carbon Sequestration Potential

Sl. No	Tree species	Carbon sequestration potential (CSP) (Mg C/ha/yr)
1	*Eucalyptus tereticornis*	4.40
2	*Tectona grandis*	3.74
3	*Cedrus deodara*	2.47
4	*Acacia/Dalbergia/Prosopis*	1.13-3.08
5	*Malus domestica*	1.15
6	*Dendrocalamus hamiltonii*	15.91
7	*Populus deltoids*	12.02
8	*Bambusa spp*	19.14
9	*Grewia optiva*	2.17
10	*Acacia catechu*	1.5
11	*Pinus spp*	7.1
12	*Mangifera indica*	1.7
13	*Leucaena leucocephala*	10.4
14	*Gmelina arborea*	3.23
15	*Eucalyptus spp.*	2.81
16	*Dalbergia sissoo*	2.55
17	*Emblica officinalis*	1.55
18	*Hardwickia binate*	0.58
19	*Dichrostachys cinerea*	1.05
20	*Acacia farnesiana*	2.42

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Chirata: a useful medicinal plant in India

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Abstract

Chirata is a very popular medicinal herb. Chirata is a bitter-tasting herb that grows in the regions of higher altitudes. In fact, Chirata can be found growing in high-altitude regions of sub-temperate Himalayas. The advantages of Chirata are manifold. It can boost metabolism and burn calories. Chirata has high antioxidant activity that helps manage diabetes by enhancing insulin secretion and reducing oxidative stress. The bioactive components present in Chirata can help protect the kidney against damage. Ayurvedic studies suggest that the “Antipyretic” or “Jvarghana” property of Chirata is extremely beneficial. Consequently, taking chirata water twice a day can help combat fever. Chirata is the dried aerial part of the annual herb Swertia chirata found in the temperate Himalayas and belongs to the family Gentianaceae. It is also known as Indian gentian.

Keywords

Medicinal plant, Chirata, Alkaloids, mangiferin, gentiocrucine, enicoflavine

Introduction

Chirata is a popular medicinal herb native to high-altitude regions of the sub-temperate Himalayas ranging from the Himalayas to Bhutan. It has a bitter taste and each part of the plant has health benefits. Chirata helps in weight loss as it increases metabolism and helps in burning more calories. It is also beneficial in managing diabetes by increasing insulin secretion and reducing oxidative stress in diabetic patients due to its high antioxidant activity. Chirata also plays a beneficial role in kidneys as it helps prevent stone formation due to its diuretic property. It also protects the kidney from damage by free radicals due to the presence of certain bioactive compounds. As per Ayurveda, taking Chirata water two times a day helps manage fever due to its Jvarghana (antipyretic) property. Chirata is useful in managing skin problems including acne. Applying the paste of Chirata powder along with honey reduces the redness and inflammation and prevents infections due to its anti-inflammatory and antibacterial properties. Chirata powder with coconut oil helps manage wound healing due to its Ropan (healing) and Pitta balancing properties in Ayurveda.

Biological Name

Swertia chirata, Gentiana chirayita

Family

Gentianaceae

Indian Name

Chirayata

Morphological description

The plant is an erect annual. The stems are robust, branching, cylindrical below and 4-angled upwards, containing a large pith; the leaves are broadly lanceolate, 5-nerved and sub-sessile; the flowers occur in large panicles, are lurid greenish-yellow, tinged with purple; the capsules are egg-shaped, many-sided, sharp-pointed; the seeds are smooth and many- angled. The drug (chiretta) is obtained from the dried plant.

Principle constituent

Chiretta is reported to contain a yellow bitter acid, ophelic acid, two bitter glucosides, chiratin and amarogentin, gentiopicrin, two yellow crystalline phenols, a neutral, yellow crystalline compound, and a new xanthone, swerchirin. The herb contains swertanone, swertenol, episwertinol, chiratenol, gammacer-16-en-3ß-ol, 21-a-H-hop-22(29)-en-3ß-ol, taraxerol, oleanolic acid, ursolic acid, swerta-7, 9(11)-dien-3ß-ol, and pichierenol. It also yields, 1,3,6,7-tetrahydroxyxanthone-C-2-ß-D-glucoside (mangiferin) having a significant immunomodulatory potential.A new xanthone, 1,5-dihydroxy-3,8-dimethoxyxanthone besides swerchirin and 7-O-Me swertiarin and monohydroxy terephthalic acid and 2,5-dihydroxy terephthalic acid were isolated from the herb. The herb also yields 1,5,8-trihydroxy-3-methoxyxanthone,1-hydroxy-3,5,8-trimethoxyxanthone,1-hydroxy-3,7,8-trimethoxy xanthone, 1,8-dihydroxy-3,5-dimethoxy-xanthone, 1,8-dihydroxy-3,7-dimethoxy xanthone and 1,3,6,7-tetrahydroxy xanthone C-2-ß-D-glucoside (mengiferin), 1,3,8-trihydroxy-5- methoxy xanthone, 1,3,5,8-tetrahydroxy xanthone and 1,3,7,8-tetrahydroxy xanthone, a novel dimeric xanthone the alkaloids gentianine, gentiocrucine and enicoflavine.

Pharmacological activity:

The ethanolic extract of S. chirayita exhibits hypoglycemic activity. Chirayatra is an effective drug for reducing fevers. It is especially beneficial in the treatment of malarial fevers. It is also effective in hysteria and convulsion. The herb is an excellent drug for strengthening the stomach and promoting its action. It is used in the treatment of dyspepsia and diarrhoea. Chirata possesses anthelmintic that is, worms destroying, and properties and is used in killing intestinal worms. An infusion of the herb is taken for this purpose. It serves as an effective tonic in case of general weakness and during convalescence. The infusion of the plant can be taken in doses of 60ml or40 tablespoons twice a day, before meals. The herb is used in the form of an infusion or tincture.The infusion is prepared in the hot water with aromatics like's cloves and cinnamon. It is generally taken in doses of 15 to 30 ml or 1 to 2 tablespoon. The root of the plant is useful in checking hiccups and vomiting. It is taken in doses of 0.5 to 2 grams with honey.

The Chirata herb is remarkable for its properties in the removal of all kinds of intestinal worms. An infusion of the herb is prepared and taken regularly during parasitic infestations. The Swertia chiretta is a therapeutic plant and its remedial usage has been recognized in the Indian pharmaceutical codex as well as the British and American Pharmacopoeias. In addition, the curative value of the herb has also been recorded by the ancient Indian herbal medicine system Ayurveda and other conventional medical systems. The herb as well as its extracts is used as a bitter stimulant to treat fever as well as curing several skin problems. It is much employed in urinary complaints with uneasiness in the region of the kidneys, frequent urging to urinate, which is accomplished with difficulty, and in cases of uric acid deposits. It is a remedy also for convalescence from exhausting sickness, and for atonic and nervous forms of dyspepsia.

If you have an acne problem, you should try applying a paste made of Chirata on your skin. This paste, applied along with honey, can help reduce the affected area's redness and inflammation. A lot of people have incorporated Chirata in their daily lives because of its anti-bacterial and anti-inflammatory properties. Chirata is also very effective on wounds. The "healing" or "Ropan" property and the "Pitta Balancing" property of Chirata can be extremely helpful against wounds. If you have wounded or injured yourself, you can definitely try applying Chirata powder with coconut oil. Diabetic patients taking anti-diabetic medicines are often asked to check their blood glucose levels while consuming Chirata. That is because Chirata reduces blood glucose levels.

Ranging from the Himalayas to Bhutan, Chirata can be found in regions of high altitudes. For centuries, Chirata has served as a very important element of traditional medicines. Thanks to the huge health benefits that this herb has to offer, regular consumption of Chirata can provide you with protection against a wide array of health problems, injuries, and issues. You can avail of this herb's advantages in the form of tablets, paste, capsules, powder, and so on. There are a lot of Ayurvedic and scientific studies that point toward the amazing benefits of this herb. From diabetes to skin problems, the Chirata herb's properties make it very useful against a huge range of ailments.

How did the word "Chirata" originate?

Chirata has been mentioned in ancient Vedic texts. The Charaka Samhita has mentioned about this plant and listed its medicinal benefits. The scientific name of Chirata is Swertia chirata. A lot also knows Chirata of different names such as Kirataka, Bhunimba, Kiratatiktaka, Kariyatu, Nalebevu, and Kaddi. While different names across different regions know it, this herb is used for similar reasons across all these different parts of the country. Chirata has a long history of being used in traditional medicines to derive better results.

Historical uses of Chirata

Swertia chirata has played a huge role in traditional Indian medicines for a long time. Chirata has also been mentioned in the Charaka Samhita from the Vedic time. Ayurvedic studies have listed several advantages of Chirata. This herb species have been used for a long time for healing injuries or wounds, boosting metabolism, and helping diabetic patients. In modern times, Chirata is used to treat a vast array of ailments such as piles, ulcers, diabetes, skin diseases, and so on.

Benefits of using Chirata in Ayurvedic treatments

Ayurvedic studies point towards the huge benefits of Chirata. The Ropan and Pitta balancing properties of Chirata can be very beneficial against wounds. Chirata also has Jvarghana property that can help combat fever. It is often recommended that diabetic patients incorporate Chirata into their regular diets as Chirata can boost insulin secretion. As a result of its many benefits, Chirata has been made available in many shapes and forms. Nowadays, people can avail of this herb in the form of

Chirata Powder, Chirata Tablets, Capsules, and so on.

While Chirata is an extremely beneficial herb, you should speak with a doctor or a physician before consuming this herb. Therefore, it is recommended that people such as breastfeeding women, pregnant women, among others, always consult with their doctors or physicians before consuming this herb on a day-to-day basis.

Treating diseases/health problems using Chirata

Over the past decades, both scientific and Ayurvedic studies have acknowledged the many advantages of Chirata. As a result, this bitter-tasting herb has become increasingly popular as a medicinal herb. Read on to know about the different benefits of the Chirata herb.

1. **Malaria**

Modern Scientific View	Ayurvedic View
Chirata comprises certain components that possess antimalarial property. As a result of this property, consumption of Chirata can help inhibit malarial growth.	In Ayurveda, Malaria is referred to as Vishamajwara or intermittent fever. When a person contracts malaria, he/she may be overcome with features such as body pain, excessive thirst, headache, irregular onset, and remission, among others. Ayurvedic studies suggest that Chirata infused water can be very helpful in combating Malaria.

2. **Constipation**

Modern Scientific View	Ayurvedic View
Chirata has strong laxative property. This laxative property of Chirata can boost bowel movement and help you get rid of waste materials easily.	Ayurvedic studies suggest that Constipation can happen as a result of aggravated Vata and Pitta Dosha. Excess consumption of junk food, coffee, and tea, staying up late, stress, or depression, among others, may lead to constipation in humans. The "Rechana" or "Laxative" property of Chirata can help smooth removal of waste products from your body.

3. **Worm infection**

Modern Scientific View	Ayurvedic View
Chirata has an antihelmintic property that can help combat worm infestations. Chirata can help inhibit parasitic activity and removes these parasites from the	Ayurvedic studies refer to these worms as "krimi." Krimi, which grows inside our intestines, can hurt our body functions immensely. Chirata has Krimighna property that

body.	can help combat against these worms. Chirata can destroy the conditions that are ideal for these worms to sustain themselves.

4. **Appetite stimulant**

Modern Scientific View	Ayurvedic View
It is often mentioned that this bitter-tasting herb can work as an appetite stimulant and can help improve digestive activities. However, not enough scientific pieces of evidence are present to prove the advantages of this herb.	Not enough ayurvedic studies exist which talk about Chirata's function as an appetite stimulant. However, ayurvedic studies point towards a lot of other benefits of this particular species.

5. **Upset stomach**

Modern Scientific View	Ayurvedic View
Several scientific studies suggest that Chirata can work wonders when it comes to stomach problems. Chirata can be very beneficial against problems such as acidity or flatulence. It not only improves digestion immensely but also strengthens the stomach.	A lot of ayurvedic studies suggest that Chirata has a lot of health benefits, and incorporating this herb into our daily lives can do wonders for our body.

Forms of Chirata in Ayurveda with the recommended dosage

Chirata can be incorporated into our daily lives in the form of Chirata Powder, Chirata Capsule, and Tablet.

Consumption of Chirata powder is recommended. The recommended dosage is 1-3gm of the same twice a day or whatever amount is recommended by the doctor.

The recommended dosage of the Chirata tablet is one capsule a day or whatever is recommended by the doctor.

Taking 1 Chirata capsule twice a day can be very beneficial for your health. You can also consume the Chirata capsule in a dosage that is recommended by a physician.

A paste made out of these herbs can be applied to the skin in order to get rid of acne and pimples.

Types of Ayurvedic care with Chirata

Chirata Powder

Chirata can be consumed in the form of powder. Consuming this product daily can help you combat worm infections. Here's how you can incorporate Chirata Powder into your daily diet.

Tips

- Consume 1-6 gm of Chirata every day to get rid of worm infections. However, you can also change the amount of consumption as per your requirements.

- Mix the required amount with lukewarm water and drink this concoction every day to keep your health problems at bay.

Chirata Decoction

Chirata is a bitter-tasting herb that can provide you with great relief against constipation. Here is what you can do to get rid of your digestive issues.

Tips

- Fill a pan with a cup of water and some raw or dried Chirata and bring it to boil.
- Reduce this concoction to 1/4th of its original quantity. After the concoction is ready, filter it and consume 3-4 teaspoons of it twice a day.

Chirata Tablet

A lot of doctors prescribe Chirata Tablet because of the many health benefits of this herb. Read on to know about how you can incorporate Chirata into your day-to-day lives in the form of Chirata tablets.

Tips

- You can consume either one tablet or the amount that is prescribed by the doctor.
- Consume this with a glass of water 1-2 times a day.
- Chirata Capsule
- Chirata capsule is recommended by a lot of doctors or physicians for its blood purification ability. Here's how consuming chirata capsules daily can help you.

Tips

- Consume 1 capsule a day or as recommended by a doctor.
- Have this capsule with water 1-2 times a day as this capsule can do miracles for your health.

Chirata leaves

Chirata leaves are well-equipped with a lot of healthy features. The antipyretic property, for example, can help your body combat high temperatures.

Tips

- Make a paste out of a generous amount of Chirata leaves.
- Consume these leaves with lukewarm water in order to prevent symptoms of fever.

Chirata Paste for Acne and Pimples

Chirata can help with your acnes and pimples. The “kapha” and “pitta” properties of this herb can remove clogs and reduce inflammation.

Tips

- Take some Chirata powder. This powder can be taken in a quantity of 1-6 gm or according to your own requirements.
- Mix this powder along with honey or rose water to create a nice paste.
- Apply this paste onto your face and let it rest for 15-20 minutes.
- Wash off the face thoroughly with water.
- You can apply this paste on a regular basis. Thanks to this paste, you can easily get rid of acne and pimples, fine lines, wrinkles, and so on.

Chirata Paste for Skin disease

Eczema is a skin disease that can result in rough skin, blisters, bleeding, itching, among other symptoms. The “Ropan” and “Sita” properties of Chirata can help you get rid of this disease.

Tips

- Take 1-6 gm of Chirata Powder. You can customize the quantity according to your own requirements.
- Mix the powder with coconut oil to create a paste.
- Apply the paste onto your skin, and keep it on your face for 4-5 hours.
- This paste can help you get rid of persistent skin problems.

Side effects of Chirata

- The bitter taste of Chirata may lead to nausea or vomiting. Chirata, therefore, should be consumed with the utmost care. A lot of Ayurvedic studies have shown how the "Tikta" flavour of Chirata can result in a person feeling nauseous or dizzy.
- Scientific studies state that chirata may lead to a feeling of dizziness in people who are consuming this herb.
- Chirata can interfere with blood sugar levels. Consequently, it is often recommended that Chirata shouldn't be consumed around the time of important surgery.

Precautionary guide while taking Chirata?

For people who will undergo surgery:

View of Science Experts

It is a well-known fact that Chirata can interfere with blood sugar levels. As a result of this property, it is often recommended that Chirata shouldn't be consumed around the time of surgery in order to prevent any complications.

For breastfeeding individuals:

View of Science experts

Due to the lack of scientific evidence, it is recommended that lactating individuals should consume Chirata only after consulting with a doctor.

For diabetic patients

View of science experts: Chirata can interfere with blood sugar levels. Hence, you should monitor your blood sugar levels if you are consuming Chirata along with anti-diabetic drugs.

For heart patients

View of Science Experts

Due to the lack of enough scientific evidence, patients who are prone to heart-related diseases must consult a doctor before consuming Chirata.

For pregnant individuals

View of science experts

You should definitely consult a doctor before consuming Chirata during your pregnancy. Consultation is recommended due to the lack of scientific evidence.

FAQs about Chirata

How should Chirata Powder be stored?

View of Science Experts

Chirata is a medicinal herb that is native to the high-altitude regions of the sub-temperate Himalayas. It is important to store Chirata in clean, dry, and sterile spaces in order to avail of maximum benefits.

Can Chirata Powder be consumed on a daily basis?

View of science experts

Chirata has a lot of health benefits and can help you overcome a lot of ailments. Therefore, it is recommended that Chirata powder be consumed with lukewarm water on a daily basis to get rid of certain health problems. You should consult your doctor or physician before starting this routine.

Can Chirata help against Diabetes?

View of Ayurvedic experts

Chirata can be found in various forms, such as Powder, capsules, tablets, and Kwath. This powder, consumed in a quantity of 1-3g daily twice a day, can help you control your diabetes. Consultation with a doctor is recommended.

Can chirata help against Diabetes?

View of science experts

Chirata has antioxidant and anti-inflammatory properties. These properties are very effective against diabetes. Consuming Chirata on a regular basis can help prevent damage to your pancreatic cells. Chirata can also boost insulin secretion, which can work wonders against high blood sugar levels.

Is Chirata good for your liver?

View of science experts

The antioxidant property of Chirata can help your liver in a lot of different ways. Liver cells can suffer damage as a result of free radicals. Antioxidants, however, can prevent cell damage by eliminating these radicals from your body. Thanks to its anti-inflammatory property, Chirata can also help reduce liver inflammation.

Can Chirata help against symptoms of fever?

View of Science Experts

The antipyretic property of Chirata can help you battle symptoms of fever. This property can help reduce increased body temperature and help you in regaining your normal strength.

Can Chirata aid in weight loss?

View of science experts

Chirata possesses Methanol, which boosts metabolism and helps our body in getting rid of excess weight.

Is Chirata beneficial for anaemic patients?

View of science experts

Chirata boosts the production of blood in our bodies. According to science experts, this property of Chirata can help manage anaemia.

Can Chirata prevent gastrointestinal disorders?

View of science experts

The anti-inflammatory property of Chirata might be beneficial against gastrointestinal disorders. The lowered acid production can provide you great relief and help get rid of recurring bouts of acidity.

Can a patient with ulcers consume Chirata?

View of science experts

According to scientific studies, Chirata can worsen gastric or duodenal ulcers. You should, therefore, consult a doctor or a physician before consuming this herb.

Can Chirata result in vomiting?

View of science experts

Chirata is a bitter-tasting herb, and its taste can induce nausea or vomiting in a lot of people.

Can Chirata lead to Hypoglycaemia?

View of science experts

A lot of scientific studies have shown that Chirata can interfere with blood sugar levels. Chirata consumption, therefore, can lead to hypoglycaemia or lowered blood sugar levels. If you are consuming Chirata along with your anti-diabetic drugs, you should keep a sharp eye on your blood sugar level as well.

What are the benefits of Chirata leaves?

View of science experts

The antipyretic property of Chirata leaves is extremely beneficial against symptoms of fever. Besides managing fever in our bodies, Chirata leaves can also manage headaches and blood pressure.

Tips

- Take a generous amount of Chirata leaves and soak these leaves in water overnight.
- Use some water to prepare a paste from these leaves.
- Use this paste daily in order to avail of the benefits of Chirata leaves.

View of Ayurvedic experts

In Ayurveda, "intermittent fever" is referred to as "Vishamajwara." When consumed with water, Chirata paste can help manage the symptoms of fever. Chirata possesses "antipyretic" or "jvaraghna" property and antimalarial property.

How can Chirata help prevent skin diseases?

View of science experts

Paste made out of Chirata can be extremely beneficial for your skin. Eczema is a disease that can harm your skin in a lot of different ways. The anti-bacterial and anti-inflammatory properties of Chirata can help your skin fight against Eczema and other skin-related issues. Chirata can also end to inflammation, pain, redness, and other problems associated with acne and pimples.

Is Chirata beneficial for Contagiosa?

View of science experts

A very infectious disease, Contagiosa, can result in redness and inflammation. The anti-inflammatory property of Chirata can help combat the symptoms of this disease.

How can Chirata heal wounds?

View of science experts: Chirata is well-equipped with antioxidant, anti-microbial, and anti-inflammatory properties. If applied to the region of injury, constituents in Chirata can help in the contraction and closure of wounds. Chirata also helps in the regeneration of new skin cells.

How can Chirata protect you from microbial infections?

View of science experts

The anti-microbial property of Chirata inhibits the growth of bacteria. As a result of this property, you can prevent a lot of intestinal and respiratory infections.

Conclusion

Basically, Swertia chirata is an Ayurvedic therapeutic plant. An astringent stimulant prepared with the plant is an outstanding medication for a weak stomach, particularly when it results in indigestion, bloating and nausea. In addition, this bitter tonic is also said to be effective in protecting the liver. Chirata is a valuable bitter tonic. It is a laxative and an appetizer. It also corrects the disordered process of nutrition and restores the normal function of the system. It is an effective herb for reducing fevers. It is especially beneficial in the treatment of malarial fevers. It is also effective in hysteria and convulsions. It also shows hypoglycaemic activity.

Possible solutions of plastics through insects

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Introduction

Global production and consumption of plastic has increased by over a factor of 20 since the 1960s. Today, 40 percent of global plastics production is for packaging and 95 percent is single-use. Although demand for plastic is forecast to continue rising, growth in production and consumption is coupled with an inefficient global waste management system, resulting in less than a fifth of plastic waste being recycled (PRI, 2019). As plastic does not break down naturally, it is polluting natural systems, including rivers and oceans. According to research by the Center for International Environmental Law, greenhouse gas emissions from plastic could represent 10-13 percent of the entire remaining carbon budget by 2050 (in the context of the 1.5 degree goal of the United Nations Framework Convention on Climate Change Paris Agreement) (Ryberg et al., 2018). This burgeoning problem needas an effective economic and ecologically sustainable solution. Polystyrene (PS), a common petroleum-based plastic made from the polymerization of styrene monomer, is used for a wide range of packaging and building constructions since its first commercial production in 1930. Nowadays, the annual production of PS reaches approximately 33 million tons, accounting for about 7% of the total global plastic production (Farrelly and Shaw, 2017). Most of PS wastes are discarded without recycling, and have become one of the major plastic debris accumulated in the environment. Dealing with the plastic wastes and remediate the plastic pollution has become a serious environmental issue within the recent years. PS is generally considered to be resistant to biodegradation because of its recalcitrant macromolecular structure. Although a few studies have reported that PS could be biodegraded and mineralized by mixed microbial cultures or isolates from various sources such as soil, garbage, and sewage sludge, the reported biodegradation efficiency of PS was still quite low.

Insects in plastic recycling

Recently, our study firstly reported that mealworms (larvae of *Tenebriomolitor*) could chew and eat Styrofoam (trade name of PS foam) as sole food, and rapidly degrade and mineralize the ingested Styrofoam after passage through the intestinal tract. The gut microbial symbiont plays an important role in the biodegradation of ingested Styrofoam in the gut. Other insect resembling giant mealworms, superworms (*Zophobas atratus*) are beetle larvae that are often sold in pet stores as feed for reptiles, fish and birds. In addition to their relatively large size (about 2 inches long), these worms have another superpower: They can degrade polystyrene plastic. Based on the analysis of DNA barcode of COI gene (cytochrome c oxidase subunit I), the average genetic divergence between *Z. atratus* and *T. molitor* is 20.9%, although both of them belong to the family of Tenebrionidae (Park et al., 2013). *Pseudomonas aeruginosa* bacteria was successfully isolated from the gut of the worms and showed that it that could grow directly on the surface of polystyrene and break it down. Finally, they identified an enzyme from the bacteria, called serine hydrolase that appeared to be responsible for most of the biodegradation. This enzyme, or the bacteria that produce it, could someday be used to help break down waste polystyrene.

Figure 1: Plastic recycling beetle *Zophobasatratus*larva and adult

Conclusion

These findings don't only open a new way for harnessing mealworms to degrade more other types of plastic wastes such as polyethylene or rubber, but also provide inspirations for exploring more other insect species for biodegradation of plastic wastes (Hong Rae et al., 2019). Although these insects potentially are not potentially enough as the mechanical recycling process, yet could supplement the recycling.

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Entomophagy

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Insects as food

The practice of consuming insects is known as ENTOMOPHAGY. Achieving environmentally sustainable food security is currently one of the biggest global challenges. A wide range of edible insect species, with their high contents in protein, fat, minerals, vitamins and fibre, can play a significant role in addressing food insecurity. Advantages of entomophagy include a high feed-conversion efficiency of insects and the rearing on organic side streams, adding value to waste and decreasing environmental contamination. It is more common than you may think, as over 2 billion people regularly consume over 1900 species of insects around the world. It has been a documented part of the human diet for more than 2000 years in some parts of the world, and some archaeological evidence suggests we have consumed insects for over 1.7 million years. Insects are commonly farmed today as a protein source for vertebrate livestock, such as poultry. Fish and soy meal, which are farmed intensively, can be partially replaced by the more sustainable production of insect protein, such as fly larvae, to reduce agricultural and fishing intensity. Unlike other substitutes, this does not place additional pressure on other industries as the flies can be reared entirely on waste products.The presence of high-quality protein and various micronutrients as well as potential environmental and economic benefits render edible insects globally a major potential future food.However, consumer acceptance remains a major obstacle to the adoption of insects as a food source in many countries.

Nutritional benefits

Part of the reason insects may help with food shortages is because they are a highly nutritious food source. While the nutritional content varies by species and their diet, insects are more nutritious than many foods we currently eat. Per unit weight, insects provide more calcium than milk, more iron than spinach, and more magnesium and vitamin B12 than beef. They also provide all 9 amino acids essential to humans, and protein can make up as much as 50% of an insect's dry weight. Some insects also have a high quantity of natural fats. Their overall nutrient content is comparable to many of the animals that are farmed and consumed by humans today.

While insects are extremely high in protein, their chitinous exoskeletons are largely indigestible by humans. The indigestible exoskeleton, however, acts as a good source of fibre, which can promote healthy communities of endosymbionts in the human gut. As we learn more about the importance of microbiota in the human gut, we begin to understand how important it is to promote the maintenance of these communities through the addition of probiotics and prebiotics to human diets. Probiotics are living microbes that complement naturally occurring gut fauna, while prebiotics are types of fibre that nourish the gut fauna. Chitin can act as a prebiotic for the good microbes in the human gut.

Interesting fact

A recent study has found that arthropods regularly consumed by humans in some parts of the world are also high in antioxidants. Crickets and silkworms both showed antioxidant capacity similar to that of olive oil and orange juice, foods that are well-known to have antioxidant effects in humans. In fact, insect extracts have 5 times the antioxidant capacity of fresh orange juice. Antioxidants are molecules that can help protect our cells from damage caused by free radicals, which are constantly produced through regular cellular processes.

Sustainability

One of the major issues with much of livestock production today is the sustainability of the practice. Insects can be more sustainably reared than most livestock today, and use less input and a smaller footprint of land, while producing fewer greenhouse gas emissions.

1. Insects can be reared on a smaller carbon footprint partly due to the fact that they are ectothermic.
2. Unlike endothermic livestock reared today, insects convert a large proportion of food into edible tissue because they do not need to use energy to maintain body temperature. This generally means less food and water is required to rear the animals.
3. Crickets have an impressive ratio of conversion of food into body mass. For every 2 kilograms of food consumed, crickets gain 1 kg in body mass. Compare this to pigs, which require 5 kg of food for each kilogram of body weight, or cows, which require 10 kg of food for each kilogram of body weight gain.
4. The consumption of water is also more efficient for cricket rearing than endothermic livestock. Since endotherms maintain high body temperatures, more water is lost through evaporation compared to ectotherms.
5. Insects also contain a higher proportion of edible tissues compared to traditional livestock. Only 40% of the mass of a cow is used as food, with inedible tissues put to other uses. Compare this to crickets, in which 80% of the insect's mass is made up of edible tissues.
6. In addition, the rapid growth and short lifespan of insects means a quick turnover of plant food into animal protein, which can make entomophagy even more useful in times of resource scarcity.
7. Another one of the benefits to the use of insects as food is the space efficient conditions in which these animals are reared. While consuming less food and water than traditional livestock, insects also have minimal requirements for growth.

8. Small areas and vertical spaces can be better utilised than in the rearing of vertebrate livestock. For instance, cows require 6 times more space than crickets in order to produce a single kilogram of protein.
9. The rearing of insects also produces less waste than vertebrate livestock in terms of greenhouse gas emissions. Insects produce significantly less carbon dioxide, ammonia, methane, and nitrous oxide than vertebrate livestock. For instance, cricket rearing produces 90% less methane and 99.7% less nitrous oxide compared to the rearing of cattle.
10. The faces of mass-raised insects can also be put to use. Just as waste from vertebrate livestock can be used as fertiliser and for other applications, the frass of reared insects, such as silkworms, is used to feed fish, either directly or by using it to culture plankton.

In order to feed an ever-growing human population, we need to explore sustainable food sources, such as the use of insects as food. While the benefits of entomophagy are abundant in terms of health and sustainability, the overall perception of insects held by much of the world hinders the progression of entomophagy in many nations.

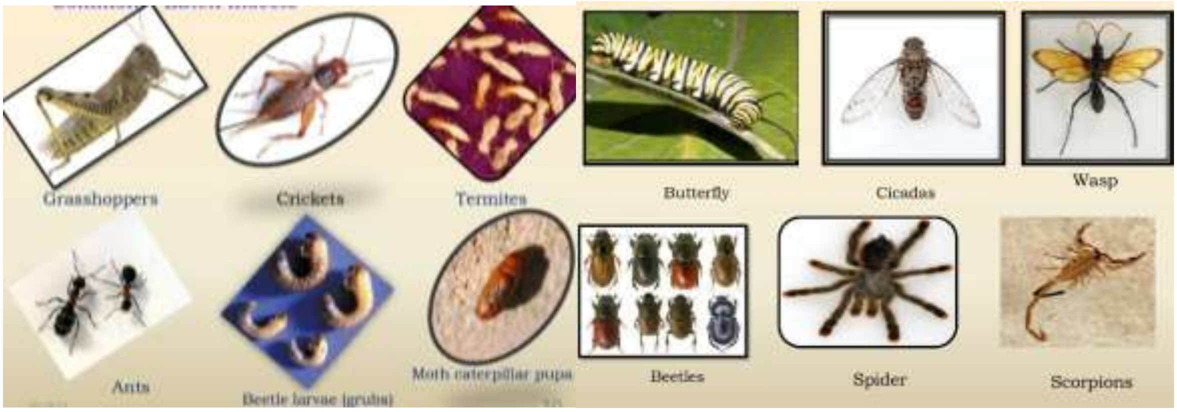
Entering the market

Many people struggle with the thought of insect consumption due to the common perception people hold that insects are "unclean" or "gross". Fortunately, entomophagy is on the upswing as sustainability is brought to the forefront of global policies. Most examples of insect foods today come in the form of novelty items, such as seasoned dried insects or those covered in chocolate or candy. However, some insect-based foods in North America are beginning to be marketed as a staple in human diets.

Cricket and mealworm flours have become popular as protein-filled substitutes to wheat flour in cooking and baking. These are much more nutritious than wheat flour, and can provide a gateway into entomophagy since the consumer doesn't see or chew whole insects while eating. Challenging the perception of insects in society can be tricky, but the first step in introducing insects into the human diet may be as simple as presenting the foods in a visually appealing manner.

However, there are other challenges in bringing insects to the dinner table. Even once the perspective of citizens changes and insects become more widely accepted as a food source, there are few regulations to govern the use of insects as food for human consumption. It requires the development of clear guidelines that state whether insects have been raised or produced at a standard conducive to human consumption. This blocks many large-chain grocery stores from stocking insect-based foods, which further hinders the progression of entomophagy in developed nations.

Commonly Eaten Insects



Insect Commodities sold in the market

Conclusion

Insects have had an undeniable influence on human society. They provide us with important ecosystem services and a variety of products as well. Insects are also widely present in aspects of human culture, such as art, literature, and television. Their influence has spread into virtually all forms of media. Insects have also acted as inspiration for science and technology through bio mimicry, and research on insects contributes to many scientific fields such as robotics and genetics. In the future, insects may become even more present in our lives as human diets shift toward insect-based protein. Entomophagy may be an important solution to global food shortages, but there are challenges entering the market when the food you're promoting is viewed negatively by much of the population. Regardless of the way arthropods are perceived, these animals will always have important impacts on many aspects of human culture.

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Atmospheric ozone – Its beneficial and harmful effects

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Introduction

Ozone, O_3, a pale blue unstable and toxic gas with a distinctively pungent smell is an allotrope of oxygen and is less stable than the diatomic allotrope O_2. It is both a natural and man-made product that occurs in Earth's upper atmosphere (the stratosphere) and lower atmosphere (troposphere). Although it resembles oxygen in many respects, it is much more reactive and an extremely powerful oxidizing agent. At standard pressure and temperature, the solubility of ozone is thirteen times that of oxygen. At sea level, the atmosphere contains about 0.05 ppm ozone (Budavari 1996). However, at sites with smog condition, its concentration may rich 0.5 ppm or higher (Francis 1997). The oxidation potential of 2.07 volts proves that it is a strong oxidizer. It is rather unstable in an aqueous solution; its half life period in water is about 20 minutes. In the air, ozone has a half life of 12 hours which explains its higher stability in the air. Compared to other gases in the atmosphere, ozone is pretty rare (0.02-0.1 ppm) (Lutgens and Turbuck 1998). According to NOAA (National Oceanic Atmospheric Administration), there are only about three molecules of ozone for about ten million molecules of air.

Ozone are of two types: i) "good" ozone and "bad" ozone. Most ozone is produced over the tropics (where levels of UV radiation are highest) but then carried away by stratospheric wind to higher latitude which extends from about 10 to 50 km above the Earth's surface and that ozone is "good" as it protects life on Earth from Sun's ultraviolet rays. The thickness of the ozone layer remains relatively constant throughout the years.The basic equations determining ozone formation (Chapman 1930) in the atmosphere are

O_2 + UV-C -----→ O + O

O + O_2 ------→ O_3

This reaction absorbs all the extra terrestrial UV – C radiation before it reaches the Earth's surface. This reaction takes place in the lower atmosphere, so ozone is produced in this region and this ozone will absorb UV –B radiation and prevent this radiation from reaching the Earth's surface.

O_3 + UV – B ------→ O_2 + O

O + O_3 ------→ O_2 + O_2

This process when combined with Chapman reaction produces the ozone cycle:

O_2 + O_2 + UV-C -----→ O + O + O_2 --→ O + O_3

O + O_3 + UV – B ---→ O + O_2 + O -→ O_2 + O_2

Ozone depletion

The thin layer of stratospheric ozone is the Earth's natural protection and is shielding our planet from biologically ultraviolet radiation (UV radiation) emitted by the Sun. Ultraviolet radiation is divided into three categories based on its wavelength: UV-A (400 – 315 nm), UV-B (315 – 280 nm) and UV-C (280 – 100 nm); UV-C is very harmful to all living things and is entirely screened out by ozone at about 35 km altitude; UV-B radiation is harmful to humans, animals and plant life and is the main cause of sunburn. The ozone layer is very effective in screening out UV-B. UV-A reaching the surface is comparatively less harmful although it may cause genetic damage.

In the stratosphere, the average amount of ozone remains fairly constant when the formation and depletion occur naturally. But the balance has gradually been disturbed in recent decades due to various anthropogenic activities releasing ozone destroying chemicals in the atmosphere such as chloro carbon compounds (CCl_4, CH_3Cl_3), chlorofluoro carbon compounds ($CFCl_3$, CF_2Cl_2) and halon compounds (CF_3Br, CF_2ClBr). When these compounds reach to stratosphere, the chlorine and bromine atoms from these chemicals are released and interact with UV-radiation in the atmosphere and the following reaction takes place resulting most of the ozone loss.

CFC + UV-radiation ----→ free chlorine atoms

Free chlorine atoms + O_3 ----→ O_2 + ClO

ClO + NO_2 ------→ $ClNO_3$ (Chlorine nitrate)

Halons having bromine act in a similar way (Rowland and Moline 1976). Therefore, ozone layer depletion is the thinning of the ozone layer present in the upper atmosphere. This happens when the chlorine and bromine atoms in the atmosphere come in contact with ozone and destroy the ozone molecules. The thinning is most pronounced over Antarctica. One chlorine atom can break apart more than 1,00,000 ozone molecule. Similarly, one bromine atom can destroy about 4,000,000 ozone molecules; it means that bromine atom is highly detrimental to the stratospheric ozone layer. Most ozone destruction in the atmosphere is believed to be anthropogenic. World Meteorological Organization (WMO 1999) estimated that only 18 per cent of the sources contributing to ozone depletion were natural and the remaining 82 per cent were industrial chemicals.

Anthropogenic	Per cent	Natural	Per cent
CFC – 12	28	CH_3Cl	15
CFC – 11	23	HCL	3
CCl_4	12		
CFC – 113	6		
HCFC – 22	3		
CH_3CCl_3	10		

Ozone depletion is a major environmental problem because it increases the amount of ultraviolet radiation that reaches the Earth's surface increasing the rate of skin cancer, eye cataracts and genetic and immune system damage and disruption of many ecosystems on lands. Rice production may be drastically reduced by the effect of UV-B radiation affecting the supply of nitrogen to ecosystem. Many species of crops like sweet corn, soybean, barley, oats, carrots, cauliflowers, tomato, peas and broccoli are highly sensitive to UV-radiation (Runeckles and Krupu 1994). Photosynthetic activity of plants is affected by UV-B radiation (Teramura and Sullivan 1994). UV-B damages vegetation and ecosystems by inhibiting the ability of plants to open the microscopic pores on their leaves to breathe. It interferes with the photosynthetic process by reducing the amount of CO_2 the plants can process and release as oxygen. It also causes visible damage to leaves reducing photosynthetic rates. UV-B radiation changes the species composition (mutation) in forest and grassland ecosystems thus affecting the biodiversity. The greater amount of UV-B radiation due to ozone depletion will have an impact on terrestrial and aquatic bio-geochemical systems altering both sources and sinks of greenhouse gases including ozone resulting complex alteration in atmospheric chemistry (Thomson and Solomon 2002). UV-B rays may lead to minimal plant growth, smaller leaf size and flowering in plants and lower quality crops for humans and declining in plant productivity would in turn affect soil erosion and the carbon cycle. Planktons and zooplanktons are greatly affected by the exposure to UV-B rays. If the plankton declines, it would likely have wide-reaching effects for all marine life in the lower food chain.

UV-B radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians and other marine animals. The most severe effects are decreased reproductive capacity and impaired larval development. Small increases in UV-B exposure could result in population reduction for small marine organisms with implications for the whole marine food chain.

Ozone depletion and climate change are linked in a number of ways but ozone depletion is not a major cause to climate change (Makenzie *et al.* 2011). Atmospheric ozone has two effects on the temperature balance

UV-B radiation has been found to cause damage to early developmental stages fish, shrimp, crab, amphibians and other marine animals. The most severe effects are decreased reproductive capacity and paired larval development. Small increases in UV-B exposurecould result in population reduction for small marine organisms with implications for the whole marine food chain.

UV-radiation causes many materials to degrade more rapidly. Synthetic polymers, natural occurring biopolymers as well as some other materials of commercial interest are rapidly affected by solar ultraviolet radiation. Wood and other naturally occurring bio-polymeric substances as well as synthetic polymers (plastic, rubber, polythene etc.), PVC sidings, window and door frames, pipes etc. degrade faster.

Ozone depletion and climate change are linked in a number of ways but ozone depletion is not a major cause of climate change (Mackenzie *et al.* 2011). Atmospheric ozone has two effects on the temperature balance of the Earth. It absorbs solar ultraviolet radiation which heats the atmosphere. It also absorbs infrared radiation emitted by the Earth's surface effectively trapping heat in the troposphere. Therefore, the climate impact of changes in ozone concentrations varies with the altitude at which these changes occur. The major losses that have been observed in the lower in the lower stratosphere due to human produced chlorine and bromine containing gases has cooling effect on the Earth's surface. On the other hand, the ozone increases that are estimated to have occurred in the troposphere because of surface pollution gases has a worming effect on the Earth's surface, thereby contributing to greenhouse effect. Therefore, ozone impact on climate consists primarily of changes in temperature. The more ozone in a given parcel of air the more heat it reyains. Ozone depletiom affects climate and climate change affects ozone. There is a strong interaction between ozone depletion and changes in climate induced by increasing greenhouse effects.

Tropospheric ozone

The troposphere is the lowest layer of the Earth's atmosphere. About 75 – 80 per cent of the mass of the atmosphere is in the troposphere and almost all weather occurs within this layer. In the stratosphere, ozone molecules play an important role – absorbing ultraviolet radiation from the sun and shielding Earth from dangerous rays. But in the troposphere near ground level, ozone molecules are both air pollutants causing health hazards of living things and green house gases trapping heat and contribute to climate change (Mickley *et al*. 2001). However, a small amount of ozone does occur naturally at ground level. Plants and soils release some. Some migrates down from the stratosphere. But neither of these sources contributes enough ozone to be considered a threat to the human health or the environment. Most of the ozone that is found near the ground comes from vehicle exhaust and emission from the factories, power plants and refineries which is dangerous.

Ground level ozone is a colourless and highly irritating gas that forms above the Earth's surface. It is called a secondary pollutant because it is produced when two primary pollutants react in sunlight and stagnant air. The two primary pollutants are nitrogen oxides (NO_x) and VOC (volatile organic carbon). It is a trace gas in the troposphere with an average concentration of 20-30 parts per billion by volume (ppbv) with close to 100 ppbv in polluted area (Warneck 1999). In the troposphere ozone concentrations are influenced by the intensity of the solar radiation, the absolute concentrations of NO_x and VOCs and the ratio of NO_x and VOCS. Ozone formation in the troposphere requires both NO_x and VOC.

NO_x + VOC + Sunlight → O_3 + other products

The global natural and anthropogenic emissions of NO_x and VOCs from different sources are:

Emission in Tg (10^{12})/year	NO_x	VOCS
Biomass burning	6	45
Lighting	5	-
Biogenic emission from land areas	15	350 (isoprene) + 480 (Terprene)

Biogenic emissions from oceans	-	27
Industrial and utility activities	22	45
Solvents	-	15
Total natural emission	21	855
Total anthropogenic emission	27	150
Total emission	48	960

Source – Slanina (2008)

In India, anthropogenic sources of NO_x and VOCs are

Sources of NO_x	Approx. %	Sources of VOCs	Approx. %
Motor vehicle	65	Industrial / commercial processes	50
Electric utilities	22	Motor vehicles	45
Industrial / commercial / residential / fuel consumption	17	Consumer solvents	5
All other sources	5		

Source : Varshney and Padhi (1998)

Many factors impact ground level ozone development including temperature, wind speed and direction, time of day and driving patterns. Due to dependence on weather condition, ozone is typically a summertime pollutant and a chief component of summertime smog.

From the above two tables, it is evident that most of NO_x and VOCs come from natural sources as well as human activities. Among human activities, NO_x comes from burning coal, gasoline and oil in motor vehicles, homes, industries and power plants. VOCs from human activities come mainly from gasoline combustion and marketing, upstream oil and gas production, residential wood combustion and from the evaporation of liquid fuels and solvents. Significant quantities of VOCs also originate from natural sources such as coniferous forests. High concentrations of ozone near ground level is harmful to people, animals, crops etc. It can irritate respiration system and throat, causing to start coughing and can aggravate asthma and chronic lung diseases.

The photochemical smog or ozone smog is mainly composed of ozone (tropospheric), peroxyacetyl nitrate (PAN) and NO_x. It may damage plant as well as animal life. Several species of plants are very susceptible to PAN in smoke. PAN damages chloroplast which results in reduction of photosynthesis efficiency and growth of plants. The smog also does severe damage to the ozone layer. It also causes extensive damage to vegetation, rubber goods and destroys most forms of synthetic materials.

According to the American Lung Association there are five groups of people who are at higher risk when they breathe ozone: 1. Children and teens, 2. Anyone 65 and older, 3. People who work outdoors, 4. People with existing lung diseases, such as asthma, and chronic obstructive disease and 5. People with cardiovascular disease.

Protection

Ozone is a molecule composed of three oxygen atoms and it is present in the gaseous form in the atmosphere specially located in and extended throughout the stratosphere acting as a shield protecting the planet from solar radiation. To protect from the impact of ozone the following measures can be taken:

1. To avoid the consumption of gases dangerous to the ozone layer. Some of the most dangerous gases are CFCs (chlorofluorocarbons), halogenated hydrocarbons, methyl bromide and nitrous oxide.
2. To minimize the use of car. The best transport is bicycle or walking
3. Not to use cleaning products that are harmful to the environment and also to human beings. These dangerous substances can be replaced by non-toxic products such as vinegar or bicarbonate
4. To buy local products
5. To maintain air conditioners as their malfunctions cause CFC to escape into the atmosphere
6. Catalytic converters on motor vehicle exhausts are a way of trying to reduce carbon monoxide and nitrogen oxide emissions

There is a direct link between increased exposure to UV-radiation and elevate risk of contracting certain types of skin cancer. Risk factors include skin type, sunburn during childhood and exposure to intense sunlight. Recent changes in life style, with more people going holiday and deliberately increasing their exposure to strong sunlight, are partly responsible for an increase in malignant skin cancer. In order to minimize the risk of contracting skin cancers, cover exposed skin with clothing or with a suitable sunscreen or sun cream, wear a hat and wear UV-certified sunglass to protect the eyes.

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Impact of solar ultraviolet radiation on our environment

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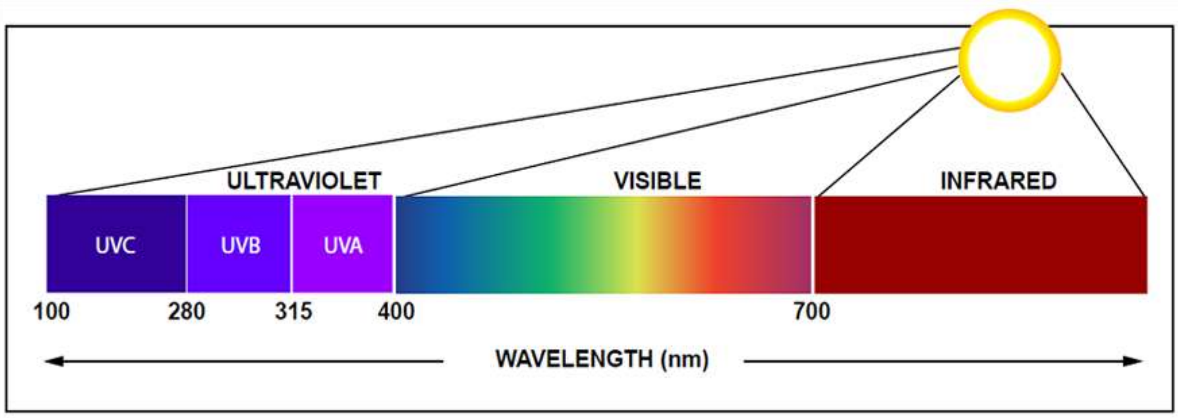
Solar ultraviolet radiation has always been part of the environment of man. UV radiation emits more photonic energy than visible light and infrared radiation, thus having a much stronger influence on materials, flora, fauna and people. Short wavelength UVB radiation has more energy per photon than longer wavelength UVA radiation and is potentially more harmful.

UVB is only a small proportion of the UV energy from the sun reaching the earth's surface, UVA is 15-20 times greater in intensity, but the amount is highly dependent upon the concentration of Ozone in the stratosphere. 'Holes in the Ozone layer', with large reductions in concentration of 25% or more, are mainly confined to the North and South Poles. However, areas of up to 10% Ozone depletion are spread more widely. A reduction in Ozone means that more UVB reaches the ground.



Ecosytems and biomes have adapted over long periods to a particular range of UV intensities and a significant change in the situation will influence their stability, geographical range, and possibly survival. Whether changes wrought by an increase in UV flux will be profound or subtle, minor or dramatic, beneficial or inconsequential, depends on many factors, most of which are poorly understood. There is, therefore, a pressing need to measure, monitor, and understand the effects of enhanced UVB irradiance on biological communities if we are to be able to predict the impacts that will occur in the next 30–40 years and to manage the consequences.

Alterations in UV irradiance can affect primary production in all ecosystems, terrestrial and aquatic, natural, managed, or exploited with a potential cascade of effects. Current understanding of these processes does not enable confident prediction of the impacts. There has been little systematic research on the impact of enhanced levels of UVB on flora and fauna. A few studies of some agricultural and commercial forest species provide limited insight into the problem, but it is difficult to extrapolate from these to predict impacts on whole ecosystems.

It is important that the effects of both chronic increases in irradiance leading to cumulative doses, and also episodic peaks or events that may coincide with critically vulnerable stages in life cycles, be evaluated. Further, the influence of ozone depletion must also be considered in conjunction with the effects of other stressors such as climate change, acidification, and the presence of toxic chemicals, making it essential that UVB impact studies be integrated with existing ecological research, monitoring, and assessment programs.

Ultraviolet radiation damages DNA, cell membranes, and organelles (e.g., chloroplasts) in plants. Plants have a capacity to repair damaged DNA, and some can protect themselves by synthesizing UV- absorbing pigments and by modifying key metabolic enzymes. Harm occurs when the radiation dose causes damage beyond a plant's capacity for repair and protection.

Crop damage is manifest as a decline in yield, reduced fertility with fall in seed and fruit production, drop in marketable quality, and ecological effects such as changes in crop-weed interactions and pasture mixtures. While the extrapolation from controlled environments to field conditions remains an issue, research is consistent in identifying that individual varieties differ in their sensitivity to UVB, as measured by changes in photosynthesis, growth, yield, and reproduction.

Impacts on forage and vegetable crops in Canada have been equivocal. Of over 100 varieties of 12 important crop species, 40% were unaffected by UVB equivalent to a 20% decrease in the ozone layer and 60% were affected in some fashion. Soybean, tomato, and canola losses may be expected, possibly totalling hundreds of millions of dollars annually. Maize does not appear to be vulnerable to anticipated increases in UV. UVB may accelerate the rate of decomposition of straw and chaff, with potentially beneficial effects in arid environments and under minimum-till conditions.

Although forests are of major economic, social, and natural importance, little is known about their susceptibility to enhanced UVB radiation. Trees are long-lived and will be exposed to increased UVB over decades. Short-term effects have been reported, and there is some indication of cumulative, chronic impacts. Multi-year experiments with long-lived species are desirable. The impacts of UV radiation appear to be less serious on species native to high elevations, which tend to be adapted to greater irradiance.

Impacts of enhanced UV radiation should be considered in conjunction with the effects of other stressors such as climate change and acidification. Studies of the interactive effects of UVB and CO2 enrichment on the growth and physiology of conifer seedlings suggest that future conifer seedling growth and competitive ability will be altered by the changing environment.

A field study on UVB effects on trees in North America attributed sun-scalding of white pine foliage in Ohio and Ontario to elevated ambient UVB levels. Recent research has also shown that epicuticular wax chemical composition in certain conifer species is affected by UVB exposure in a manner that inhibits photosynthesis.

The 50-year window of significant ozone depletion has sufficient potential to affect North America forest productivity on a large scale, with far-reaching consequences that are not yet apparent.

Shallow freshwater ecosystems are particularly vulnerable to enhanced levels of UV radiation, showing changes in primary productivity, nutrient cycling, community structure, and modification to the transport and speciation of toxic chemicals in the food-chain. UV penetration of surface waters is attenuated by the presence of dissolved organic carbon (DOC), and changes in DOC levels have a greater effect on the vulnerability of freshwaters to UV than changes in stratospheric ozone. In boreal lakes, where global warming and lake acidification have caused a sharp decline in DOC, UVB penetration into the water column has increased between 22% and 60%.

Even at current ambient levels, UVB inhibits some species of zooplankton from frequenting their preferred position in the water column. Under experimental conditions, enhanced levels of UV radiation depressed algal production but affected the zooplankton that fed on the algae to a proportionately greater extent. As a result, the accumulated algal biomass increased, even though primary production was reduced. Because a key link in the food chain had been weakened, less production was transferred to higher trophic levels. The implications for aquatic ecosystems are disturbing.

Concern has been expressed over synergisms between UVB, climate change, Lake Acidification, fungal infections, and toxic chemicals that could affect amphibia. However, Ontario amphibians do not seem to have been affected by current levels of radiation, despite the apparent vulnerability of eggs and larvae.

Direct impacts of UVB on microbial processes and higher trophic levels have been demonstrated, but the cumulative effects of ozone depletion on marine ecosystems are, as yet, unpredictable. Potential responses include changes in species composition, shifts in food webs (with collateral impacts on fisheries), and possibly climatic changes.

Increases in UVB alter the growth, survival, and biogeochemical activities of many microbes, plants, and animals in the sea. Damage to DNA directly influences survival, but UVB also affects spatial orientation (and hence vertical migration) of phytoplankton, nitrogen metabolism, photosynthesis, larval mortality, and processes ranging from viral infection to hatching success in fish eggs.

The sensitivity of physiological processes to solar UVB requires a biological weighting function (BWF, also called an action spectrum) to quantify the effective irradiance. BWFs need to be determined for a greater number of biological functions and estimates need to be made of the range in variation of BWFs for each process, as these appear to be highly variable between species.

Biological effects of UVB have been detected tens of metres into the water column, most notably the inhibition of short-term photosynthesis in Antarctic phytoplankton. Quantitative estimates of the inhibition of photosynthesis by UV radiation are converging as research continues. Some toxic dinoflagellates show UV photo-protective mechanisms that might give them a competitive edge, perhaps leading to a greater dominance of toxic or nuisance algae. Increases in UVB may favour species of phytoplankton that produce dimethyl sulphide (DMS), a gas involved in cloud formation, and thus contribute to climate change.

Interpretations of UV effects in oceans require recognition of the fundamental differences that exist between the Antarctic and waters of the northern hemisphere, including the Arctic. Consequently, basic research on marine ecosystems is essential. UV radiation causes significant and deleterious changes to many materials used in outdoor applications. Any increase in UV flux to the earth's surface will degrade infrastructure more quickly and so generate significant costs for repair and replacement.

Canadian research has addressed the effects of UV on polymers, wood and paper, building materials, paints and coatings, and textiles and clothing, although the main thrust has been on the evaluation of radiation resistance of materials used in outer space and of clothing materials. UV-B radiation damages synthetic polymers and other materials, but the mechanisms are not well understood at the molecular level and the combined impacts of both short and long wavelength radiation, and other environmental variables, adds further complexity to the issue.

Bleached pulp and paper products made by inexpensive processes are discoloured by UV radiation. Canadian researchers have made significant advances in understanding how this occurs. The ability to reduce discolouration could greatly expand the market for this class of paper. Non-plastic building materials such as roofing membranes and outdoor sealants are currently being studied with respect to their resistance to UV but not specifically in the context of enhanced, ozone-related irradiance.

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Occurrence of larval parasitoid, *Apanteles expulsus* in teak leaf skeletonizer, *Eutectona machaeralis*

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Abstract

The present article deals with *Apanteles expulsus* Turner (Hymenoptera : Braconidae) emerged from laboratory reared larvae of leaf skeletonizer, *Eutectona machaeralis* (Walker) (Lepidoptera : Pyralidae) collected from teak (*Tectona grandis* L.f.) forests of Madhya Pradesh and Odisha. The diagnostic features and cocoon characters are mentioned.

Key words: *Apanteles expulsus*, larval parasitoid, teak leaf skeletonizer, *Eutectona machaeralis*.

Introduction

A checklist of world species of Microgastrinae parasitoid wasps (Hymenoptera : Braconidae) reveals a total of 81 genera including *Apanteles* and 2,999 extant species are recognized as valid, including 36 nominal species that are currently considered as *species inquirendae* (Fernandez-Triana et al., 2020). *Apanteles* is a very large genus of braconid wasps, containing more than 600 described species found worldwide (https://en.wikipedia.org/wiki/Apanteles).

The parasitic wasps, *Apanteles* species are important larval parasitoids of several lepidopterous pests of agricultural crops, commercial cash crops and forest tree species. Adult wasps are free-living and females insert their eggs beneath the skin of the host larvae, where eggs hatch and their young ones feed. Finally, mature larvae leave the hosts and spin cocoons before larval-pupal transformation. After pupal-adult transformation wasps emerge from the cocoons. *Apanteles* Foerster belongs to the order Hymenoptera, family Braconidae and sub-family Microgastrinae. It is the most conspicuous single group of endo-parasitoids of Lepidoptera in the world, both in terms of species richness and economic importance. In India, considerable work has been carried out on identification of *Apanteles* species only (Wilkinson, 1928a, b). Several *Apanteles* species have been recovered from a large number of native Lepidoptera and are potential biocontrol agents to check the population of important insect pests (Chatterjee and Misra, 1974).

Beeson (1941) recorded 25 species of *Apanteles* from India as parasitising various insect pests. *A. puera* and *A. malevolus* on *H. puera* and *A. machaeralis* (Fig. 2) and *A. ruidus* on *Eutectona machaeralis* have been recorded from teak forests (Beeson, 1941). Chatterjee and Misra (1974) enlisted 49 species of *Apanteles* from India, out of which four species of *Apanteles*, viz. *A. malevolus* and *A. puera* are reported to parasitise the larvae of *H. puera*, and *A. machaeralis* and *A. ruidus* parasitise the larvae of *E.*

machaeralis. Till date 85 species of *Apanteles* infesting various insect pests have been recorded from India. Nair et al. (1995) have recorded *A. hyblaeae*, *A. machaeralis*, *A. malevolus* and *A. puera*, as parasitoids of teak defoliator *H. puera*. Roychoudhury (2010, 2016) has recorded that *A. machaeralis* is a major larval-pupal parasitoid of *E. machaeralis* in teak forests of Madhya Pradesh. Roychoudhury (2013) has also recorded 30 species of *Apanteles* on major defoliators of teak and nine species on major defoliators of sal in Odisha (Roychoudhury et al., 2020). Recently, Roychoudhury et al. (2022) have published detailed biology of *A. machaeralis* on *E. machaeralis*. The present article deals with *Apanteles expulsus* Turner (Hymenoptera : Braconidae) emerged from laboratory reared larvae of leaf skeletonizer, *Eutectona machaeralis* (Walker) (Lepidoptera : Pyralidae) collected from teak (*Tectona grandis* L.f.) forests of Madhya Pradesh and Odisha. The diagnostic features and cocoon characters are mentioned.

***Apanteles expulsus* Turner**

Apanteles expulsus Turner, 1918: 346

(Fig. 1)

Diagnostic characters

Fore-wings with first abscissa of radial just longer than recurrent and just shorter than the breadth of stigma, longer than transverse cubital, first abscissa of radial and transverse cubital evenly rounded, apical portion of first abscissa of the cubital is shorter than transverse cubital, just longer than the pigmented portion of the second abscissa of cubital, the latter is longer than half length of transverse cubital and longer than the upper portion of basal vein, pterostigma is shorter than metacarp. In hind legs, longer tibial spur just less than half while shorter spur is one-third the length of basal joint of hind tarsus. Ovipositor sheaths are just shorter than basal joint of hind tarsus. Larvae spin white cocoons in clusters under the crescent web of the host caterpillar (Fig. 2).

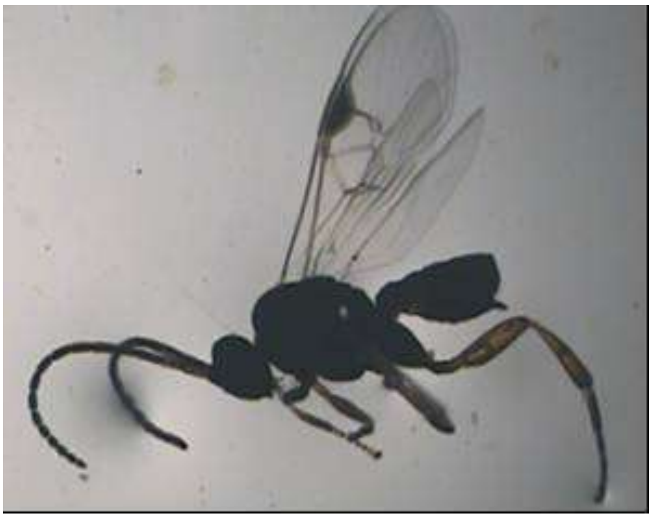

Fig.1. Adult wasp of *Apanteles expulsus*

Fig.2. Cocoons of *Apanteles expulsus*

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