



Biodiversity Conservation, Environment and Sustainability:



LIANAS

2025-26



“To plant a garden is to believe in tomorrow”

DEPARTMENT OF BOTANY
DAULAT RAM COLLEGE
UNIVERSITY OF DELHI

EDITOR
DR. ASMITA GUPTA

महाविद्यालय प्रार्थना

संगच्छध्वं संवदध्वं
सं वो मनांसि जानताम्
देवा भागं यथा पूर्वं
सज्जनाना उपासते ॥

समानो मन्त्रः समितिः समानी
समानं मनः सह चित्तमेषाम्
समानं मन्त्रमभिमन्त्रये वः
समानेन वो हविषा जुहोमि ॥

समानी व आकूतिः
समाना हृदयानि वः ।
समानमस्तु वो मनो यथा
वः सुसहासति ॥ (ऋग्वेदः)



(एक पद गति, एक वाणी चित्त मन सब एक हो
संकल्प अविरधी, सदा परहित लक्ष्य हो जन का, रहें सुख से सभी)

अस्तो मा सद गमय
तमसो मा ज्योतिर्गमय
मृत्योर्मा अमृतं गमय (बृहदारण्यकोपनिषद्)

(हों अग्रसर सत् पर असत् से, ज्योति में तम से प्रभो
मर्त्यत्व से अमरत्व की ही ओर ले चलिये प्रभो)



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LIANAS 2025-26

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PREFACE

Welcome to the latest edition of Lianas, the annual botanical compendium of the Department of Botany at Daulat Ram College. This publication remains a cornerstone of our department's academic journey, providing a prestigious platform for young, enthusiastic minds to showcase their skills, express their creative vision, and explore the vast complexities of the botanical world.

This edition features a carefully curated collection that bridges science and art. Through a collaborative effort between our dedicated faculty and students, we have assembled a diverse range of scientific reviews, environmental essays, and original creative works. From striking photography and paintings to rigorous research, Lianas offers a unique view into the fascinating life of plants and their ecological importance.

For our students, Lianas is more than a publication. It is a professional milestone. It provides an invaluable opportunity for budding botanists to refine their research voices, publish their articles, and share their knowledge with a global audience. Each contribution reflects the passion and diligence that define our academic community.

Our mission is to raise awareness about nature and emphasise the importance of preserving our planet. In an era of rapid environmental change, we aim to promote a culture of biodiversity conservation and sustainability and encourage our readers to marvel at the intricate wonders of the natural world.

DR. MEENAM BHATIA

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FROM THE PRINCIPAL'S DESK

I extend my heartfelt congratulations to the Convenors of Vasundhara, the Botanical Association, and the Department of Botany for the successful compilation of botanical facts and events presented in Lianas. It gives me immense pleasure to acknowledge the release of Lianas 2025-2026, centred on the theme "Biodiversity Conservation, Environment and Sustainability."



PROF. SAVITA ROY

This publication reflects the dedication, creativity, and collaborative efforts of our students and teachers, who have worked tirelessly to showcase their knowledge and passion for Botany. Lianas continues to serve as a vibrant platform for students to express their ideas, research perspectives, and artistic talents, while fostering scientific curiosity and environmental awareness among readers.

I hope that Lianas will continue to inspire young minds to explore the fascinating world of plants and understand their ecological significance. May this publication encourage readers to embark on a journey of discovery and develop a deeper appreciation for nature through the insights of our budding botanists.

FROM TIC'S DESK



DR. MEENAM BHATIA

It is my distinct privilege to present this edition of "Lianas". We present this magazine on the 2026 theme, "Biodiversity Conservation, Climate Change, and Sustainability". As we navigate the complex ecological realities of 2026, the disciplines of botany and ecology have shifted from the periphery of scientific observation to the epicentre of global discourse. This publication serves as a critical pedagogical platform, enabling our student community-and specifically our fourth-year students, who stand at the culmination of their undergraduate tenure-to articulate their research findings, theoretical inquiries, and scientific narratives. It is an arena where the theoretical knowledge acquired in the classroom meets the empirical discipline of field research, allowing our scholars to contribute substantive insights to the broader botanical community while refining their professional scientific writing skills and critical thinking.

Our editorial focus is structured around the conviction that scientific advancement must be inextricably coupled with environmental responsibility. We prioritise the study of phylogenetic diversity as a fundamental metric of ecosystem integrity, recognising that the preservation of endemic species is critical safeguard against the systemic erosion of biological resilience. Furthermore, as anthropogenic factors continue to alter terrestrial biomes, our research examines the adaptive responses of flora, analysing the botanical capacity for carbon sequestration, reducing carbon footprint and climate mitigation within the broader framework of atmospheric stability.

Simultaneously, this issue underscores the paradigm shift from extractive resource utilisation to regenerative systems, seeking to establish a viable development trajectory that honours planetary boundaries. The rigour of our scientific endeavour is defined by its application.

This volume is a testament to the intellectual discipline of our students and the guiding mentorship of our faculty, balancing data-driven analysis with the visionary scope necessary to confront the environmental challenges of our epoch. I encourage our readers to engage with these pages not merely as observers but as active participants in the discourse of ecological preservation. It is through such informed inquiry and shared commitment that we may hope to secure the stability of the biosphere for future generations.

FROM EDITOR'S DESK

Lianas, the annual publication of Vasundhara, the Botanical Association of Daulat Ram College, University of Delhi, is a compilation of scientific articles and association activities contributed by students and faculty of the Botany Department of the college.



DR. ASMITA GUPTA

It provides an opportunity for the inquisitive and creative minds to showcase their intellectual and creative skills and explore the world of botanical wonders through words and art. This year, Lianas 2025-2026 with the theme of Biodiversity Conservation, Environment and Sustainability has been released with the International Standard Book Number, ISBN on the college annual day, 11th March 2026.

Lianas 2025-2026 offers an insight in the field of biodiversity, environment, sustainability and conservation through scientific articles, prose, paintings, photography and annual events of the Botanical Association, underscoring the department's dedicated efforts and contributions in the field. This year's publication also includes research articles and scientific reviews contributed by B.Sc. (Hons.) Botany 4th year Dissertation students related to their ongoing research work in the area. I hope that Lianas 2025-2026 engages the readers well and the objective of the publication to spread knowledge and awareness about biodiversity, its importance and conservation efforts, environment and sustainability is successfully met.

SCIENTIFIC/ RESEARCH ARTICLES



A REVIEW OF CANTEEN WASTEWATER CONTAMINANTS AND BACTERIAL TREATMENT

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INTRODUCTION

Canteen wastewater is the liquid waste generated from the kitchens of canteens, cafeterias, messes, and other food establishments where food and drinks are prepared on a large scale and served to the customers. Water is used for cooking, cleaning fruits, vegetables and other food items, washing dishes, mopping the floors among other activities, and the used water gets discharged into the drains. Due to changes in lifestyle, people prefer to eat outside or buy food rather than cooking at home. There has been a rapid growth in eateries, and it is expected to intensify in the coming decades. Although the volume of wastewater generated from canteens is lower than that of domestic sewage or industrial wastewater, it can no longer be ignored.

Sources of canteen wastewater:

- Food waste- vegetable peels, leftover food, water used for rinsing or boiling, other food remnants, animal or vegetable fats and oils.
- Cleaning agents- Detergents, surfactants (Goel & Kaur, 2012).

COMPOSITION OF CANTEEN WASTEWATER:

- High concentration of organic and solid matter (Paramitha et al., 2021).
- Rich in Fats, Oils and Greases (FOG) (Laohatrakul, 2018).
- Very high Biological Oxygen Demand(BOD) and Chemical Oxygen Demand (COD) (Mohamed et al., 2015; Ying et al., 2011).
- Alkaline pH (Yin et al., 2022).
- High Nitrogen and phosphate content due to degradation of food matter.
- Elevated Total Dissolved Solids (TDS) and Suspended Solids (SS).
- Presence of heavy metals like Iron and Zinc (Chen et al., 2000).
- The warm nutrient rich environment supports millions of microbial communities.

UNIQUE FEATURES OF CANTEEN WASTEWATER:

- Very high amounts of biodegradable organic load, far exceeding that of domestic sewage (Paramitha et al., 2021),making it very suitable for bacterial treatment.
- Highly variable due to the frequent changes in the menu, with different types of food prepared at different times of the day and week (Dada et al., 2019).
- Very high amounts of fats, oils and grease compared to most municipal sewage (Gurd et al., 2019).
- FOG clogs the pipes and interferes with conventional wastewater treatment plants (Sam, 2025).
- It is both a resource and a threat to the environment. It contains nutrients that can promote growth in plants. It can be used for irrigation after sufficient treatment, but the nutrients percolate into the soil and contaminate the groundwater (Mahmood and Maqbool, 2006).

IMPACT ON THE ENVIRONMENT:

- Eutrophication/algal bloom: If such untreated water, which has very high levels of N and P, is directly released into natural water bodies, causes unrestrained growth of algae. The algae form a mat-like structure on the surface of water, blocking sunlight from penetrating within the water. Once the algae start to die, the BOD of the water becomes very high. The microbes start degrading the dead matter and consuming excess amounts of oxygen in the process. This causes depletion of oxygen content within the water, harming aquatic plants and animals.
- Oils and greases present in the wastewater clog the underground pipes and corrode them. It must be removed before the water is sent for further biological treatment because oils and grease inhibit microbial activity (Cudjoe et al., 2024).

DIFFERENT WAYS TO TREAT CANTEEN WASTEWATER:

- Bacterial treatment
- Sequencing Batch reactors (SBRs) and Membrane Bioreactors (MBRs) (Ashokan & Madhu, 2018)
- Phytoremediation (Rodge et al., 2023)
- Electrocoagulation (Vinod et al., 2022)
- Anaerobic Digestion (Sharma & Ethiraj, 2024)

BACTERIAL TREATMENT OF CANTEEN WASTEWATER:

Bacteria treat canteen wastewater by breaking down the organic matter, in the presence of oxygen, into carbon dioxide, water and bacterial cells (Carneiro et al., 2022; Mathew et al., 2022; Sotirou et al., 2024) significantly reducing the Biological Oxygen Demand(BOD) and Chemical Oxygen Demand (COD) of the wastewater.

TREATMENT PROCESSES :

Activated Sludge System with bioballs:

- Bacteria grow floating in water (suspended growth)
- Bacteria stick to bioballs (attached growth)

Within a span of 48 hours, a 93% decline in BOD and COD was observed followed by a decline of 92% in dissolved solids and ions (Paramitha et al., 2021). Using bioballs have proved to give better results than using the sludge alone.

Aerobic Granular Sludge System:

It is a novel technology in which microbes form a cluster and concentrate into compact ball like structures, with the help of Extracellular Polymeric substances, called granules. There is a gradual gradation based on the availability or lack of oxygen. The microbial colonies on the surface and just underneath the surface are exposed to oxygen and perform aerobic degradation, while the ones in the deepest layer perform anaerobic degradation. It allows simultaneous removal of organic matter, nitrogen, phosphorus, and pharmaceutical pollutants. (Rosa-Masegosa et al., 2024)

ALGAL- BACTERIAL HYBRID SYSTEM :

Microalgae are single-celled chloroplast containing microorganisms that can perform photosynthesis. Algae and bacteria form a symbiotic relationship, where algae releases oxygen by photosynthesis. Aerobic bacteria uses this oxygen to breakdown organic matter and produce carbon dioxide (CO₂), which is then consumed by the microalgae. The high Nitrogen and phosphate in the wastewater are directly utilised by the algae for its growth. It also removes heavy metals by adsorption. The algal biomass generated can be used as a biofertilizer. It is an eco-friendly and sustainable treatment method.

KEY BACTERIAL STRAINS USED:

Bacterial Strain	Function	References
<i>Pseudomonas aeruginosa</i> and <i>Pseudomonas citronellolis</i>	FOG breakdown into simpler components	(Wong et al., 2025)
<i>Bacillus subtilis</i> , <i>Bacillus cereus</i> and <i>Bacillus velezensis</i>	Starch, protein, FOG degradation	(Fontalvo et al., 2022; Wong et al., 2025)
<i>Nitrosomonas</i> sp., <i>Nitrobacter</i> sp., <i>Nitrospira</i> sp	Nitrification	(Cydzik-Kwiatkowska & Zielińska, 2016; Osunmakinde et al., 2019)
<i>Thauera</i> spp., <i>Zavarzinia</i> sp	Denitrification	(Tyagi et al., 2024)
<i>Stenotrophomonas acidaminiphila</i>	Oil degradation	(Yin et al., 2024)
<i>Enterobacter cloacae</i>	Breakdown of organic matter	(Paulson et al., 2024)
<i>Gordonia</i> spp.	Breakdown of FOG, cellulose and other macromolecules	(Gu et al., 2024)
<i>Acinetobacter venetianus</i>	Hydrocarbon break down	(Osunmakinde et al., 2019)

Conclusion:

There are a number of ways to treat canteen wastewater, bacterial treatment being one of the most efficient, economical and environmentally friendly methods. It uses microorganisms to clean the water by reducing the organic content, fats, oils and greases and other pollutants, making it suitable for safe discharge

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AN INTRODUCTION TO *WITHANIA SOMNIFERA*: A PROMINENT HERB IN TRADITIONAL MEDICINE

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INTRODUCTION

Withania somnifera (Linn) Dunal is known as Ashwagandha belongs to the family Solanaceae (nightshade). In English it is commonly known as Winter cherry because of the restorative property of roots (Teipathi et al 1996; Anadallu & Radhika 2000, Winter 2006). It is a perennial evergreen shrub where it survives and regenerates years after year (Datta et al 2010). In the Indian Ayurvedic medicinal system Ashwagandha is known as an important medicinal herb due to the presence of various alkaloids such as Withanolide (Withaferin A). They possess anticancerous, antibacterial, antifungal properties and are best known for adoptogenic plants that help in the reduction of anxiety and boost the immune system. Ashwagandha is generally utilized for curing several diseases which have direct involvement with nerves (Thakur et al 2021).

Vernacular names of Ashwagandha:

Languages	Vernacular name
Hindi	Asgandh, Punir
English	Indian ginseng , Winter cherry
Sanskrit	Ashvagandha, Gandhapatri
Urdu	Asganda nagori, Asgand

Tamil	Asubam, Amukkira
Odiya	Asugandha
Telugu	Penneru, Asvagandhi, Dommadolu
Marathi	Tilli, Askandha
Gujarati	Asana, Asoda, Asan
Malayalam	Pevetti
Persian	Asgand Nagaori
Danish	Withania
Swedish	Indisk gingeng
Bengali	Ashvaganda

GEOGRAPHICAL DISTRIBUTION AND HABITAT

W. somnifera, commonly known as Indian ginseng, Ashwagandha, or winter cherry is indigenous to the Indian subcontinent, the parts of North Africa and the Middle East and Southern Europe. It is widely distributed to drier parts and sub-tropical regions of India. Uttar Pradesh, Gujarat, Bombay, Punjab, Rajasthan, Madhya Pradesh, Maharashtra are the major Ashwagandha producing states in India. Madhya Pradesh is the largest cultivation area with high production of Ashwagandha farming; more than 5,000 hectares are under cultivation, making it a higher producer of Ashwagandha (Govindaraju et al 2003). It is also widely distributed in other countries like Afghanistan, Pakistan, Egypt, Canary Island, South Africa, Morocco, Jordan (Thakur et al 2021).

HABITAT

W. somnifera is an evergreen herbaceous plant, widely grown in dry, semi-arid, and subtropical regions in India also cultivated in different parts in India as a medicinal plant (Gaurav et al., 2015). The best growth observed in the areas where the yearly rainfall lies between 500-700 mm and the condition of the soil is sandy- loam and red-light area ideal for the optimal growth. It can tolerate soil pH from acidic to alkaline.

MORPHOLOGY OF WITHANIA SOMNIFERA

W. somnifera is a small perennial shrub, which belongs to the family Solanaceae (nightshade). Its height reaches about 2 feet (Thakur et al., 2021). The stem of Ashwagandha is upright and dark brown in colour. The branches are completely covered with silvery branched hairs. Leaves are alternatively arranged and opposite on flowering shoots, and absent on the lower portion of the stem (Gaurav et al., 2015). The leaves possess a slightly wavy margin with reticulate venation, and possess a very strong smell like green tomatoes (Mirjalili et al 2009). Flowers are hermaphrodite or monoecious, small with greenish- yellow in colour, the numerous seed inside the fruits with discoid, yellow colour, the corolla have 5 petals, with yellow to green in colour. The fruit of Ashwagandha is red to orange in colour when it is ripped. The fruit is hairless round berry, and completes its life cycle around 150 - 200 days from germination to the production of seed(Gaurav et al.,2014).

Phytochemical studies of Ashwagandha (*Withania somnifera*)

Ashwagandha show presence of various phytochemicals present in root, stem, leaf and fruit (Mir- jalili et al. 2009). These phytochemicals compounds vary from part to part of the plant. They have different biochemically active components like cysteine, somniferinine, steroidal lactone, phenols, tannine, anaferine, flavonoids, withanine, chlorobenzene acid, (Naz and Choudhary 2003; Saleem et al. 2020). The whole plant of *Withania somnifera* extract have abundant number of phytochemicals, with more than 138 withanolide, 13 alkaloids and different sitoindosides were separated from the roots, upper portion and fruits of *W. somnifera* (Thakur et al.,2021). Withanolides is a group of steroidal lactones present widely in roots and leaves, it contains different constituents including, tropine, glycosides, free amino acids, anahygrine, anaferine, cuesohygrine. The condensed tannins present in the stem(Umadevi et al.,2012).

WITHANIA SOMNIFERA AS MEDICINAL PLANT

In Ayurveda Ashwagandha is considered to be one of the very important herbs and used by native people since ancient times. Due to its vast medicinal properties, it is also known as the “King of herbs”.

Table 1. Different parts of Ashwagandha and its medicinal uses

Plant parts	Functions	References
Roots	It is used in the treatment of nervous disorders, rheumatic pain and to remove the undigested waste from the body	Shifali Thakur et al., (2021) Gaurav et al., (2023)
Dried roots	It cure the cough, hiccup, cold, female disorders, sexual disorders	Gaurav et al., (2023) Singh et al., (2010)
Bark decoction	Used for the asthma patient and bed sores	Gaurav et al., (2023) Umadevi et al., (2012)
Leaves	It is used in the treatment of eye infections, reduces the ear discharge problems, and the paste of leaves used as a sunscreen, and treatments of several skin problems. Kidney related disease	Gaurav et al., (2023) Umadevi et al., (2012) Duke et al., (1985).

Seeds	Used to treat chest diseases	Gaurav et al., (2023)
Berries	In the blood purification, and treats liver diseases	Gaurav et al.,(2023) Thakur et al., (2021)
Twigs	The main function of twigs is to clean teeth	Gaurav et al., (2023)

THE PHARMACOLOGICAL ACTIVITIES OF ASHWAGANDHA

Anti- stress activity: Ashwagandha is a beneficial herb used for elimination of stress in both animal and human beings. Its effect was demonstrated in rats using a swimming cold water stress test. Ashwagandha blocks the stress pathway in rat by regulating the signals in the nervous system. Ashwagandha is also known to help in the management of stress by reducing cortisol levels and removing symptoms of anxiety. It also helps in the body improvement by acting against fatigue (Jana and Charan,2018)

Immune system support: Withanolides is a bioactive compound present in Ashwagandha plant that boosts immune response, providing anti-inflammatory, and antifungal-microbial benefits(Umadevi et al.2012).

Diabetes: Ashwagandha helps to reduce high blood sugar and enhance insulin sensitivity (Umadevi et al.,2012)..

Enhance Energy level: Research indicates that Ashwagandha provides necessary energy to the body and helps in long term workouts(Umadevi et al., 2012).

Anti-Cancer activity: Ashwagandha inhibits the growth of breast, lung cancer cells. It is reported that human cells show reduction in the growth of the tumor cell without damaging the normal cells (Umadevi et al.,2012).

Side effects of Ashwagandha: If it is consumed in large amounts causes abortions in the female. So it is advised to the pregnant women to steer clear of this plant, and the large doses lead to nausea, gastrointestinal discomfort, diarrhea (Umadevi et al., 2012)

W. somnifera is an important medicinal plant widely used throughout the world, due to its medicinal properties, it is used for the treatments of different diseases.

Ashwagandha is used for the suppression of tumor cells without damaging the normal cells. It shows the anti-aging effects through improving hemoglobin and enhancing red blood cell number, and improving hair melanin by the reduction of serum cholesterol. Ashwagandha shows positive effects in weight loss by reducing cortisol levels in the body. It reduces stress, anxiety, calms the nervous system and enhances memory by the lowering of cortisol levels, it is a neurotonic.



Fig A: Plant of *W. somnifera*.



Fig B: Chyme inflorescence, yellowish-white flower

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SEEDS: DORMANCY AND GROWTH

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Seeds are the starting point of the plant's life and it plays a crucial role in the survival of plant species. Seeds act as carriers of genetic material from one generation to another. In agriculture seeds are the basic inputs for the crop and their quality directly influences plant growth, yield and basic uniformity in the field. Seed germination is the process in which mature seeds Resume growth and becomes a seedling . In natural ecosystems ,seeds support biodiversity and helps in maintaining the plant populations and by doing this they contribute ecological balance.

Seeds have natural mechanism that allows them to delay sprouting in unfavorable conditions which is known as Dormancy. It may be beneficial when it act as for young seedlings from a harsh environmental conditions such as extreme temperature , Dry soil, or limited nutrients. Seed dormancy May arise due to several internal and external factors. It is broadly classified into physical ,Physiological ,Morphological and combinational dormancy .

Some seeds like *Ricinus communis* (castor), which is an important oilseed plant that belongs to the family Euphorbiaceae. It is Widely cultivated in tropical and subtropical regions due to its adaptability and high economic value. Castor plant exhibits erect growth and large palmate leaves with long petioles and have a well developed taproot system. They are oval and smooth in appearance and contain large Endosperm which is rich in castor oil .

Castor seeds are generally considered non dormant seeds but physiological stress can induce delayed germination responses. Some studies reveal that seed harvested at improper maturity stages or Store under unsuitable condition can show reduced germination.

Some seeds show Strong dormancy to adapt harsh environmental conditions they have hard seed coat which protect seed from mechanical damage and premature germination. Seed like *Acacia nilotica* (babul) Which is a member of the family Fabaceae, It is a multi-purpose woody tree species that is commonly found In arid and semi arid region. It has strong taproot system ,thorny branches, bipinnate leaves And spherical in fluorescence. Babul Seeds are small ,hard and possess a thick seed coat which induces physical dormancy.

That physical dormancy in *Acacia* seeds is caused by they are impermeable seed coat which prevents water absorption and therefore there is a delay in germination.

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EXPLORING THE POTENTIAL OF BACTERIA IN TREATING LABORATORY WASTEWATER: A BRIEF REVIEW

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ABSTRACT

Laboratory wastewater is produced from various sources like academic institutions, diagnostic labs, research facilities, and medical establishments. It contains various chemicals and biological pollutants. If laboratory wastewater is discharged into the environment without any treatment it can cause threats to both human and environment health. Conventional methods tend to be expensive, require more energy and are not eco-friendly. In recent years, wastewater treatment using bacteria has become a promising, eco-friendly and cost-effective method. This article examines the potential of bacteria in treating laboratory wastewater.

INTRODUCTION

Laboratory wastewater refers to the water containing pollutants like acids, bases, chemicals, microorganisms, organic solvents and disinfectants (Rana et al., 2017). It may have harmful substances like heavy metals e.g., mercury and chromium. All these pollutants affect human lives and environmental health (Novita et al., 2022). In academic laboratories, various dyes are also present in significant quantities, such as safranin, crystal violet, methyl orange and coomassie blue (Rai et al., 2025).

LABORATORY WASTEWATER CHARACTERISTICS

Characteristics which are usually studied for wastewater are Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, Total Dissolved Solids (TDS), Temperature, Presence of heavy metal, Phosphorous and Nitrogen content (Kumar, 2022).

LABORATORY WASTEWATER TREATMENT

Laboratory wastewater can be treated by physical and chemical methods like filtration, sedimentation, floatation, chlorination, and ozonation. However, these treatments use chemicals which generate secondary pollutants. Additionally, this type of treatment might not yield positive results and could be regarded as an expensive treatment method (de Souza et al., 2022).

LABORATORY WASTEWATER TREATMENT USING BACTERIA (BIOLOGICAL METHOD)

The biological approach employs microbial organisms like bacteria. Bacteria utilize contaminants as a source of energy, breaking them down into non-toxic or less harmful substances. The biological method is cost-effective and environmentally friendly (Mahajan and Prakash, 2024). This process also produces minimal sludge (Gupta et al., 2015)

BIOREMEDIATION

Bioremediation is generally classified into two categories: in-situ, which involves treating wastewater at its original location, and ex-situ, which involves treating wastewater at a different site away from the production area (Nyika et al., 2022). Bioremediators are the microorganisms that carry out the bioremediation process (Samer, 2015). This treatment does not rely on chemical agents. Aerobic and anaerobic microorganisms are utilized to address pollutants, which also reduces the biochemical oxygen demand (Hussain et al., 2021).

Bacteria are the main organisms utilized in the bioremediation of wastewater. They decompose contaminants through processes that require oxygen, processes that do not require oxygen, and metabolic processes that can function in both conditions. For instance, aerobic bacteria include *Pseudomonas*, while anaerobic bacteria consist of types like *Methanobacterium*. These microorganisms break down organic matter into methane, carbon dioxide, and stabilized sludge (Mishra et al., 2025)

Advantages of using bacteria



Figure 1: Advantages of using bacteria for laboratory wastewater treatment.

The use of microbial remediation like bacteria is particularly beneficial because microorganisms are found everywhere, readily accessible, and capable of consuming a wide range of pollutants. They reduce the toxicity of contaminants (Lakhani et al., 2022).

Bacteria break down the contaminants found in wastewater into harmless substances. Different enzymes employed by bacteria to degrade pollutants include hydrolases, lyases, transferases, ligases, isomerases, and oxidoreductases. (Aragaw, 2021)

Table 1: Bacteria used in biodegradation of wastewater:

Serial No.	Contaminants	Bacteria used in biodegradation	References
1	Antibiotics	<i>Bacillus subtilis</i>	Vijayaraghavan et al. (2021)
2	Color and other polluting parameters.	<i>Alcaligenes aquatilis</i> , <i>Priestia aryabhatai</i> , <i>Citrobacter werkmanii</i> and <i>Shewanella chilikensis</i>	Dhameliya et al. (2024)
3	Chromium and Lead	<i>Cyanobacteria</i>	de Souza et al. (2022)
4	Synthetic dyes: congo red, malachite green, methyl red and methylene blue,	<i>Bacillus altitudinis</i> , <i>Citrobacter freundii</i> and <i>Bacillus subtilis</i>	Kushvaha et al. (2019)
5	Heavy metals	<i>Pseudomonas aeruginosa</i>	Al-Ansari et al. (2021)
6	Methyl Orange Dye	<i>Bacillus stratosphericus</i> SCA1007	Moyo et al. (2022)
7	dyes and heavy metals	<i>Enterobacter sp</i> , <i>Klebsiella pneumoniae</i> , <i>Acinetobacter calcoaceticus</i> .	Rathour et al. (2024)

LIMITATIONS AND CHALLENGES

Laboratory Wastewater treatment using bacteria can face some limitations and challenges, which include significant capital expenses, inconsistent performance, scalability of reactors, safety issues as well as regulatory and societal obstacles. The bioprocess efficiency is linked with characteristics and sensitivity of the biocatalysts, composition of the substrate, low productivity and yield. Emerging contaminants play a drastic role since these contaminants interfere with the bioprocess by either inhibiting or exterminating microorganisms, altering their metabolic pathways or generating toxic by-products. Therefore it becomes necessary to effectively treat wastewater (Sarvan et al., 2024).

CONCLUSION

Laboratory Wastewater contains hazardous pollutants, which need to be reduced into simpler forms, without forming the secondary pollutant. It is important to treat the laboratory wastewater because these pollutants significantly affect the environment and human health. Using bacteria for laboratory wastewater treatment has become an effective, sustainable and environment friendly method. By using mechanisms like biodegradation, nutrient elimination and biosorption bacteria can decrease the toxicity of pollutants. Although some challenges are there, but it can be solved by doing research and finding new technologies. So, it can be concluded that bacteria have a potential to treat laboratory wastewater.

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A REVIEW ON EMERGING CONTAMINANTS IN LABORATORY WASTEWATER

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Water is essential for life, so it must be used carefully to meet the needs of a growing population. As industrial and agricultural activities increase, so does water demand, which leads to more wastewater and creates challenges affecting the health of environment and human beings. Wastewater treatment plants (WWTPs) are used for water safety by effectively reducing contaminants, toxicants, pathogens, and making water safe to reuse or release. The rising demand for water highlights the essential need for better treatment technologies designed to enhance sustainable management of water resources (B.A. Alotaibi, 2023). The emerging contaminants including endocrine disruptors, pharmaceuticals and their intermediaries, microplastics, steroids, personal care products (PCPs), have been reported to have possible adverse effects on the health of humans, animals, and overall environmental systems (Deepak Yadav, 2021).

The emerging wastewater contaminants include industrial chemicals, disinfection by-products, pharmaceuticals, PCPs, synthetic chemicals, endocrine-disrupting chemicals (EDCs), micro- and nano-plastics, biological agents and other micropollutants from research, testing, and analytical activities. As new industrial and consumer products are introduced, contamination becomes more diverse and complex. These substances often evade conventional treatment due to low concentrations and persistence, posing risks to natural ecosystems and human health upon discharge. (P.S. Nishmitha, 2025).

Emerging contaminants have generated serious concern because of their long-term stability, tendency to accumulate in living organisms, and harmful impacts on ecological systems as a result of their widespread occurrence in air, water and soil (Koigoora Srikanth, 2019).

Emerging contaminants may include substances that have been newly released into the environment, such as industrial compounds and byproducts, or substances, including some pharmaceuticals, that have existed in the environment for extended periods but whose persistence and associated risks have only recently been identified. The third group includes chemicals that have long been known, yet their potential harmful effects on human health and environmental systems have only recently been recognized, such as hormones. (Ebenezer Boahen, 2025) (Alexandros I. Stefanakis, 2020) .

Laboratory waste liquid (LWL) encompasses liquid wastes arising from various laboratory-based analytical, experimental, and research operations in universities and colleges. The composition of this waste can vary significantly and may include numerous organic and inorganic substances, some of which are hazardous, such as heavy metals like zinc (Zn), chromium (Cr), cobalt (Co), copper (Cu), cadmium (Cd), mercury (Hg), nickel (Ni), lead (Pb), and solvents, etc (Swati P. Dhenkula, 2025). ECs detected in wastewater effluents, relevant to lab sources, encompass 124 pharmaceuticals (PHACs) (Weiwei Yang, 2024) like sulfamethoxazole (mean 219 ng/L), ofloxacin (1151 ng/L), erythromycin (1415 ng/L), carbamazepine, ibuprofen, and ciprofloxacin (Ishfaq Showket Mir, 2022), alongside 16 endocrine-disruptors (Xu, et al., 2022).

Labs contribute via batch processes involving solvents, APIs, and reagents, generating diverse, high-strength wastewaters with antibiotics, hormones, and solvents. Concentrations range from ng/L to µg/L, with antibiotics and analgesics frequently exceeding ecological risk thresholds ($RQ > 0.1$) (Weiwei Yang, 2024).

Laboratory liquid waste (LWL) tends to accumulate slowly because most of our individual procedures and analyses only require a few milli litres at a time (Jie-Chung Lou, 2007). Small-scale experimental waste may seem negligible, but its environmental footprint is significant when viewed collectively. This highlights the severity and concentrated impact on the issues arising from inadequate handling and disposal of heavy-metal-containing laboratory waste liquids (Swati P. Dhenkula, 2025).

Risk and Impacts

<u>CONTAMINANT</u>	<u>MEAN CONCENTRATION (ng/L)</u>	<u>RISK QUOTIENT (MEDIAN RQ)</u>	<u>LWQC(ng/L)</u>
<i>Carbamazepine</i>	Variable, up to >1000	>1	96.4 (Weiwei Yang, 2024)
<i>Ibuprofen</i>	525 (Shandong)	>1	1010 (Weiwei Yang,2024)
<i>Bisphenol A</i>	485-540	67.9	288 (Weiwei Yang,2024)
<i>Sulfamethoxazole</i>	219	High	Not derived (Weiwei Yan, 2024)

A range of wastewater treatment strategies, including primary, secondary, tertiary or advanced methods such as ion exchange, reverse osmosis, and membrane filtration, are being employed to remove heavy metals from wastewaters. (C. Femina Carolin, 2017). Wastewater bioremediation can be effectively achieved using microorganisms, which are widely present in natural environments. Cyanobacteria have demonstrated a strong capacity for heavy metal removal, making them a promising agent for wastewater bioremediation. Their ability to reduce metal toxicity is evident in their high retention rates; for instance, they can capture up to 65% of lead and 30% of chromium from complex laboratory waste.

In more controlled synthetic environments, this retention is even more pronounced, with sequestration rates reaching 86% for chromium and 62% for lead. (Priscila Oliveira de Souza, 2022) (Weiwei Yang, 2024).

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MYCORRHIZAL ASSOCIATIONS : NATURE'S HIDDEN NETWORK DRIVING

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INTRODUCTION

Sustainability in natural ecosystem and agriculture system totally depends on efficient nutrient cycling which are mainly nitrogen and phosphorus cycle, soil health, low dependence on chemical materials and flexibility to environmental stresses (Smith and Read, 2008). One of the biological mechanisms which is important in supporting these goals are the mycorrhizal association, it is a mutualistic symbiosis between the fungi present in soil and roots of higher plants (Brundrett, 2002). This is an ancient association, which is evolved over 400 millions years ago, which has played a vital role in the successful colonization with land plants and continues to support sustainability in plants productivity today (Redecker et al., 2000).

Mycorrhizal fungi help in enhancement of plant nutrient uptake, improving soil structure, in enhancing tolerance to biotic and abiotic stress, also promotes biodiversity (van der Heijden et al., 2015). Due to its multiple benefits, it is considered keystone of agricultural and ecological sustainability (Smith and Smith, 2011).

UNDERSTANDING MYCORRHIZAL ASSOCIATION

The word Mycorrhiza originates from Greek, meaning “fungus-root” (Frank, 1885). In this symbiotic relationship, fungi colonize the roots of higher plants and establish functional interface for the exchange of resources. The plants provide carbohydrates and compounds rich in energy synthesized during photosynthesis, while fungi supplies essential minerals nutrients, water, and protection against environmental stresses (Smith and Read, 2008).

This relationship is not incidental; fossil evidence suggests that early terrestrial plants relied on mycorrhizal fungi to survive in nutrient-deficient terrestrial environments (Redecker et al., 2000). Even today, about 90% of vascular plant species depend on mycorrhizae to some degree, highlighting their ecological importance (Wang & Qiu, 2006).

Based on their structure and mode of colonization, mycorrhizae are broadly classified into:

- Arbuscular mycorrhiza (AM)
- Orchid mycorrhiza
- Ectomycorrhiza
- Ericoid mycorrhiza

Among these types, arbuscular mycorrhizae are the extensively spread and are associated with around 80–90% of land-dwelling plant species, covering many crops.

MYCORRHIZAL NETWORKS: THE UNDERGROUND NETWORK OF NATURE

Mycorrhizal fungi creates large underground networks that connects different individuals and this is often called as “wood wide web” in literature (Simard et al., 1997). These types of networks enable the water and chemical signalling between plants, translocation of nutrients, which increases the resilience in the community level (van der Heijden & Horton, 2009). Therefore, it does not favour competition but instead results in a cooperative positive interaction, which provide strengths to ecological sustainability on the ecosystem level (Simard et al., 2012).

MYCORRHIZAE AND THE MANAGEMENT OF SUSTAINABLE NUTRIENTS

1. Nitrogen and Phosphorus Absorption.

Phosphorus is one of the major limiting factors of most soil systems since it moves at a very low rate. Mycorrhizal hyphae spread a long way beyond the root zone and are able to reach phosphorus which are inaccessible to roots (Smith et al., 2011).

Mycorrhizae enhance the nitrogen availability in legumes and the fixation of nitrogen by other nitrogen-fixing bacteria and also reduce the frequency of using synthetic fertilisers (Barea et al., 2005).

2. Curtailment of Chemical Releases.

Mycorrhizal associations are associated with a significant reduction in reliance on chemical fertilizers because of better nutrition use efficiency (Gianinazzi et al., 2010). This decrease contributes to the decrease in the cost of production and the reduction in the contamination of the ground water and eutrophication of the water bodies, which are the goals of sustainable farming (Tilman et al., 2002).

3. Sequestration of carbon and Soil Health.

The foundation of sustainability is healthy soils, and the mycorrhizal fungi are the major factor which contributes to soils quality (Rilling and Mummey, 2006). These fungi help in the aggregation of soil by the secretion of glomalin, a glycoprotein that is viscous, hence stabilizing the soil. Subsequent to the strong soil structure, there is greater aeration, water retention, and root penetration (Wright & Upadhyaya, 1998). In addition, mycorrhizae help in the sequestration of carbon by translocation of plant-derived carbon into soil matrix whereby it can be stored over a long period. The process of sequestration helps in reducing the climate change and enhances the worldwide countermeasure of lessening carbon dioxide levels in the atmosphere (Rillig et al., 2015).

4. Water Sustainability and Mycorrhiza.

The problem of water scarcity is a growing international problem. Mycorrhizal fungi increase the water uptake through increasing the absorptive surface area of roots (Augé, 2001) Mycorrhizae colonized plants show increased drought, salinity and temperature stress tolerance. Their use, therefore, has specific merits in dryland farming and in areas that are susceptible to climatic changes (Ruiz-Lozano et al., 2012).

5. Natural Defense and Decreased Pest Pressure

Mycorrhizal associations enhance plant defense mechanisms by inducing systemic resistance as well as by enhancing the overall plant vigour (Pozo & Azcón-Aguilar, 2007). Mycorrhizae decrease the occurrence of root diseases

by competing with harmful soil microorganisms and improving the resistance of plants. This natural defense is in favor of sustainable pest management practices and reduces dependence on the chemical pesticides (Newsham et al., 1995).

PLANT EXAMPLES: MYCORRHIZA TO PROMOTE SUSTAINABILITY

Clitoria ternatea (Butterfly Pea) This plant legume forms strong arbuscular mycorrhizal interactions to increase the uptake of nutrients and fixation of nitrogen. It helps in enhancing the soil fertility and promotes sustainable growth of medicinal plants(Lakshman, 2014).

Zea mays (Maize) Maize is greatly enhanced by mycorrhizal colonization especially in low-phosphorus soils. Increased nutrient and water absorption will help in maintaining a steady production with less fertilizer application (Sawers et al., 2010).

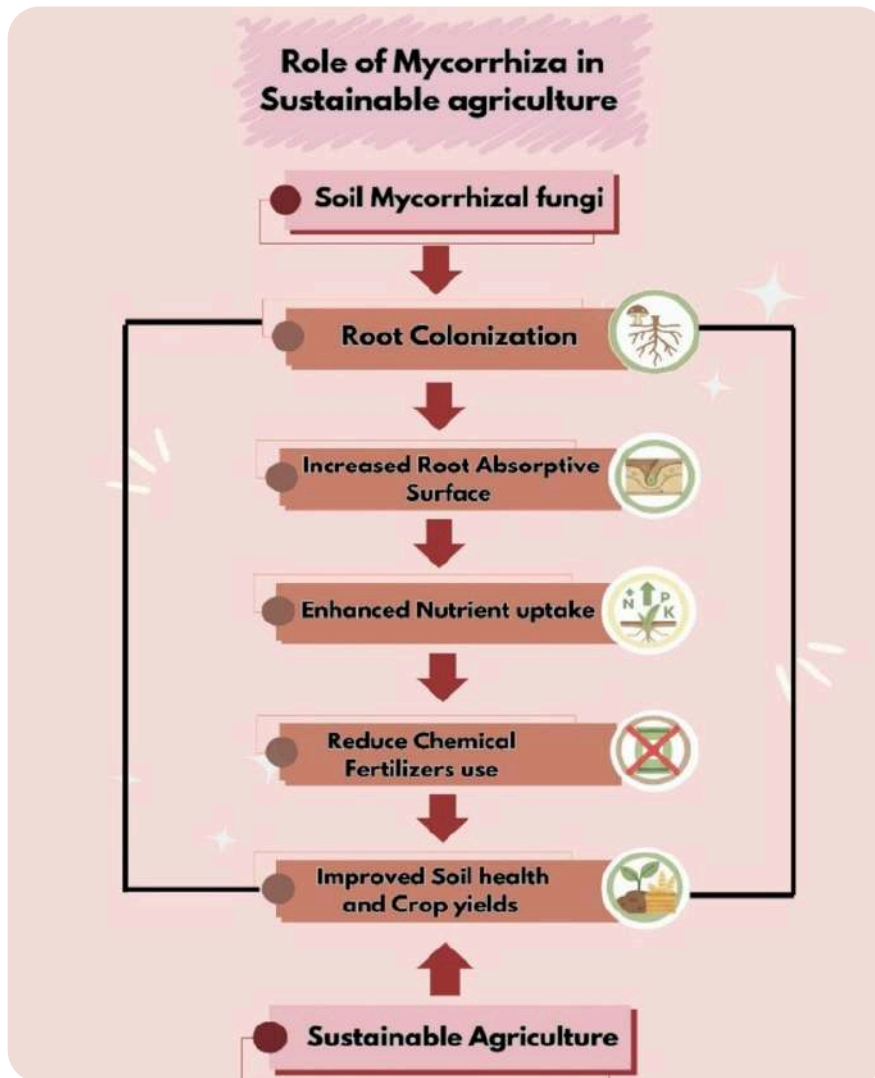
Oryza sativa (Rice) The mycorrhizal associations present in upland rice systems provide the systems with benefits such as reduced reliance on fertilizer and support of sustainable rice production (Solaiman & Hirata, 1997).

Pinus and *Quercus* species The forest trees cannot survive without the ectomycorrhizae in the nutrient-poor soils. Sustainability of forests, biodiversity and reestablishing ecosystems all rely on these associations (Smith & Read, 2008).

Camellia sinensis (Tea) The Mycorrhizal fungi increase soil nutrient absorption and microbial diversity of the soil in tea plantations, decrease the application of chemicals, and encourage sustainable management of the plantation (Chen et al., 2017).

Mycorrhiza: Sustainable Agriculture and Restoration Ecology.

Mycorrhizal fungi are currently being used as biofertilizer and biological soil conditioner in the contemporary sustainable farming systems (Gianinazzi et al., 2010). Their use promotes organic farming, conservation agriculture, and ecological rehabilitation of the degraded lands. The inoculation of mycorrhizae enhances the seedling establishment and survival in reforestation projects (Brundrett & Ashwath, 2013).

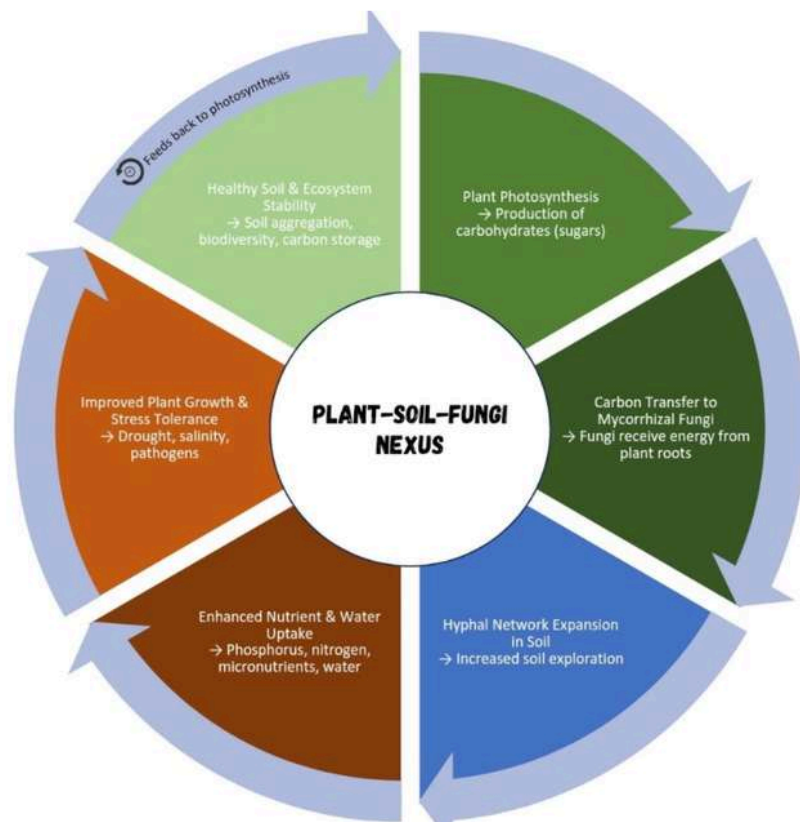


Future Perspectives

With the modern world agriculture having to face issues of climate change, soil erosion, and increased food demand, the research of mycorrhizal holds a promising future (Rillig et al., 2016). Combining mycorrhizal management to farming and forestry practices can result in resilient and low-input and environmentally friendly systems. This natural symbiosis needs to be made the best of to achieve full potential through increased awareness, education of farmers and policy support.

Conclusion

Mycorrhizal relations are a significant but poorly known driver of sustainability in natural and human-controlled ecosystems. Mycorrhizae offer a biological route to sustainable development by improving nutrient efficiency, improving soil health, conserving water and promoting biodiversity (van der Heijden et al., 2015). It is essential to note and safeguard this underground partnership to secure a sustainable and robust future of the plants and human beings.



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BAUHINIA VARIEGATA : AN OVERVIEW OF ITS MEDICINAL VALUE

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INTRODUCTION

Medicinal plants have always played an important role in human health since ancient times, many plants which were used in the traditional medicines are now being studied to understand their Morphology, Medicinal value, Chemical composition. One such plant is *Bauhinia variegata* which is commonly known as kachnar in India and orchid tree in English. It belongs to the family Fabaceae, and it is recognised for its wide range of medicinal and therapeutic properties. This plant has been used traditionally for treating goitre, diabetes, inflammation, ulcers, and microbial infections. The plant has dual significance firstly the plant owns attractive flowers and also serves as a rich source of biologically active compound.

TAXONOMICAL CLASSIFICATION (ROYAL BOTANIC GARDENS, KEW, 2024)

Kingdom: plantae

Clade: Angiosperms

Order: Fabales

Family: Fabaceae

Genus: *Bauhinia*

Species: *Bauhinia variegata* L.

MORPHOLOGICAL CHARACTERISTICS

It is medium-sized plant, deciduous tree attaining a height of 10-14 metres. The bark is grey to brown in colour which is rough in texture. The most characteristic feature of this plant is the presence of deeply bilobed, alternate leaves. Which resembles the footprints of a camel commonly named as “camels foot tree”. The flowers are large showy and attractive their flower colour varies from pink, purple to white. Flowers are not only attractive but also used as seasonal vegetables across many parts of India.

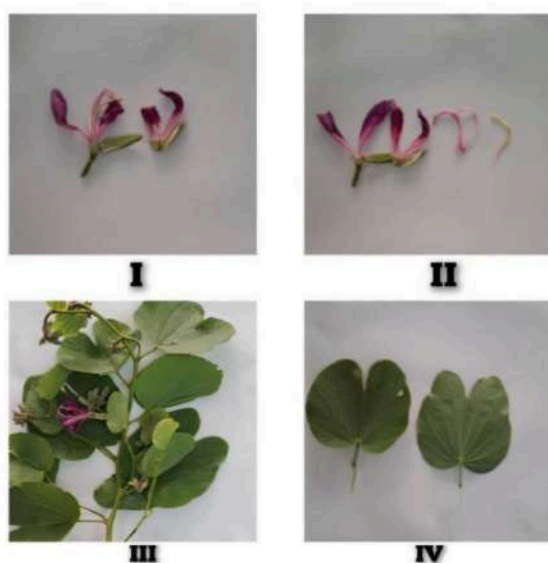


Figure: 1. floral part 2. Dissected flower 3. Twig 4. Leaves of *B. variegata*

MEDICINAL AND PHARMACEUTICAL IMPORTANCE:

Traditional Medicinal Uses

Every part of *B. variegata* is used for therapeutic purposes; the bark is highly used in the treatment of diarrhoea, ulcers and skin issues. It has also been utilised for reducing enlarged lymph nodes, and swellings. The flowers and buds are used in the herbal medicines for reducing inflammation, curing digestive disorders and cough. The leaves are applied externally on the wounds and ulcers. Root barks are used for healing wound and also exhibits detoxifying effects.

Phytochemical Composition:

These are the secondary metabolites which are well recognised for their antioxidant, antiinflammatory, anti microbial properties (Mishra et al., 2013; Kumar et al., 2012). Bark, leaves and seeds have rich are rich in these bioactive constituents such as flavonoids, tannins, alkaloids, saponins and phenolic compounds. The presence of high concentration of phenols and flavonoids helps in neutralising harmful reactive oxygen species and therefore reducing the oxidative stress in the body (Singh et al., 2011).

PHARMACOLOGICAL ACTIVITIES:

Antioxidant and Anti-Inflammatory Activities:

Plant shows strong antioxidant activity, leaves and bark removes free radicle from the body (Singh et al., 2011). As these free radicals can damage cells and lead to disease. This antioxidant effect is primarily due to the presence of flavonoids and phenolic compound. Extract of bark and leaves shows inflammatory activities which leads to the suppression of inflammatory hormones such as prostaglandins and bradykinins. (Manisha et al., 2025).

Anti-Diabetic Activity:

The plant exhibits anti-diabetic activity by reducing blood glucose levels and also regenerate pancreatic cell which release beta cells. Extracts of bark and leaves mainly ethanolic component shows the potent and insulin-like properties, making it efective against diabetes.

Anti-Microbial Activity:

Methanolic extract of *B. variegata* leaves shows antibacterial activity against *Escherichia coli*, *Staphylococcus aureus*. This activity is mainly due to the presence of natural compounds like flavonoids and tannins they can disrupt microbial cell wall and interfere with the enzymatic mechanism.

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CENTELLA ASIATICA: A MAGICAL HERB WITH MULTIPURPOSE BENEFITS

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fig: *Centella asiatica* in land and aquatic habitat

Traditional Medicinal Systems has played a crucial role in health sector since ancient times. ***Centella asiatica*, a well-regarded medicinal plant is a native of Southeast Asia and popularly known as “Indian pennywort, tiger herb or Gotu Kola”.** *Centella asiatica* (L.) Urb. is a perennial herbaceous plant belonging to family Apiaceae. A native of tropical and sub-tropical regions of the world, the plant thrives well in marshy and damp environment such as paddy fields, wetlands, riversides etc. Leaves of the plant are reniform, orbicular, oblong-elliptic shape. The plant spreads horizontally with its green stolons and underground roots. The ethnobotanical plant has been known since ancient times due the presence of potential metabolites, centelloside and madecassoside. It serves a reservoir of bioactive compounds that contributes to its therapeutic potential globally. Due to its immense medicinal importance, it has been formally documented in the WHO monographs on selected medicinal plants (2003). The plant is well known for its wound healing and memory enhancemen properties. . It also shows cardioprotective, hepatoprotective, antidiabetic, antitumor, antifungal, antipsoriatic, antioxidant effects. It has been used to cure various neurological disorders in different pharmaceutical disorders. However, reckless exploitation, habitat destruction and overuse in the pharmaceutical industry has led to decline of the plant in wild. Consequently, sustainable utilization of this plant for future use is imperative. The IUCN has classifies *Centella* as a ‘threatened species’, indicating a notable decline in its natural population. Therefore, immediate attention is required for its sustainability and conservation efforts .

Table shows secondary metabolites of Centella attributed to its role in Pharmacology

Secondary metabolites	Constituents	Pharmacological roles	References
Triterpenoid saponins	Asiaticosides, madecassosides	Wound healing, collagen synthesis, anti-inflammatory effects, neurodegenerative disease therapies, dermatological actions	Shukla et al., 1999
flavonoids	Quercetin, kempferol, rutin, luteolin, apigenin, hesperidin,	Neuroprotective activity, scavenge ROS, anti-inflammatory properties, UV- protective effects, antioxidative property, anti-aging and anti-microbial properties	Khan et al., 2020 Michalak et al ., 2022 Ullah et al., 2020
Alkaloids	Hydrocotylin, thunkuniside	Neurotropic potential	Kunjumon et al., 2022
Essential oils	Alpha-humulene, beta-pinene	Antimicrobial and dermal applications, stress relieving, skin soothing, mind-calming effects	Joshi et al., 2007
Phytosterols	Stigmasterol, campesterol, beta-sitosterol	Modulating lipid metabolism, immunomodulatory potential	Kunjumon et al., 2022
Polyacetylenes	Centellin, isocentellin,	Dermatological formulations, wound healing	Kunjumon et al., 2022

ECOLOGICAL ROLE

Centella plays a major role in natural ecosystems, particularly in wetlands and moist grasslands habitats, which are among the most climate sensitive ecosystems. It forms dense mat that covers the ground, aiding in the prevention of soil erosion alongside riverbanks and waterlogged areas. Its abundance presence naturally indicates high moisture content, reduced pollution and relatively undisturbed habitat, underscoring its potential as a bio-indicator species. consequently, a decline in its natural population may indicate early signs of environmental degradation. The dense mat covering provides micro-habitats for soil microbes, insects etc., supporting microbial communities and enhancing biodiversity. Its rapid growth, consistent leaf shedding, and regeneration, contributes to nutrient cycling and improves soil fertility. Despite being a moisture loving plant, it can also withstand short term-flooding and drought conditions, demonstrating resilience to changing climatic conditions. This adaptability to diverse environmental circumstances plays a vital role in enhancing ecological stability and sustainability in an ecosystem.

SUSTAINABLE CULTIVATION - THE WAY FORWARD

As the population grows and the demand of the plant is increased, it becomes crucial to engage in sustainable cultivation practices. Several studies have indicated that many regions are suitable for its cultivation worldwide in both present and future climatic conditions. The plant is resilient in nature but changing temperature and altered precipitation may alter the metabolite profile. Changing climate may not impact its distribution globally but the quality and productivity in specific regions will be affected (Lin et al., 2024). Study also revealed that there will be less metabolite production with changing climate in future, stating it as a deep concern. Therefore, utilizing plant sources from cultivation is a dependable and environmentally beneficial option. Practices of sustainable cultivation ensures long-term supply of raw materials while reducing environmental and genetic variations in plants that grow in the wild. This approach helps to avoid cases of misidentification and adulteration cases. Commercial cultivation cum smart farming strategies like hydroponics can be helpful in producing large number of plants with stable and high quality metabolite production

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FROM ROOTS TO CANOPY: HOW PLANTS ARE OUR CLIMATE WARRIORS

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Long before humans learned to protect the Earth, the Earth learned how to protect life.”

In a world racing toward development, we often forget to pause and listen—not to speeches or statistics, but to nature itself. Climate change is no longer a distant threat; it is unfolding silently around us. Yet, standing firm against this crisis are the most overlooked warriors of our planet—plants. Rooted in the soil and reaching for the sky, they fly everyday to keep Earth alive.

Plants are not passive elements of the environment; they are active protectors of life. Through photosynthesis, they absorb carbon dioxide and release oxygen, maintaining the delicate balance of the atmosphere. Every leaf that breathes becomes a shield against global warming. Forests, wetlands, and grasslands work tirelessly as natural carbon sinks, slowing the pace of climate change without demanding recognition.

Beneath the surface lies a hidden world of strength—the roots. Often unseen, they hold the soil together like nature’s own threads, preventing erosion and

protecting fertile land. During floods, they reduce soil loss; during droughts, they help retain moisture. These underground networks silently support ecosystems, proving that the strongest forces often operate out of sight.

Rising above the ground, the canopy tells another story of protection and balance. Tree canopies cool the Earth, soften harsh sunlight, and regulate temperature. In cities crowded with concrete, a single tree can lower heat levels and offer relief to both people and wildlife. Standing under a tree is more than comfort—it is experiencing nature’s quiet resilience.

Biodiversity adds strength to this natural system. Each plant species plays a unique role, forming a web of life where balance is key. When diversity declines, ecosystems weaken. Deforestation, pollution and unchecked urbanization are not just environmental issues; they are warnings. When plants disappear, stability disappears with them.

Plants also sustain life beyond climate regulation. They form the base of food chains, support pollinators, and ensure food security. The disappearance of flowering plants threatens bees, butterflies, and birds- and ultimately, human survival. Protecting plants is not an act of kindness; it is an act of survival.

Climate action cannot succeed without green action. Restoring forests, conserving wetlands, promoting sustainable agriculture, and respecting biodiversity are not optional anymore- they are urgent responsibilities. Even small efforts, like planting a sapling or reducing waste, creating ripples of change larger than we can imagine.

As young individuals, we are not powerless spectators. We are the generation that can choose awareness over ignorance and action over apathy. Sustainability begins when we understand that nature is not separate from us- we are a part of it.

From the silent strength of roots to the protective embrace of canopy, plants continue to fight for a future where life can thrive. If we learn to protect them today, they will continue protecting the planet tomorrow. Because when nature survives, so do we.

“if we listen closely, nature still whispers hope- all we need to do is respond.”

THE RIVET EFFECT

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Imagine you are sitting by the window on a flight cruising at 30,000 feet. The engine hums steadily and the wing stretches wide and solid beneath you. Then, imagine noticing a mechanic outside calmly popping a single rivet out of the wing . Just one .

You probably wouldn't panic. The structure looks massive, secure, and over-engineered, losing one tiny bolt surely won't matter , right ?

Now picture him removing another and another. At what point does your stomach drop? Which specific rivet is the one that causes the wing to snap?

This unsettling thought experiment was proposed in 1981 by ecologists Paul and Anne Ehrlich. They called it the Rivet Popper Hypothesis and its message is deeply uncomfortable: Nature isn't just a collection of independent animals but a pressurized vessel held together by countless small, invisible connections. We can lose a few without noticing but we cannot lose them forever.

THE ILLUSION OF SAFETY

One reason biodiversity loss feels less urgent than it should is because nature is very good at hiding the damage. Ecologists call this Functional Redundancy.

In an ecosystem, many species perform overlapping roles. If one type of wild bee disappears, a different hoverfly might step in to pollinate the same flowers like spare rivets in a wing, these backups allow the plane to keep flying even after parts are lost. This creates a dangerous illusion. We look at a forest where species are vanishing and think, "See? It's still standing." But in reality, we are stripping away the insurance policy. The structure is holding but it is becoming brittle, rivet by rivet.

Not all rivets are equal

While the loss of some species might be absorbed by the system others are "load bearing rivets." In ecology, we call these Keystone Species.

Research shows that removing a keystone species causes a collapse wildly disproportionate to its numbers. These are the rivets holding the main spar of the wing.

THE SUNDARBAN MANGROVE ECOSYSTEM : THE MASSIVE MANGROVE FOREST IN WEST BENGAL

The Sundarbans acts as the "airplane." It provides services like protecting the coast from cyclones, filtering water, and supporting fisheries.

The forest is made up of thousands of species , various types of fungi, small insects, or specific marsh grasses exist here however the Royal Bengal Tiger and the Sundari tree (*Heritiera fomes*) are the keystone species .

If a specific species of beetle or a minor shrub (minor rivets) goes extinct due to local pollution, the Sundarbans ecosystem might continue to function. The "plane" keeps flying because other species step in to fill the gap (functional redundancy). Whereas If the Royal Bengal Tiger (a critical rivet on the wing) is removed, the balance collapses. Without the tiger, the population of spotted deer (Chital) and wild boars explodes. These herbivores overgraze the young mangrove seedlings. Without new trees, the forest stops regenerating. The "plane crashes": The land washes away into the Bay of Bengal, and the ecosystem can no longer stop cyclones or support human livelihoods.

OBJECTIVE

The hypothesis highlights that we often do not know which "rivet" is critical until it is too late. In Indian conservation, this is used to justify protecting biodiversity hotspots (like the Western Ghats) entirely, rather than just specific famous animals, because losing the small rivets (like pollinators or soil bacteria) might eventually weaken the wing enough for the whole system to fail.

The most frightening aspect of the Rivet Popper Hypothesis is that ecosystems don't fail gradually. They fail suddenly.

Scientists describe this as crossing a Non-Linear Threshold or a tipping point . Human intuition expects a slow decline , if we lose 10% of species , we also expect the forest to work 10% less effectively. But nature doesn't follow that math.

An ecosystem can appear stable even after losing 20% or 30% of its species. Then one more disappears and everything collapses . A clear lake turns toxic overnight. A coral reef bleaches beyond recovery. By the time we notice the crash, the rivets are already gone.

Conclusion

We often delay conservation by saying, "We don't know if this specific beetle really matters." The Rivet Popper Hypothesis flips that argument upside down because we don't know which rivet is the critical one and because we don't know how close we are to the tipping point, the only scientifically responsible response is the Precautionary Principle which says save every rivet you can.

In an era of accelerating extinctions, conservation is no longer just about saving beautiful animals but it is a matter of structural integrity. We are all passengers on the same aircraft and popping rivets to see what happens is an experiment humanity cannot afford to run.

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NATURE'S SURVIVAL CODE IS WRITTEN IN DNA

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When we look at a forest or a wildlife reserve, our eyes naturally look for abundance. We count the tigers in the grass and we measure the acreage of the canopy, we track the migration of birds in winter. If the numbers are high, we assume the system is safe but conservation science has learned often through painful failures that the real battle for survival isn't happening in the visible world but is happening in the microscopic invisible strands of DNA.

Genetic conservation is the discipline of saving the "options" within a species. It operates on a scary premise and it is that a population can look healthy, robust and numerous on the outside while being fundamentally broken on the inside. If the individuals are too genetically similar, they are living on borrowed time.

Biologists refer to genetic diversity as Adaptive Potential. Think of it as a species' survival toolkit. Nature is unpredictable. Climates shift, new viruses emerge and food sources change. If a species has a deep diverse gene pool, it is similar to having a toolkit filled with every wrench, hammer and screwdriver imaginable. When a crisis hits, there is a good chance some individuals will have the right tool (gene variant) to survive. They live, they reproduce and they steer the species through the storm.

However if you strip away that diversity then you empty the toolkit. A genetically uniform population is a sitting duck because everyone shares the same weaknesses. A single disease or a freak heatwave doesn't just kill a few individuals, it can wipe out the entire group. Evolution cannot plan for the future as it relies on having options on standby.

WHERE DIVERSITY DIES

The most dangerous moment for any species is the Population Bottleneck. When hunting or habitat loss crashes a population, it's like squeezing a bag of marbles through a funnel where only a few make it through even if the population numbers eventually recover, the genetic variety does not.

The survivors can only pass on the genes they happened to carry , the rest are gone forever.

This leads to the death spiral known as Inbreeding Depression. With no new mates, relatives breed with relatives and the harmful mutations that are usually rare , start to pile up. The animals might still be there but they become slower, less fertile and sickly. Extinction stops being a sudden event and becomes a slow creeping certainty.

THE KING'S FRAGILE CROWN: THE ASIATIC LIONS OF GIR

If you visit the Gir National Park in Gujarat, you will witness one of India's greatest conservation victories. The Asiatic Lion which once roamed from the Middle East to Eastern India, was hunted down to a terrifyingly small number by the early 20th century. By 1910 , fewer than 20 lions remained in the wild, protected only by the Nawab of Junagadh.

TIME BOMB

While the census numbers have gone up the genetic numbers have remained dangerously low because every single Asiatic lion alive today is a descendant of those same 20 survivors, they are effectively an entire population of close cousins. Research shows that the genetic diversity of the Asiatic lion is shockingly low compared to their African counterparts. They have passed through a severe Population Bottleneck.

The danger of this genetic uniformity stopped being theoretical in 2018. A deadly outbreak of Canine Distemper Virus (CDV) , a disease spread by local dogs swept through Gir. In a genetically diverse population, some individuals would likely have a natural immunity to the virus but in Gir, the lions were so genetically similar that the virus tore through them with terrifying ease which led to over 20 lion's death in a short span.

The Asiatic Lion serves as a stark reminder of why genetic conservation is necessary. We have saved the animal but we haven't yet secured its future because they lack the 'genetic toolkit' to fight off new diseases, the entire species is vulnerable to a single catastrophic event. This is why scientists have long argued for a second home for the lions (like the Kuno National Park project) which isn't just about giving them more space but about creating a separate genetic insurance policy.

If we keep all our eggs in one basket especially when those eggs are genetically identical, we risk losing the king of the jungle forever.

THE PANTHER THAT CHEATED DEATH

The story of the Florida Panther is the classic textbook example of how close we can come to the edge and how genetics can pull us back.

By the 1990s, the Florida panther was the "walking dead." The population had shrunk so much that inbreeding was rampant. Panthers were being born with kinked tails, heart defects and sperm counts so low that reproduction was failing. The habitat was protected but the cats were genetically trapped. In a controversial move, scientists introduced eight female pumas from Texas into the Florida population which caused a genetic transfusion.

The result was immediate since the fresh DNA fixed the heart defects and restored fertility. The population stabilized proving that you cannot just save the land but first will have to save the code.

THE LIE OF NUMBERS

This brings us to a concept that challenges how we count nature. Researchers distinguish between two very different numbers:

Census Size (N): The total headcount i.e., the effective Population Size defined as the number of individuals actually passing genes to the next generation.

In many species, the effective number is shockingly low. In a herd of 100 animals perhaps only a few dominant males breed. Genetically, that herd of 100 might effectively be a population of 10.

This is the basis of the 50/500 Rule often cited in conservation papers that says a population needs an effective size of 50 to prevent immediate inbreeding but needs 500 to keep its evolutionary potential alive for the future. Anything less and we are just managing a slow decline.

MODERN APPROACH

To prevent this loss, we are now building backups for the planet.

Deep in the Arctic permafrost lies the Svalbard Global Seed Vault. It is a secure facility storing duplicates of crop seeds from every corner of the globe and can be called as a 'fail-safe' against famine and disaster.

For animals, we have turned to Cryobanking or "Frozen Zoos." Scientists are freezing sperm, eggs and skin cells of endangered species. It is a way to pause time ensuring that even if a population crashes, we still have access to the genetic diversity of their ancestors.

Conclusion

Genetic conservation teaches us a humbling lesson Survival isn't about perfection but about variation. Life on Earth doesn't endure because it found one perfect design, it endures because it keeps its options open hiding its resilience in the invisible code of its own making.

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PROTECTING NATURE TODAY FOR A SUSTAINABLE TOMORROW

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“Nature does not need humans, but humans need nature.”

This simple statement highlights the importance of biodiversity conservation, climate action, and sustainability in today's world.

Biodiversity refers to the variety of plants, animals, and microorganisms found on Earth. These living organisms form ecosystems that provide us with food, clean air, water, medicine, and a stable environment. However, due to deforestation, pollution, rapid urbanisation, and overuse of natural resources, biodiversity is declining at an alarming rate. This loss has serious consequences for both nature and human life.

Healthy ecosystems play a vital role in maintaining environmental balance. Forests absorb carbon dioxide and help regulate climate, wetlands reduce the impact of floods, and plants support soil fertility and pollination.

“When ecosystems are disturbed, human life is also affected.”

Loss of biodiversity weakens these natural systems, making the environment more vulnerable to disasters such as droughts, floods, and disease outbreaks.

Climate change has further intensified this crisis. Rising global temperatures, irregular rainfall, melting glaciers, and extreme weather events are changing natural habitats. Many species are unable to adapt to these rapid changes and are facing the risk of extinction. Coral reefs are bleaching due to increased ocean temperatures, while polar species are losing their habitats because of ice melting. Climate change clearly shows how human actions can disrupt natural processes on a global scale.

At the same time, biodiversity loss also contributes to climate change. Large-scale deforestation releases carbon dioxide into the atmosphere and reduces the Earth's ability to absorb greenhouse gases. Destruction of mangroves, forests, and grasslands weakens nature's natural climate regulation.

“Climate change and biodiversity loss are two sides of the same coin.”

Both problems are closely connected and must be addressed together.

Sustainability provides a long-term solution to these environmental challenges. Sustainable development focuses on meeting present needs without compromising the needs of future generations. Practices such as using renewable energy, conserving water, reducing waste, and adopting sustainable agriculture help protect natural resources while supporting development. Biodiversity conservation is a key part of sustainability, as healthy ecosystems ensure environmental stability.

Students and young people have an important role to play in protecting the environment.

“The future of the planet depends on the choices we make today.”

Simple actions like planting trees, avoiding single-use plastics, conserving water, and spreading awareness can bring meaningful change. As students of science, understanding ecological balance and respecting nature is essential.

In conclusion, biodiversity conservation, climate action, and sustainability are deeply interconnected. Protecting nature is not only an environmental responsibility but also a duty towards future generations. By adopting sustainable practices and respecting biodiversity, we can help create a healthier and more resilient planet.

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NIGHTTIME GLOBAL WARMING: WHY WARMER NIGHTS MAY HURT PLANTS MORE THAN HOT DAYS

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ABSTRACT

Nighttime temperatures are rising nearly three times faster than daytime temperatures, creating an asymmetric warming pattern that poses a serious threat to crop productivity. Although daytime heat stress has been widely studied, growing evidence shows that warm nights cause greater yield losses than equivalent daytime warming.

This review synthesizes findings from field and physiological studies to show that elevated nighttime temperatures damage crops by accelerating respiration, shortening reproductive development, inducing early leaf senescence, increasing water stress, causing floret abortion, and reducing grain quality. Field evidence indicates yield losses of about 10% per 1°C increase in nighttime temperature for rice and 21–25% losses for wheat under modest nighttime warming. Importantly, tolerance to nighttime heat is genetically independent of daytime heat tolerance.

As current adaptation strategies focus mainly on daytime heat, developing nighttime heat-tolerant crops is essential, particularly for India's wheat and rice systems under future warming.

INTRODUCTION: WHY NIGHTS MATTER MORE THAN DAYS

Climate change is often associated with rising daytime temperatures and heat waves, yet recent evidence shows that nighttime warming poses a greater threat to crop productivity. Over the last 50–60 years, nighttime temperatures have increased more rapidly than daytime temperatures, with serious consequences for major cereal crops.

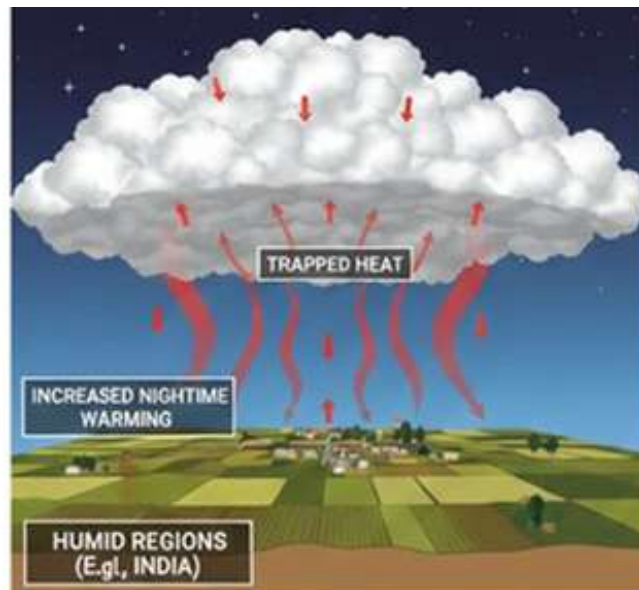
In rice, a 1°C increase in night temperature can reduce yield by about 10%, while wheat yields may decline by 15–25% under similar conditions. These losses are substantially greater than those caused by equivalent daytime warming. The underlying reason lies in plant physiology: photosynthesis occurs only during the day, whereas respiration continues throughout the night. Warm nights accelerate respiration, leading to excessive loss of stored carbohydrates without any opportunity for compensation.

As a result, crops face a persistent energy deficit that limits growth and grain filling. This phenomenon is particularly critical for India, where rice and wheat together support the food security of over 1.4 billion people

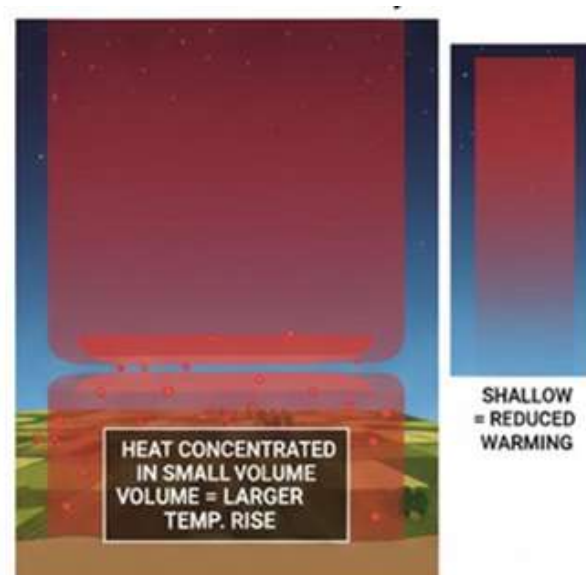
WHY NIGHTS WARM FASTER THAN DAYS: ATMOSPHERIC PHYSICS

A. Clouds Act as an Insulating Blanket

With climate warming, the atmosphere holds more water vapor, leading to increased cloud cover. During the day, clouds reflect incoming solar radiation and limit surface heating.

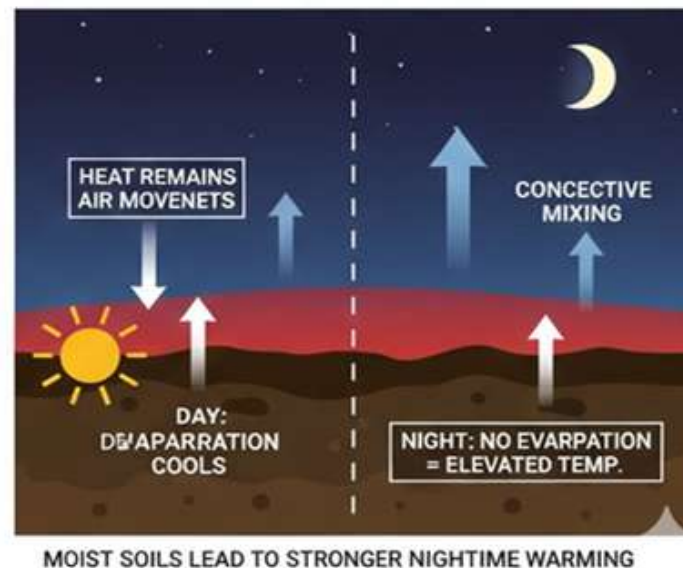


At night, however, they trap outgoing heat and re-radiate it back toward the Earth's surface, resulting in slower daytime warming but faster nighttime warming, particularly in humid regions such as India.



B. Shallow Nocturnal Air Layers

At night, the layer of air near the ground is relatively thin. Heat retained by greenhouse gases is therefore concentrated within a smaller air volume, producing a larger rise in surface temperature. In contrast, daytime heating is distributed through deeper atmospheric mixing, reducing surface warming.



C. Influence of Soil Moisture

Moist soils cool the surface during the day through evaporation. At night, when evaporation ceases, this cooling effect disappears, allowing temperatures to remain elevated. Consequently, regions with high soil moisture experience stronger nighttime warming.

PHYSIOLOGICAL IMPACTS OF WARM NIGHTS ON CROPS

A. Increased Respiratory Carbon Loss

Respiration rates increase exponentially with temperature. Warm nights significantly enhance respiratory activity, leading to rapid depletion of carbohydrates that are essential for growth and grain filling. Studies in wheat have reported 50–94% increases in nighttime respiration under elevated temperatures.

B. Disruption of Developmental Timing

Plants rely on cool nights as environmental cues to regulate developmental stages such as flowering and grain formation. Elevated night temperatures accelerate phenological development, shortening the duration of critical growth phases and resulting in poor reproductive

C. Premature Leaf Senescence

Warm nights promote early degradation of chlorophyll and accelerate leaf senescence. This reduces the photosynthetic capacity of the plant during the grain-filling stage, leading to smaller and lighter grains.

D. Decline in Daytime Photosynthesis

Paradoxically, warm nights reduce photosynthetic efficiency during the following day. This occurs due to metabolic imbalances, reduced chlorophyll content, and increased water stress, further aggravating carbon deficits.

E. Reproductive Failure and Floret Abortion

Floret development is highly sensitive to energy availability and developmental timing. Warm nights increase floret abortion, reducing the number of grains per panicle or spike. In rice, yield losses associated with warm nights are largely due to reduced grain number rather than grain size.

F. Increased Nighttime Water Loss

Respiration requires oxygen uptake, which necessitates partial stomatal opening even at night. Elevated respiration under warm nights increases stomatal conductance, leading to unnecessary water loss without photosynthetic benefit. This intensifies plant stress, especially under limited water availability.

EVIDENCE FROM FIELD AND EXPERIMENTAL STUDIES

1. Rice: The IRRI Longitudinal Study

A landmark 25-year study conducted by the International Rice Research Institute (IRRI) revealed a stark correlation between nocturnal thermal stress and productivity. .

Observations indicated that nighttime temperatures in the study region increased three times faster than daytime temperatures.

Yield Attrition: Grain yield declined by 10% for every 1°C increase in the minimum nighttime temperature.

Primary Drivers: The loss was attributed to reproductive failure occurring prior to anthesis (flowering). This manifested as a significant reduction in the number of panicles and spikelets, effectively lowering the plant's sink capacity before grain filling could even begin.

2. China: Significant Yield Gaps

Research in China involving a 1.5°C increase in nighttime temperatures resulted in a staggering 21–25% yield loss. The study highlighted that different cultivars exhibit distinct failure modes:

Grain Attrition: Certain varieties suffered from a reduced number of grains per spikelet. Structural Loss: Other varieties failed to develop the spikelets themselves.

Critical Insight: A plant's ability to withstand daytime heat does not correlate with its resilience to nighttime warming, suggesting independent genetic mechanisms for nocturnal stress tolerance.

3. Mexico: The Failure of "Heat-Tolerant" Strains

In controlled field trials in Mexico, nighttime temperatures were elevated by 2°C. Even when using varieties specifically bred for high-heat environments, yields fell by 1.9% per 1°C of nocturnal warming. Key Conclusion: The current agricultural paradigm of "heat tolerance" is incomplete. Modern cultivars, while resilient to solar radiation and high daytime peaks, remain highly susceptible to the metabolic exhaustion and developmental acceleration caused by warm nights.

WHY WARM NIGHTS HURT MORE THAN HOT DAYS: A SIMPLE EXPLANATION

Warm nights are more damaging to plants than hot days because plants lose energy at night but cannot replace it. During the day, plants make food through photosynthesis. Even if heat increases respiration, photosynthesis usually increases enough to compensate. At night, however, photosynthesis stops and plants only respire. When nights are warm, respiration becomes faster, causing a pure energy loss that cannot be recovered.

Warm nights also confuse plants' internal clocks. Cool nights normally signal early growth stages, while warm nights falsely signal that the season is advancing. This forces plants to develop too quickly, even though external conditions have not changed. As a result, sensitive stages such as flower and grain formation occur under unsuitable conditions.

In crops like wheat and rice, warm nights shorten critical developmental periods, especially those needed for pollen and grain formation. Once this window is missed, the damage is permanent. Unlike daytime heat stress, which plants can often recover from, the effects of warm nights are irreversible.

Finally, plants have evolved defenses against hot days, such as closing stomata and producing protective proteins. No such defenses exist for warm nights, because plants do not recognize them as stress. Continuous high respiration during warm nights depletes stored sugars, leaving insufficient energy for growth and yield formation.

ADAPTATION PATHWAYS AND FUTURE RESEARCH

NECESSARY ADAPTATIONS:

1. Breeding for Nighttime Tolerance: Select cultivars showing:

Reduced nighttime respiration rates (genetic variation exists)

Delayed senescence maintaining photosynthesis longer under nighttime stress
Rapid carbohydrate remobilization (source-to-sink transport efficiency)
Floret development resilience (completing meiosis despite shortened pre-anthesis window)

2. Agronomic Management:

Adjust sowing dates to avoid critical developmental stages during peak nighttime warming

Increase nitrogen availability (supports carbohydrate production and replaces stress-induced losses)
Improve irrigation scheduling to mitigate transpiration water loss

3. Crop Diversification:

Evaluate alternative crops (millets, sorghum, pulse crops) that may be less sensitive to nighttime warming

Develop short-duration cultivars that complete development before nighttime warming intensifies

4. Fundamental Research:

Map genetic variation in nighttime respiration rates across crop germplasm

Identify transcriptomic signatures of nighttime stress tolerance

Develop phenotyping protocols for nighttime temperature stress

Quantify circadian-clock-mediated responses to warm nights.

Conclusion

Nighttime warming represents a silent but severe threat to agricultural productivity. Unlike daytime heat stress, its effects are subtle, cumulative, and difficult to reverse. For countries like India, where food security depends heavily on climate-sensitive cereal crops, recognizing and addressing the impacts of warm nights is crucial. The future of sustainable agriculture will depend not only on how hot our days become, but also on how warm our nights remain.

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RARE EARTHS FROM SEAWEED: CAN OCEAN PLANTS SUSTAINABLY REPLACE MINING?

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ABSTRACT

The rare earth elements (REEs), crucial in sectors like renewables, electronics, and military applications, face significant ecological harm due to traditional mining methods. Various types of algae like kelp and seagrasses now serve as eco-friendly replacements because they can concentrate rare earth elements found in ocean waters and sewage by factors over ten thousand compared to normal conditions.

The evaluation of data comprises results derived from more than thirty scholarly investigations into marine algae species like *Ulva* and *Gracilaria*, highlighting their ability to absorb rare earth elements via cell walls for purification purposes in polluted water sources, showing up to ninety percent efficiency in removing these contaminants. Although constrained by factors like productivity levels, growth capacity, and economic viability, marine algae mining demonstrates significant promise in serving as an additional supply for rare earth elements including neodymium, dysprosium, and erbium.

Beyond recovering rare earth elements, algae mining offers additional advantages such as purifying contaminated waters and storing CO₂. Additional studies focusing on combining genetic screening techniques, refining solvent processing methods, and conducting comprehensive environmental impact assessments must be conducted in order to make products commercially viable.

INTRODUCTION

The rare earth elements comprise seventeen metal compounds vital for contemporary electronics manufacturing. Their importance lies in supporting industries such as smartphone production, electric vehicle manufacture, renewable energy generation through wind turbines, advanced medical diagnostic tools, and defense systems. Although these elements have an unusual moniker, they actually occur quite frequently within our planet's soil layer; nonetheless, it is challenging to locate them in pure, commercially viable quantities. Historically, extraction of rare earth minerals has been linked to significant ecological issues such as deforestation, creation of hazardous nuclear byproducts, substantial power usage demands, and contamination of aquatic resources. The hurdles necessitated researchers inquiring into new, eco-friendly alternatives for obtaining these precious minerals. Another notable development involves utilizing marine macroalgae like kelp for obtaining scarce elements naturally and sustainably.

WHY LOOK BEYOND CONVENTIONAL MINING?

Advanced gadgets like smart devices, eco-friendly cars, and sustainable power sources depend significantly upon these precious minerals. Nevertheless, extracting such vital resources frequently entails substantial ecological repercussions. Traditional extraction techniques for rare earth minerals entail significant soil removal, reliance on potent chemicals, and creation of hazardous byproducts such as potentially radioactive waste. These endeavors significantly harm the environment by producing substantial amounts of greenhouse gases.

With increasing worldwide interest in renewable energies and gadgets, this highlights the pressing necessity of adopting new methods for extracting rare earth elements that are both eco-friendly and sustainable.

Seaweed as a Natural Metal Collector

Common seaweed genera studied for metal uptake includes:



Sargassum



Ulva



Gracilaria



Fucus

FROM OCEAN PLANT TO CRITICAL METAL: HOW DOES IT WORK?

Turning seaweed into a source of rare earths involves a carefully designed but environmentally friendly process:

Cultivation or Collection

Seaweed can be cultivated in coastal farms or harvested from naturally occurring blooms, turning an environmental nuisance into a valuable resource.

Metal Uptake

As seaweed grows, it absorbs rare earth ions present in sea water or in industrial waste water

Harvesting and drying

The metal-rich biomass is collected and processed

Metal Recovery

Finally rare earth metals are extracted using controlled chemical treatments, allowing the metal to be used in modern technologies

CASE STUDY: SARGASSUM AND RARE EARTH ELEMENT RECOVERY

Sargassum filipendula, a floating brown macroalga abundant in tropical Atlantic waters, demonstrates exceptional potential as a biosorbent for rare earth elements (REEs).

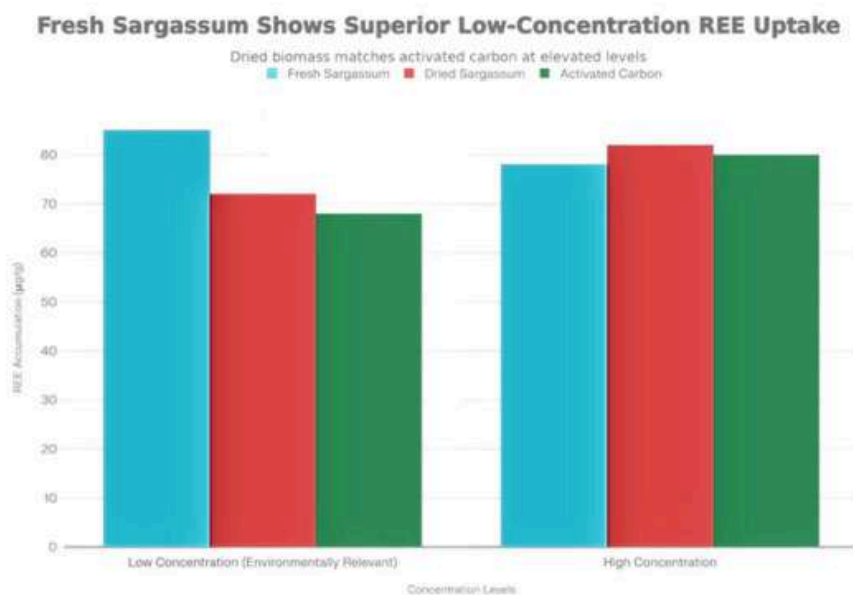
Key Findings:

FRESH VS. DRIED BIOMASS PERFORMANCE

The newly discovered species of seaweed, Fresh *Sargassum*, demonstrated exceptional REM absorption capabilities by accumulating 85 micrograms per gram of rare earth elements under minimal environmental conditions typical of real-world marine contamination situations. The dried biomass had values of approximately 72 micrograms per gram, which was marginally less than commercially available activated charcoal's density of 68 micrograms per gram but surpassed both in terms of effectiveness when tested under elevated conditions, indicating its potential for economic viability across various applications. The rare earth elements such as yttrium exhibited exceptionally strong attraction, crucial for enhancing electric vehicle batteries' performance.

SALINE ADVANTAGE:

Significantly, sargassum maintained an impressive 88% effectiveness in environments containing high salt concentrations, whereas traditional activated charcoal showed reduced performance by losing up to 40-50%. A marine-tailored facility reduces desalination expenses by allowing easy placement in proximity to acidic water sources like mining areas or contaminated ports—this innovation is pivotal for India's coastlines battling sargassum overgrowth.



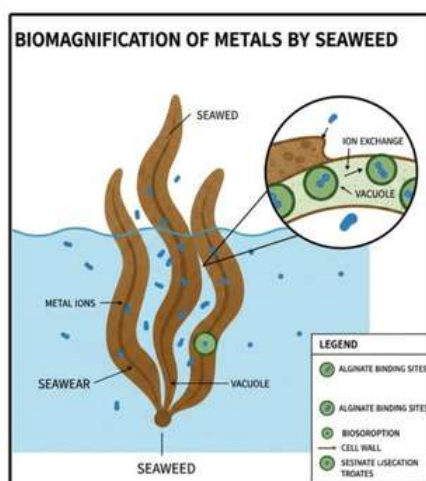
ADVANTAGES OF SEAWEED -BASED RARE EARTH METALS RECOVERY

- Sustainable-Little impact on natural habitats and decreased emissions.
- A renewable resource is seaweed, which thrives quickly and may be continuously gathered without depletion.
- Solutions derived from oceans help alleviate stress on terrestrial environments.
- Resilient in briny conditions-Differing markedly from numerous man-made substances.
- Promotes recycling systems - Excess plant material is transformed into soil enhancers, renewable energy sources, or eco-friendly plastics.

Conclusion

Seaweed offers a fascinating example of how nature can inspire sustainable technological solutions. Although marine plants cannot completely replace rare earth mining in the near future, they represent a promising green approach to mineral recovery. Integrating seaweed-based systems with existing technologies can help reduce environmental harm and support a more sustainable future for critical mineral resources.

Although seaweed cannot yet completely replace traditional mining, it offers a promising glimpse of a future where nature and technology work together. By harnessing the ocean's natural processes, scientists are rethinking how vital materials can be sustainably obtained – without digging deep holes into the Earth.



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SIDA ACUTA BURM.F.: WEED PLANT WITH BIOLOGICAL SIGNIFICANCE

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INTRODUCTION

Sida acuta Burm. F. is a perennial medicinal plant belonging to the family Malvaceae, a family well known for its economically and medicinally crucial and vital members such as Gossypium, Hibiscus, and Abelmoschus. Despite its pervasive and far-reaching incident and long-standing application in conventional and customary medicine, *Sida acuta* is frequently viewed merely as an ordinary and widespread weed. However, comprehensive observation shows that the plant possesses notable botanical, ecological, and medicinal value. This article presents a full and comprehensive scientific introduction to *Sida acuta*, covering its taxonomy, habitat, morphology, functional aspects, weed status, and medicinal relevance.

Taxonomical Position and Nomenclature

Scientific name: Sida acuta Burm. F.

Taxonomic classification:

Kingdom: Plantae

Division: Angiosperms

Class: Eudicots

Order: Malvales

Family: Malvaceae

Genus: Sida

Species: Sida acuta Burm. F.



Sida acuta pertains to the genus *Sida*, which comprises diverse and varied herbaceous species distributed mainly in tropical and subtropical regions. The species epithet *acuta* refers to the characteristic acute apex of the leaves.

Vernacular names: The plant is known by multiple standard and pervasive and far-reaching names in unlike regions, indicating its broad distribution and standard and traditional familiarity.

English: Common wireweed

Hindi: Bala, Kharenti

Sanskrit: Bala

Tamil: kurunthotti

Telugu: Mayilmanikkam

Marathi: Chikana

HABITAT AND GEOGRAPHICAL DISTRIBUTION

Sida acuta is broadly distributed across tropical and subtropical regions of the world, comprising India, Southeast Asia, Africa, and parts of the Americas. The plant commonly increases in open and disturbed habitats such as roadsides, agricultural fields, fallow lands, grasslands, gardens, and wastelands. It shows exceptional and striking adaptability to diverse environmental conditions, thriving in dry, nutrient-poor soils as well as regions with high temperature and sunlight exposure. This ecological plasticity contributes to its successful establishment and persistence in diverse and assorted habitats.

HABIT AND GENERAL MORPHOLOGY

Sida acuta is an erect, perennial herb or undershrub, generally growing 1-2 m in height. The plant exhibits profuse branching, giving it a bushy appearance. The stem is cylindrical, slender, and tough, frequently fibrous in nature, which contributes to its opposition against mechanical injury and grazing pressure.

The leaves are straightforward, alternate, and petiolate, varying from lanceolate to ovate-lanceolate in shape. Leaf margins are serrated, and the apex is distinctly acute. The leaf surface may be sparsely pubescent, while the venation is reticulate, standard and normal of dicotyledonous plants. These structural features aid in productive and effective photosynthesis and water regulation under varied environmental conditions.

Flowers are small, yellow, isolated and axillary. They are bisexual and actinomorphic, containing five petals and many and various stamens united into a staminal column, a characteristic feature of the Malvaceae family. Flowering occurs throughout the year under beneficial conditions.

The fruit is a schizocarp, which splits into 5-10 mericarps upon maturity. Each mericarp contains a single seed, enabling effective seed dispersal. Seeds are small, hard, and capable of remaining feasible in soil for prolonged and lengthened periods, contributing to the plant's persistence and weed-like nature.

The root system comprises of a well-developed taproot with lateral branches, facilitating economical and cost-effective absorption of water and nutrients, even in poor or compact soils.

FUNCTIONAL AND ECOLOGICAL SIGNIFICANCE

Functionally, *Sida acuta* plays a significant ecological role in natural and semi-natural ecosystems. The flowers provide nectar and pollen to multiple insects, comprising pollinators, thereby supporting local biodiversity. The root system aids in soil stabilization, especially in open and degraded areas, assisting to reduce erosion.

Physiologically, the plant exhibits robust tolerance to environmental stress such as drought and poor soil fertility. These adaptive characteristics allow *Sida acuta* to survive and proliferate under conditions that may be unfavorable for numerous cultivated plants.

***SIDA ACUTA* AS A WEED SPECIES**

In agricultural systems, *Sida acuta* is often classified as a weed due to its fast increase, high reproductive capability, and competitive nature. It competes with crops for water, nutrients, and light, leading to reduced crop productivity. Consequently, it is frequently removed during weed management practices. However, considering its medicinal and ecological value, the plant denotes an illustration of an advantageous weed whose potential is frequently underestimated.

MEDICINAL AND TRADITIONAL IMPORTANCE

Sida acuta has a long history of application in customary and folk medicine systems, especially in Ayurveda and native healing practices. Different parts of the plant are used for particular therapeutic purposes.

The leaves are typically applied for wound healing, swelling, and skin infections. Decoctions of the leaves have been used in the management of fever and inflammatory conditions. The stem and aerial parts are frequently utilized for their reputed analgesic and anti-inflammatory attributes.

Root extracts of *Sida acuta* have been used as broad tonics to support strength and vitality. In some regions, root preparations are administered to manage joint pain, muscle flaw, and nervous disorders. The plant is moreover associated with remedies for respiratory ailments such as cough and asthma in folk practices.

Ethnobotanical studies suggest that the medicinal attributes of *Sida acuta* are linked to the presence of varied phytochemical constituents reported in the plant, incorporating alkaloids, flavonoids, glycosides, and other secondary metabolites. While customary utilization offers valuable insight, scientific validation through pharmacological and biochemical studies is vital and crucial to validate effectiveness and safety.

Conclusion

Sida acuta Burm. F. denotes a biologically notable plant that bridges the gap between weed biology and medicinal plant science. Although commonly missed due to its weed status, the plant shows distinct morphological traits, ecological adaptability, and conventional medicinal relevance. An exhaustive and inclusive understanding of *Sida acuta* not solely enhances botanical knowledge but moreover highlights the weight of re-evaluating ordinary and widespread plants for their hidden scientific and therapeutic potential.

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AROMATHERAPY AS A COMPLEMENTARY APPROACH TO STRESS AND ANXIETY: A SCIENTIFIC REVIEW

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ABSTRACT:

Stress and anxiety are becoming common in the contemporary society especially among young adults who are under academic, social and economic stress. Complementary therapies like aromatherapy have been given focus in the past few years as an option of enhancing emotional well-being. Aromatherapy is the practice of using volatile plant-derived compounds extracted as essential oils that can affect psychological conditions and help in regulation of stress. This review focuses on the scientific foundations of inhalation aromatherapy and provides an overview of the existing studies on the effectiveness of inhalation aromatherapy in the reduction of stress and anxiety. Human trials and systematic reviews indicate that inhalation of some essential oils can result in slight yet significant changes in mood, anxiety and physiological variables like heart rate and blood pressure. Nevertheless, differences in study design, oil composition and exposure conditions do not allow direct comparisons between studies. Although aromatherapy cannot be regarded as an alternative to professional mental health care, it can be a supportive practice for short-term emotional regulation. However, more standardized studies are needed to gain a better insight into its effectiveness and safe use.

Keywords: Stress, Anxiety, Aromatherapy, Essential Oils, Physiological Parameters

INTRODUCTION:

Stress and anxiety have become common features of contemporary life. Increased academic stress, shifting social conditions, financial instability and constant digital presence may contribute to ongoing psychological distress, especially in young adults. In India, recent extensive surveys have shown that anxiety, emotional distress and decreased emotional regulation are high in populations of university age (Suresh & Dar, 2025).

In addition to traditional psychological and medical treatments, complementary practices are increasingly being explored because of their accessibility, low-cost and non-invasive nature (Herman et al., 2005). Aromatherapy is one of these methods. It involves the use of plant-based aromatic substances in the form of essential oils, to assist in emotional and psychological health.

Even though aromatherapy is not a replacement for professional mental health care, scientific studies are beginning to investigate its application as a complementary practice in dealing with mild stress and anxiety. This article reviews the evidence on efficacy of inhalation aromatherapy and why it may still be important in the modern mental health environment.

What Is Inhalation Aromatherapy?

Aromatherapy refers to the use of volatile plant compounds, primarily extracted as essential oils from various plant parts such as leaves, flowers, bark or roots. These oils are blends of bioactive phytochemicals that are responsible for the plant's typical fragrance and biological activity.

The most common way of using these is through inhalation, both in the traditional and modern context. Under this method, the vapours of essential oils are inhaled using techniques like diffusion, inhalation of steam or aroma patches. When inhaled, volatile aromatic molecules may interact with olfactory receptors in the nasal cavity and transmit signals to brain regions involved in emotional processing, potentially contributing to observed effects on relaxation and stress responses (Cui et al., 2022). Due to its simplicity, non-invasive character and convenience of use, inhalation aromatherapy is becoming an option to be considered as a complementary measure to facilitate relaxation and emotional health in both clinical and everyday environments.

SCIENTIFIC EVIDENCE FOR STRESS AND ANXIETY CONTROL

Based on human trials and systematic reviews, inhalation aromatherapy has been proposed to have small, yet reliable effects on subjective anxiety, mood and emotional calmness. Meta-analyses indicate that there are statistically significant changes in state and trait anxiety scores after exposure to essential oils along with small changes in heart rate and systolic blood pressure as well (Tan et al., 2023).

However, the intensity of these effects varies. The differences in oil composition, dosage, duration of exposure, experimental design and characteristics of participants make it hard to compare them directly. Notably, aromatherapy is not to be considered a clinical treatment but a complementary one. The existing evidence does not justify its use as a primary treatment for anxiety disorders or depression, but as a supportive method that can be used to improve short-term emotional regulation.

EXAMPLES OF ESSENTIAL OILS TO REDUCE ANXIETY

Various essential oils have been explored in terms of their possible psychological usefulness. Lavender, chamomile, rose, jasmine, sandalwood, peppermint and lemongrass oils have been associated with a decrease in anxiety, stress, physiological parameters and other related effects in various study contexts (Table 1).

Table 1 summarizes commonly studied essential oils and their reported effects on stress and anxiety. It includes the plant source, major bioactive constituents, and the primary effects reported in experimental and clinical studies. The information is compiled from previously published research evaluating the impact of inhalation aromatherapy on mood, anxiety and stress outcomes.

THE SIGNIFICANCE OF CHEMICAL COMPOSITION

The effects associated with essential oils are mainly due to their chemical composition. Even essential oils from the same plant species may vary in constitution of major constituents depending on climatic and geographical factors, age of plants and harvesting conditions.

For example, regional variations in lemongrass oil composition, particularly in compounds like E-geranial, Z-geranial and myrcene influence both its aroma and biological activity (Cortes-Torres et al., 2023). Therefore, techniques such as gas chromatography-mass spectrometry (GC-MS) are used to characterize oil profiles and ensure reliable comparison between studies.

Table 1. Essential oils and their reported effects on stress and anxiety

Essential Oil	Major Compounds	Reported Effects	Reference
Lavender	Linalool, Linalyl acetate	Anxiety reduction, improved sleep	Wang et al., 2025
Chamomile	Bisabolol	Reduction in anxiety, mild reduction in blood pressure and heart rate	Ebrahimi et al., 2022; Pourshaikhian et al., 2021
Damask Rose	Citronellol, Geraniol	Reduction in anxiety, improved sleep quality	Jodaki et al., 2021; Mokhtari et al., 2023
Jasmine	Benzyl acetate, Linalool	Reduction in anxiety, improved alertness	Ashraf et al., 2009; Sayowan et al., 2017
Sandalwood	α -santalol	Relaxation	Das & Khan, 2022
Lemongrass	Geranial, Neral	Reduction in anxiety and stress, mild reduction in blood pressure and heart rate	Goes et al., 2015; Maybodi et al., 2025
Peppermint	Menthol	Reduction in anxiety	Akbari et al., 2019

LIMITATIONS AND MISCONCEPTIONS

Despite the growing popularity, aromatherapy has a number of limitations. Its effects are usually short-term, differ greatly among different individuals and are often founded on small sample-studies which have not been standardized in terms of oil composition and dosage. Psychological expectations can also have some influence on a few perceived benefits.

Moreover, essential oils are not entirely risk-free, since they may lead to negative reactions in cases of improper dilution, prolonged exposure or allergy. Thus, aromatherapy must be employed carefully as a supportive practice and not a medical one

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Why Aromatherapy remains relevant today?

Despite the limitations, aromatherapy still remains relevant since it provides a straightforward supportive measure of dealing with daily stress which does not necessarily involve clinical intervention. Anxiety and emotional distress are on the rise among the young adults in India (Suresh & Dar, 2025), and there is a demand to have convenient and affordable complementary practices.

The systematic reviews indicate that essential oil inhalation results in statistically significant decreases in anxiety and small increases in physiological relaxation indicators (Tan et al., 2023). These effects are not extensive, yet they make it worth implementing as a complementary measure to be used in conjunction with evidence-based psychological care.

Conclusion

Aromatherapy does not substitute psychological or medical therapy for anxiety, but scientific evidence indicates that it may have mild, short-term effects on emotional relaxation and stress reduction. Hence, aromatherapy shows potential to be used as a low-cost and accessible complementary practice when used in a responsible way and in combination with evidence-based mental health care. However, additional standardized studies are needed to better understand its usefulness in practice and ensure its safe application.

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MUSHROOMS AS FUNCTIONAL FOODS: NUTRITIONAL AND PHYTOCHEMICAL PERSPECTIVES

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ABSTRACT

Mushrooms are valuable foods rich in active phytochemical compounds, which contribute to their nutritional and therapeutic potential. This review summarizes the major bioactive constituents of mushrooms, including polysaccharides, phenolics, flavonoids, tannins, terpenes, sterols, tocopherols, proteins, and nitrogenous compounds. These compounds possess diverse biological activities, such as anticancer, immunomodulatory, antimicrobial, antioxidant, anti-inflammatory, and cholesterol-lowering properties. The chemical composition and bioactive potential of mushrooms vary with the species, cultivation conditions, and processing methods, highlighting the importance of careful selection and handling. Understanding the chemical and functional diversity of mushrooms supports their use as functional foods and provides insights into their potential applications in nutrition, disease prevention, and therapeutic interventions. Overall, mushrooms represent a natural resource with significant health-promoting properties and promising roles in food and medicinal sciences. This review also highlights the importance of integrating mushrooms into modern dietary systems for improved health outcomes.

Keywords: Mushrooms, Bioactive compounds, Nutritional and therapeutic potential, Biological activities, Functional foods

INTRODUCTION

Mushrooms are macrofungi that belong to the kingdom Fungi. These are biologically and chemically diverse organisms which are distinct from plants. Their unique metabolic characteristics enable to produce a wide variety of secondary metabolites with diverse structures and biological functions (Kalac, 2013; Valverde et al., 2015). The mushrooms have long been known for their organoleptic qualities, including their unique taste, texture, and umami flavor. In recent times, they have gained increasing recognition as functional foods due to scientific evidence supporting their potential role in health promotion and disease prevention (Chang & Miles, 2004; Cheung, 2010).

Fungi represent one of the most diverse groups of living organisms, with the number of species estimating between 2.2-3.8 million throughout the Earth. Among them, approximately 1,50,000 species have been named, nearly 2,000 of them are considered edible, and more than 200 wild species are known for their medicinal significance (Chang & Miles, 2004; Wasser, 2014). Despite this remarkable diversity, the global consumption is limited to a comparably small number of the estimated 14,000-22,000 known mushrooms species, out of which only a few are cultivated commercially (Heleno et al., 2015; Kalac, 2013).

The chemical and nutritional characteristics of medicinal and edible mushrooms are extremely diversified and depend on several intrinsic and extrinsic factors (Kalac, 2013). Additionally, the biological factors such as type of substrate and microbial competition along with the environmental conditions (water availability, light exposure, Ultraviolet radiation) significantly influence the phenotypic appearance and phytochemical profiling of mushrooms (Kalac, 2013; Valverde et al., 2015) (Fig. 1; Table 1). Mushrooms are considered nutritious foods because of their low calories and fat content, while being rich in vitamins, proteins, fibres and minerals (Wang & Zhao, 2023).



Figure 1. Major commercially cultivated mushroom species (Zhou et al., 2024)

NUTRITIONAL PROFILE OF MUSHROOMS

Mushrooms have long been a significant component of the human diet because of their distinctive taste and texture. Their nutritional value has been demonstrated through several studies (Jacinto-Azevedo et al., 2021). The characteristic flavour of mushrooms is widely appreciated by the consumers, which comes from the presence of numerous flavour compounds (Rotola-Pukkila et al., 2019). The nutrient and bioactive profile of mushrooms is of significant interest.

CARBOHYDRATES AND DIETARY FIBER

Carbohydrates represent a significant portion of a mushroom’s biochemical makeup, typically accounting for more than half of its total components (Rathore et al., 2017). While this profile is highly species-dependent, trehalose and mannitol consistently emerge as the primary saccharides in most edible varieties. Beyond their role as an energy reservoir, these specific sugars are fundamental to the sensory and flavor profile of the fungi. Furthermore, minor concentrations of other sugars including raffinose, xylose, and sucrose, have been identified within various mushroom tissues (Cheung, 2010; Marçal et al., 2021).

Mushrooms are known for their high dietary fibre content, which distinguishes them from many other food sources. Mushrooms are reported to contain around 20-33% of insoluble fibre and 4-9% of soluble fibre (Cheung, 2010; Yu et al., 2023). Chitin and β -glucans constitute the majority of insoluble component, serve as structural polysaccharides of fungal cell wall (Kalač, 2013).

Category	Key Compounds	Functions
Polysaccharides	β -glucans, heteropolysaccharides, glycoproteins	Immunomodulatory, anticancer, cholesterol-lowering
Phenolic compounds	Caffeic acid, ferulic acid gallic acid, p-coumaric acid	Antimicrobial, antioxidant, anti-inflammatory
Flavonoids	Flavonols, flavones, flavanones, isoflavones, anthocyanidins	Antioxidant; may originate from substrate absorption
Tannins	Hydrolyzable tannins, condensed tannins; found in Agaricus	Antioxidant, antimicrobial
Terpenes /Terpenoids	Sesquiterpenoids, lanostane-type triterpenoids, carotenoids	Antioxidant, anti-inflammatory, anticancer, neuroprotective,
Sterols & Phytosterols	Ergosterol (fungal sterol), β -sitosterol, campesterol,	Cholesterol-lowering, antioxidant
Tocopherols (Vitamin E)	A-, β -, γ -, δ -tocopherols; high in Pleurotus ostreatus, Neolentinus	Antioxidant, cardioprotective, neuroprotective
Proteins & Peptides	Fungal immunomodulatory proteins (FIPs), laccases,	Immunomodulatory, antioxidant

Table 1. Major bioactive compounds found in mushrooms, with examples and functions

PROTEIN AND LIPID

Mushrooms are considered a valuable food source because they contain high levels of protein and all essential amino acids. The protein content generally varies from 18-37 % of their dry mass, depending on the species and developmental stage (Cheung, 2010; Gonzalez et al., 2020). As per Food and Agriculture Organization (FAO) standards, Mushroom protein is nutritionally better and has been suggested as a good alternative to animal protein, particularly in vegetarian diets (Kato et al., 2009). Essential amino acids generally constitute 30-50 g per 100 g of mushroom protein, although the ratios differ in different species (Aletor, 1995; Manzi et al., 2001). Among the amino acids present, aspartic acid, glutamic acid, threonine and arginine, are exceptionally abundant in mushroom proteins. Mushrooms contain certain rare amino acids, including γ -aminobutyric acid and ornithine, whereas some species may contain comparatively low amounts of leucine and lysine (Cheung, 2010; Rathore et al., 2017).

Mushrooms are characterized by a low levels of lipids, accounting for 2-6% of dry matter (Cateni et al., 2021). The lipid component is mainly composed of unsaturated fatty acids (Linoleic and Oleic acids), which generally predominate over saturated fatty acids, approximately 2:1 (Correa et al., 2016; Sande et al., 2019). Linolenic acid contributes to the characteristic aroma of mushrooms, by serving as a precursor of 1-octen-3-ol, a key compound responsible for the typical mushroom flavour (Guillamon et al., 2010).

VITAMINS AND MINERALS

Mushrooms are important sources of vitamins B-complex, such as niacin, riboflavin and folate. High levels of these vitamins have been reported in many mushrooms species including *Agaricus bisporus* and *Pleurotus* spp. (Kalac, 2013; Manzi et al., 2001). They are also considered a valuable non-animal source of vitamin D2. The ergosterol present in

mushrooms undergoes a conversion process into Vitamin D₂, also known as ergocalciferol when subjected to UV radiation or natural sunlight (Phillips et al., 2021; Simon et al., 2011).

Mushrooms provides significant amount of various minerals such as phosphorus, potassium, zinc and magnesium. The smaller amounts of calcium, iron, and copper are also present (Kalac, 2019). *Agaricus bisporus* is a widely cultivated commercial mushroom species, which is particularly rich in potassium and phosphorus (Zhang et al., 2018). Mushrooms are known to accumulate heavy metals, such as cadmium, chromium, and nickel, particularly, when they grow in contaminated areas (Falandysz et al., 2020). Thus, cultivation in the low contaminated regions is essential to ensure the food safety, and especially in the areas where the wild mushrooms are commonly consumed.

PHENOLIC ACIDS

Mushroom are recognized to contain all four major classes of phenolic compounds, though the exact composition and amount vary with species. These classes are phenolic acid-hydroxybenzoic acid derivatives, phenolic acid-hydroxycinnamic acid derivatives, flavonoid compounds and tannins (Fig. 2). These non-flavonoid metabolites are primarily categorized into two groups: derivatives of cinnamic acid (C₆-C₃) and benzoic acid (C₆-C₁).

Common phenolic acids identified in mushrooms include caffeic, cinnamic, ferulic, gallic, p-coumaric, protocatechuic and p-hydroxybenzoic (Alkan et al., 2020; Mostafiqu et al., 2013; Nowacka et al., 2014; Taofiq et al., 2015) (Fig. 2). Quantitative analyses have demonstrated significant variations depending on mushroom species and extraction methods. For example, ferulic and gallic acids are predominant in *Agaricus brasiliensis*, whereas sinapic and rosmarinic acids are commonly found in *Hyphodontia paradoxa*. Similarly, gallic or caffeic acid has been reported as the dominant phenolic acid in *Inonotus obliquus*, *Lentinula edodes*, and *Pleurotus pulmonarius* (Bach et al., 2019; Islam et al., 2016; Nowacka et al., 2015).

FLAVONOIDS

Certain mushroom species contain flavonoids which may account for a considerable proportion of their phenolic compounds (Manach et al., 2004). Structurally, Flavonoids possess a C6-C3-C6 basic structure and are classified into several groups, including flavones, flavanones, isoflavones, flavonols and anthocyanidins, based on the oxidation state of the central ring (Gonzalez-Vallinas et al., 2013; Lewandowska et al., 2016). These flavonoids are synthesized by plants, by using phenylpropanoid pathway and malonyl-CoA pathway. Although it is believed that mushrooms do not synthesize flavonoids endogenously. Instead, it is likely that an appearance of flavonoid in mushrooms was caused by its growing media or surrounding plants (Gil-Ramirez et al., 2016).

TANNINS

Tannins are phenolic secondary metabolites which are found in various mushroom species. They are broadly categorized into hydrolyzable and condensed tannins based on their chemical structure (Okuda & Ito, 2011). Quantitative studies have reported variable tannin contents in mushrooms, with significant amounts being found in *Agaricus silvaticus*, *Hydnum rufescens*, *Meripilus giganteus* and *Pleurotus tuber-regium*, (Akindahunsi and Oyetayo, 2006; Garrab et al., 2019). The concentration of tannin depends on species, extraction solvents, and processing environments, including cooking, which could cause decline in tannin concentration (Pavithra et al., 2016; Kant Mishra et al., 2016).

PHYTOSTEROLS AND PHYTOSTANOLS

Phytochemicals structurally related to cholesterol are collectively referred to as phytosteroids, also called as membrane-associated phytochemicals. Depending on branching of side chains and saturation, they are categorized as β -sitosterol, campesterol, stigmasterol, stigmasterol, and cholesterol (Jones et al., 2017). Mushrooms have been reported to contain campesterol and brassicasterol, while other phytosterols are found in low concentrations (Barros et al., 2014; Heleno et al., 2010).

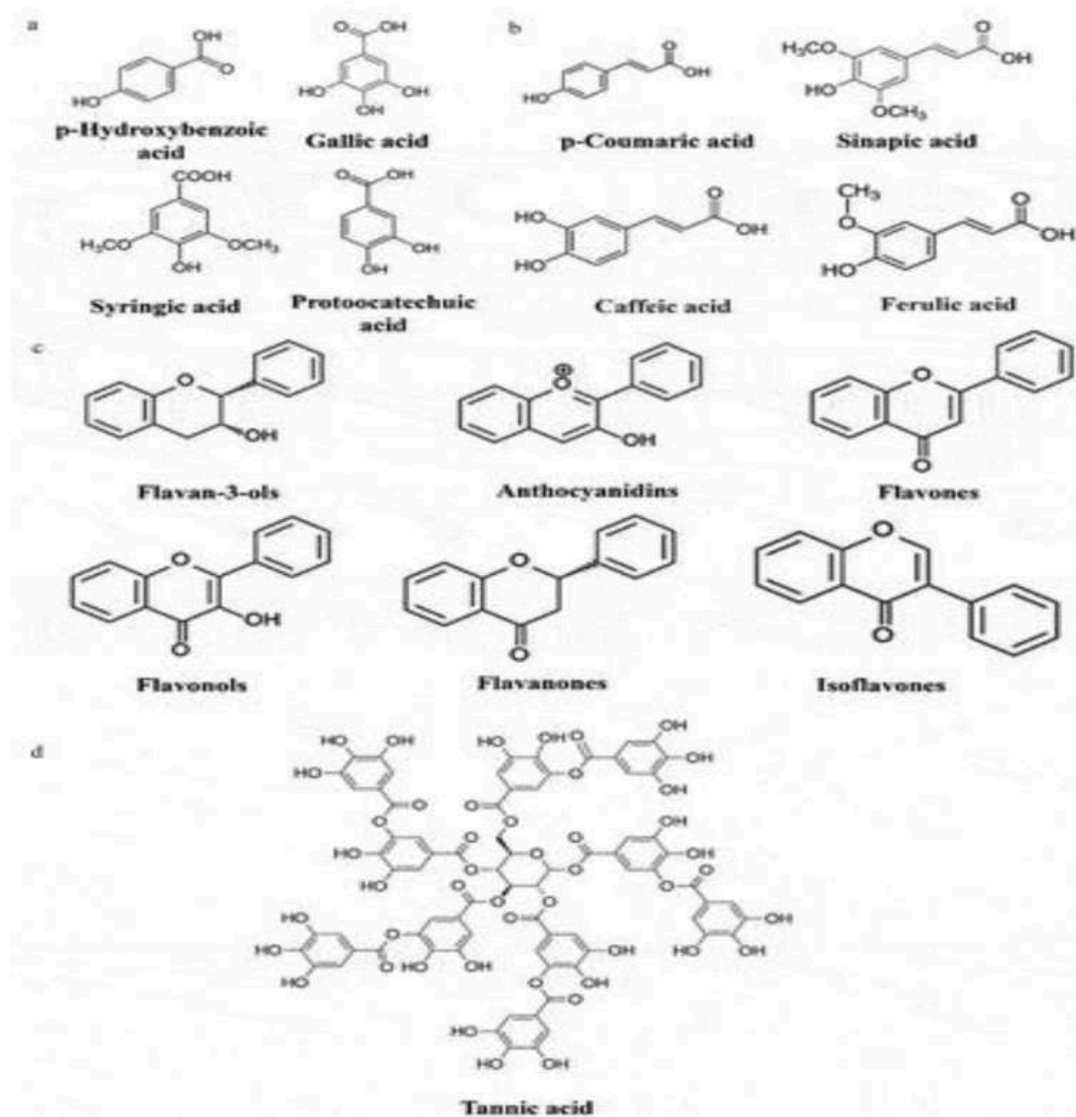


Figure 2. Four major classes of phenolic compounds and their chemical structures (Zhou et al., 2024)

Phytosterols and phytostanols both are recognized for their therapeutic capacity to reduce systemic cholesterol, specifically by targeting low-density lipoprotein (LDL) levels. Both have similar efficacies in reducing LDL cholesterol at a recommended intake of 2 g/day, but they differ in chemical structure, absorption in the intestine, and natural dietary availability (Plat et al., 2019; Ras et al., 2014). Although the main sterol in fungi is ergosterol, it differs from plant derived phytosterols, as it is unique to fungi, and not found in plants.

TERPENES

Terpenes are unsaturated hydrocarbons, available in the form of mono-, sesquides, di-, tri- terpenes and carotenoids according to the number of carbon (Duru & Cayan, 2015). Mushrooms are particularly rich in sesquiterpenoids and lanostane-type triterpenoids, possessing pharmaceutical and therapeutical potential due to their antimicrobial, anti-inflammatory, antioxidant, anticancer and neuroprotective bioactivities (Asakawa et al., 2014; Kumari et al., 2021).

TOCOPHEROLS

Tocopherols are lipid-soluble vitamin E homologues, including α -, β -, γ -, and δ -tocopherols, and are known for their anti-inflammatory, anti-oxidant, cardioprotective and neuroprotective properties (Heleno et al., 2010; Shahidi, 2000). Among mushrooms, α -tocopherol has been identified at relatively high levels in *Pleurotus ostreatus*, *Neolentinus lepideus* and *Morchella esculenta*, contributing to the overall antioxidant potential (Bouzgarrou et al., 2018; Quintero-Cabello et al., 2019). Even though their concentrations are quite low, tocopherols contribute to the muscle nutritional as well as antioxidant qualities (Antunes et al., 2020; Yu et al., 2023).

Conclusion

Mushrooms are affluent in bioactive compounds for instance phenolics, proteins, polysaccharides, terpenes and sterols etc., which supports their salutary and therapeutic properties. These compounds provide anti-inflammatory, antioxidant, immunomodulatory and cholesterol-lowering benefits, making mushrooms valuable functional foods. Careful selection of species and cultivation conditions can further enhance their health-promoting potential.

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PLANT-MEDIATED SILVER NANOPARTICLES: MECHANISMS, PROPERTIES, BIOLOGICAL ACTIVITIES AND APPLICATIONS

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ABSTRACT

Biogenic synthesis of silver nanoparticles (AgNPs) involving the plant extracts has emerged as a sustainable and environment friendly alternative to conventional physical and chemical methods. The present paper explains how different compounds found in medicinal plants, like alkaloids, flavonoids, polyphenols and terpenoids, help in reduction, capping and stabilization of AgNPs. The process of formation of nanoparticles is explained along with important factors that influence synthesis such as pH, temperature, extract concentration, and reaction time. This review covers different aspects of nanotechnology, including various techniques used to confirm nanoparticle formation and their properties (UV-Vis spectroscopy, TEM, XRD, and FTIR) along with the biological activities of silver nanoparticles (antimicrobial, antifungal, antioxidant, anti-diabetic, and anti-cancer properties) along with their applications. There are still challenges including issues with reproducibility, scalability, and stability, which need to be solved for further progress.

Keywords: Biogenic synthesis, Silver nanoparticles, Plant extracts, Medicinal plants, Nanotechnology, Biological activities

1. INTRODUCTION

Nanoparticles are tiny particles measuring 1 to 100 nm in size, possessing unique chemical and physical characteristics.

Compared to their size, they have a big surface area. Among different types of metal nanoparticles, silver nanoparticles (AgNPs) are studied mostly, because they have strong antimicrobial, antifungal, and anticancer properties. Most traditional chemical or physical methods for synthesis of AgNPs involve toxic chemicals and pure silver salts which leads to environmental pollution. These nanoparticles are also expensive and unsustainable for mass production.

Biogenic synthesis of nanoparticles uses natural plant materials, which can act as reducing agents as well as stabilizers, avoiding the need for harmful chemical substances. Plants contain various phytochemicals - flavonoids, alkaloids, terpenoids, polyphenols, which help to reduce silver ions and keep the nanoparticles stable. Medicinal plants like *Tinospora cordifolia* (Giloy), *Trigonella foenum-graecum* (Fenugreek), and *Catharanthus roseus* (Sadabahar) are especially useful for this process because they have a wide range of phytochemicals.

This review covers how plants help to synthesize AgNPs, the role of different plant compounds in the process, and the factors that affect nanoparticle formation with their biological activities and applications, as well as the challenges and future possibilities in the field of research.

2.SILVER NANOPARTICLES: AN OVERVIEW

Silver nanoparticles are small sized metal particles having high surface-to-volume ratio. These distinctive features make them very popular in many areas like medicine, farming, environmental science, and biotechnology.

3.PROPERTIES OF SILVER NANOPARTICLES

AgNPs possess unique physical, optical, chemical and biological characteristics, which are as follows

3.1 *Physical Properties*

- High surface area to volume ratio enhances reactivity and solubility
- Typical sizes range from 1-100 nm
- Shapes include spheres, rods, triangles, plates, cubes

3.2 *Optical Properties*

- Localized Surface plasmon resonance (LSPR) causes strong light absorption/scattering, peaking at 400-450 nm for spheres
- Peak shifts with size/shape: smaller spheres absorb (~400 nm), larger scatter (longer wavelengths)

3.4 *Chemical Properties*

- Excellent catalytic activity due to active surface atoms
- Stable in various media with capping agents like PEG for salt resistance
- Release Ag⁺ ions, contributing to reactivity

3.5 *Biological Properties*

- Strong antibacterial/ antifungal activity via membrane disruption
- Antioxidant and anticancer potential, enhanced by green synthesis coatings

4. GREEN SYNTHESIS OF SILVER NANOPARTICLES

Plant derived AgNPs is a sustainable environment friendly method, in which plants, microbes or any other natural system can be used to synthesize nanoparticles without the high energy use or harmful chemicals. This process uses naturally occurring biomolecules as both reducing and stabilizing agents to produce affordable nanoparticles (Figure 1).

4.1 ROLE OF PLANT EXTRACTS IN AGNP SYNTHESIS

4.1.1 Reducing agents: Flavonoids, polyphenols, terpenoids help to turn Ag^+ ions from AgNO_3 into Ag^0 (metallic silver) by giving up electrons or hydrogen.

4.1.2 Capping/stabilizing agents: They coat the surface of nanoparticles, preventing them from clumping together and controlling their size and shape. Proteins, alkaloids prevent aggregation via steric/electrostatic repulsion.

4.1.3 Shape/size control: Extract composition (e.g., Neem, Tulsi) influences monodispersity and bioactivity.

Plant Extract $\longrightarrow$ Phytochemicals $\longrightarrow$ Reduction of Ag^+ $\longrightarrow$ Formation of Ag^+ nuclei $\longrightarrow$ Growth of Nanoparticles $\longrightarrow$ Stabilization by Plant Molecules

Fig. 1. Mechanism of plant-mediated silver nanoparticles

5. FACTORS AFFECTING GREEN SYNTHESIS OF AGNPS

The properties of AgNPs are greatly affected by the conditions used during their creation:

5.1 pH: When the solution is neutral to slightly basic (pH 7–10), it helps plant-based reducing agents work better, leading to quicker nanoparticle formation.

5.2 Temperature: Keeping the solution at 25 to 40°C is ideal. The reaction speed increases when the temperature reaches 60°C.

5.3 Silver nitrate concentration: Using low amounts (0.5–2 mM) generally results in smaller and more uniform AgNPs.

5.4 Reaction time: The reaction should be allowed to run for 1 to 24 hours. If it continues for long hours, the nanoparticles may become unstable.

These factors should be carefully adjusted to make sure the green-synthesized AgNPs are consistent in size, shape, stability, and effectiveness.

6. CHARACTERIZATION TECHNIQUES OF GREEN-SYNTHESIZED AGNPS

Characterization is important to check the formation, size, shape, purity, and stability of green-synthesized AgNPs. Various tools are used to study the properties of AgNPs, which are as follows:

6.1 UV–VISIBLE SPECTROSCOPY (UV-VIS)

It detects the surface plasmon resonance peak at 400-450 nm, indicating AgNP formation and balance. No peak shift denotes monodispersity.

6.2 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

It identifies functional groups of phytochemicals from plant extracts that can cap or stabilize AgNPs. Typical peaks include a broad absorption band at 3400 cm^{-1} , which is characteristic of O–H stretch stretching vibrations, likely originating from the phenolic compounds present in the plant extract. Additionally, the presence of carbonyl (C=O) groups, typically indicated by a strong, sharp absorption peak in the $1600 - 1700\text{ cm}^{-1}$ range, Concurrently, C–O stretching, which is characteristic of ethers, esters, or alcohols, is confirmed by peaks in the $1000\text{--}1400\text{ cm}^{-1}$ region.

6.3 X-RAY DIFFRACTION (XRD)

It determines the crystal structure of NPs, which shows the specific diffraction peaks at 2θ angles of 38.1° , 44.3° , 64.4° , and 77.4° , corresponding to the face-centered cubic (FCC) structure of silver. The crystallite size was estimated to be approximately 20 -30 nm using the Debye-Scherrer equation.

6.4 SCANNING AND TRANSMISSION ELECTRON MICROSCOPY (SEM / TEM)

SEM gives detailed images of the surface structure and how nanoparticles cluster together.

TEM provides information about the internal structure, size (e.g., 10–50 nm), and shape (spherical, triangular) of the nanoparticles.

7. BIOLOGICAL ACTIVITIES OF GREEN SYNTHESIZED AGNPS

Biogenic synthesized AgNPs exhibit significant biological effects because they release silver ions (Ag^+), create reactive oxygen species (ROS), and work together with biomolecules from plants (Table 1).

7.1 ANTIBACTERIAL ACTIVITY

AgNPs can damage bacterial cell walls and membranes, leading to the leakage of important cell contents and eventually killing the bacteria. Gram-negative bacteria like *Escherichia coli* is usually more sensitive because of their thinner cell walls, whereas Gram-positive bacteria such as *Bacillus subtilis* tend to be more resistant.

7.2 ANTIFUNGAL ACTIVITY

Green-synthesized AgNPs stop fungal growth by damaging cell membranes and disrupting metabolic processes. They affect fungi like *Candida albicans* and *Aspergillus niger*.

7.3 ANTIDIABETIC ACTIVITY

Green-synthesized AgNPs can block enzymes such as α -amylase and α -glucosidase which helps control blood sugar levels hence managing diabetes.

7.4 ANTICANCER AND CYTOTOXIC ACTIVITY

Green-synthesized AgNPs can induce apoptosis in cancer cells. They often target tumour cells more than healthy cells, which makes them a promising approach for cancer treatment.

Table 1. Biological Activities of Green-Synthesized AgNPs

Plant Extract	Activity/ Application	Target / Pathogen / Use	Effect / Result		Reference
			ZOI (nm)	MIC (μ g/mL)	
Giloy leaves	Antibacterial	<i>Escherichia coli</i>	18	20	Sharma et al., 2020
Neem leaves	Antibacterial	<i>Pseudomonas aeruginosa</i>	20	15	Singh et al., 2021
Fenugreek seeds	Antifungal	<i>Aspergillus flavus</i>	16	20	Kumar et al., 2022
Giloy stems	Antifungal	<i>Fusarium oxysporum</i>	17	25	Sharma et al., 2020
			IC ₅₀ (μ g/mL)		
Tulsi leaves	Antidiabetic	α -Glucosidase /	30 / 50		Gupta et al., 2023
Fenugreek seeds	Antidiabetic	α -Glucosidase /	40 / 65		Kumar et al., 2022
Sadabahar leaves	Antioxidant	DPPH radicals	35		Patel et al., 2021
Amla fruit	Antioxidant	DPPH radicals	28		Rao et al., 2022
Neem leaves	Anticancer	MCF-7 cells	25		Singh et al., 2021
Sadabahar leaves	Anticancer	HeLa cells	18		Patel et al., 2021

Note: Quantitative assessment of the plant extracts involved determining the Zone of Inhibition (ZOI) for microbial susceptibility and the Minimum Inhibitory Concentration (MIC) for potency. Furthermore, the antioxidant and anticancer capacities were benchmarked using the half-maximal inhibitory concentration (IC₅₀), where a lower value signifies a more potent biological response. IC₅₀ denotes the concentration required to inhibit 50% of cellular viability.

8. APPLICATIONS OF GREEN-SYNTHEZED AGNPS

Stable, active, and environmentally friendly green-synthesized AgNPs can be used in different fields (Table 2):

Table 2. Applications of Green-Synthesized AgNPs

Plant Extract	Activity / Application	Target Pathogen / Use	Effect / Result	Reference
Sadabahar leaves	Biomedical/ Diagnostics	Cancer detection	IC ₅₀ 18 µg/mL	Patel et al., 2021
Tulsi leaves	Biomedical/ Diagnostics	Biomarker detection	95% detection	Gupta et al., 2023
Giloy stems	Drug Delivery	Doxorubicin	85% release at pH 5.5	Sharma et al., 2020
Neem leaves	Drug Delivery	Antibiotics	2.5x solubility	Singh et al., 2021
Neem leaves	Food Packaging	<i>Salmonella</i>	Shelf life extended 7–10 days (Fruits)	Singh et al., 2021
Green tea	Food Packaging	<i>Listeria</i>	Shelf life extended 15 days (Meat)	Safa et al., 2025
Tulsi leaves	Water Treatment	<i>Escherichia coli</i>	95% removal	Gupta et al., 2023
Banana peel	Water Treatment	Methylene blue dye	82.6% removal in 120 min	Ibrahim et al., 2015
Fenugreek seeds	Agriculture	<i>Fusarium</i> control	80% inhibition	Kumar et al., 2022
Neem leaves	Agriculture	Seed germination	25% increase	Singh et al., 2021

8.1 BIOMEDICAL APPLICATIONS

Silver nanoparticles are used for fighting microbes, sensing biological changes, and killing cancer cells. They can find and attack sick cells without harming healthy ones.

8.2 DRUG DELIVERY

AgNPs made with plant materials can carry and slowly release medicines. This helps the body absorb the drugs better and deliver them to the right place.

8.3 FOOD PACKAGING

AgNPs are added to packaging materials used for food. This helps prevent food from spoiling and makes it last longer.

8.4 WATER TREATMENT

AgNPs can clean water by removing harmful substances and killing bacteria and other harmful microorganisms.

8.5 AGRICULTURE

AgNPs are used to help seeds grow, protect plants from pests, and help them handle stress. This reduces the need for chemical treatments.

9. LIMITATIONS AND CHALLENGES OF GREEN-SYNTHEZIZED AGNPS

Despite advantages, green synthesis has certain limitations for practical and commercial applications (Table 3).

Table 3. Challenges of Green synthesized AgNPs alongwith the possible solutions.

Limitation / Challenge	Description / Impact	Possible Solutions
Reproducibility	Lack of standardized protocols for extract preparation, concentration, pH, and temperature, leading to polydispersity.	Standardized plant cultivation, selection of consistent plant parts.
Scale-up Issues	Lab-scale synthesis (10–100 mL) does not directly translate to industrial volumes; Batch-to-batch variability occurs because phytochemical profiles of plant extracts are influenced by environmental, seasonal and genetic factors.	Use continuous flow reactors and optimized plant-based industrial setups.
Scale-up Issues	Long-term aggregation despite capping; sensitive to pH, light, and salts.	Lyophilization, polymer encapsulation, or refrigeration to extend shelf life.

10. Conclusion

The plant extract mediated silver nanoparticles provide a sustainable and environment friendly alternative to conventional methods. Medicinal plants such as giloy, fenugreek and sadabahar contain diverse bioactive compounds that function as reducing and stabilizing agents. These phytochemicals enable the synthesis of silver nanoparticles, which exhibit enhanced biological activities including antimicrobial, antioxidant, anti-cancer, anti – inflammatory and wound healing properties. Owing to these biological activities, biogenic AgNPs have potential applications in biomedicine, drug delivery, food packaging, water treatment and agriculture. Despite challenges in achieving consistency, scalability, and stability during synthesis, recent advancements in nanotechnology are expected to improve the production and practical use of plant mediated silver nanoparticles across diverse fields.

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VITEX NEGUNDO: A TREASURE TROVE OF MEDICINAL AND ETHNOBOTANICAL SIGNIFICANCE

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INTRODUCTION

Vitex negundo, commonly referred to as the five-leaved chaste tree, is a deciduous shrub belonging to a genus that includes nearly 250 species. Based on molecular (DNA sequence) evidence, the APG IV classification system (2016) places this species within the family Lamiaceae (Thomas et al., 2012), although it was previously assigned to the subfamily Viticoideae under Verbenaceae. The plant typically exhibits tri- or penta-foliolate leaves borne on quadrangular stems and produces bluish-purple flowers arranged in branched, tomentose cymes. The Plants have significant medicinal properties and are utilized in a number of conventional medical systems, including Ayurveda, Chinese, Siddha, and Unani, for the medical intervention of diverse illness. *Vitex negundo* is used as a poultice for tubercular neck swelling, sinus infections, neck gland sores, and headaches. A root bark solution of *V. negundo* relieves dysmenorrhea, rheumatism, and irritable bladder, it is used to treat asthma, toothaches, and cancer. In Jharkhand, the bark and leaves are used to alleviate headaches and muscle aches. It is used to reduce body aches, while in Assam it is employed to treat liver disorders, urticaria, eczema, jaundice, and to manage kwashiorkor (Basri et al., 2014).

GEOGRAPHICAL DISTRIBUTION OF *VITEX NEGUNDO*

Vitex negundo L. occurs extensively throughout South and Southeast Asia, where it grows both as a native and a naturalised species. In South Asia, its natural distribution includes India, Nepal, Sri Lanka, Pakistan, Bangladesh, and Bhutan.

Across Southeast Asia, the plant is widely recorded in countries such as Myanmar, Thailand, Vietnam, Cambodia, Malaysia, Indonesia, and the Philippines. The plant is also distributed in East Asia, including China, Japan, Korea, and Taiwan, and extends into West Asia, particularly Afghanistan. Outside of Asia, *Vitex negundo* has become naturalised in parts of Africa, especially in eastern regions such as Kenya, Tanzania, Mozambique, and Madagascar. In India, the geographical distribution of *Vitex negundo* L. is extensive, and it is found in various agro-climatic zones. Within India, *Vitex negundo* is widely distributed across the northern and central regions, with its presence reported from states such as Uttar Pradesh, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Himachal Pradesh, as well as the Delhi National Capital Region.

Vernacular names and medicinal uses of *Vitex negundo*

S.no	Language /Region	Vernacular Name	Plant Part	Medicinal & Traditional Uses
1.	English	Five leaved chase tree	Leaves	Reduces joint pain, swelling, cough, and headaches.
2.	Gujarati	Nagod	Bark	Treats fever, urinary complaints, and rheumatism.
3.	Bengali	Nishinda	Flower	Used for diarrhea, liver disorders, and fever.
4.	Kannada	Lakkigida	Fruit	
5.	Malayalam	Vellanochi	Seed	Relieves nervous disorders and menstrual pain.
6.	Punjabi	Banna	Root	
7.	Assamese	Posutia	Stem	Used for skin diseases and as a cooling agent.
8.	Himachal Pradesh	Bana		Heals wounds and improves digestion.
9.	Manipuri	Urikh Shibi		
10.	Telugu	Vavili		

HABITAT

Vitex negundo grows well from sea level to elevations of approximately 2,000 meters and occurs in warm, temperate to tropical climates. The species typically occurs in areas receiving annual rainfall between 600 and 2,000 mm and is capable of withstanding brief exposure to low temperatures, tolerating cold conditions of up to -10°C . Propagation is easily achieved through stem cuttings, and root suckers also serve as effective planting material (Dass & Muralidharan, 2021). The species is easy to cultivate and prefers light, loamy, well-drained soils in warm, bright environments protected from dry, cold winds.

MORPHOLOGICAL CHARACTERISTICS

Vitex negundo L. is a long-lived, aromatic woody plant that grows as a shrub or small tree, usually reaching a height of about 2–5 m. It is well adapted to tropical and subtropical climates and occurs across diverse habitats, favouring open areas with ample sunlight while also enduring mild shade. The leaves are opposite, exstipulate, and palmately compound, usually with three to five leaflets.

It exhibits a long, active phenological cycle, flowering from June to December (often peaking April–October) and fruiting from September to February. The leaflets are lanceolate to ovate-lanceolate, with the central leaflet being larger than the lateral ones.

The adaxial surface of the leaf is deep green and smooth, whereas the abaxial surface appears paler and is covered with dense hairs, particularly along the vein network. Leaf edges range from smooth to faintly toothed, the tips are sharply pointed, and the venation is clearly visible. The inflorescence is a terminal and axillary, branched cymose panicle that is dense and pubescent. The flowers are small, bisexual, zygomorphic, and blue-violet to light purple in color. They are five-parted, with a bilabiate corolla and a hairy, bell-shaped calyx that persists in the fruit.

The androecium consists of four didynamous stamens, while the gynoecium is bicarpellary and syncarpous with a superior, four-chambered ovary. A long style with a bifurcated stigma extends beyond the stamens, indicating adaptation for insect pollination. The fruit is a small, spherical to ovoid drupe, approximately 3–6 mm in diameter. Upon ripening, it turns from green to black or dark purple.

PHYTOCHEMICAL PROPERTIES OF *VITEX NEGUNDO*

Vitex negundo L. is an extensively studied medicinal species, valued for its complex and abundant phytochemical profile that supports its applications in both traditional and contemporary healthcare systems. Comprehensive phytochemical studies on different plant parts—such as the leaves, roots, bark, flowers, fruits, and seeds—have identified a broad spectrum of biologically active secondary compounds. Compounds such as casticin, luteolin, orientin, isoorientin, vitexin, and isovitexin have been primarily isolated from the leaves and aerial parts (Basri et al., 2014). These flavonoids are known for their potent antioxidant, anti-inflammatory, and analgesic properties, which correlate well with the plant's traditional uses in treating pain, inflammation, and fever. Alkaloids, although present in smaller quantities, have been found in the roots and seeds of *Vitex negundo*. These alkaloidal fractions are believed to contribute to the plant's analgesic, antipyretic, and central nervous system modulating effects. The phytochemical composition of *Vitex negundo* can vary depending on geographical location, plant part, developmental stage, and environmental conditions.

THE PHARMACOLOGICAL ACTIVITIES OF *VITEX NEGUNDO*

Vitex negundo exhibits broad pharmacological activities, including potent anti-inflammatory, analgesic, antioxidant, hepatoprotective, and anticancer effects, due to its rich phytochemicals like flavonoids and essential oils, making it valuable in traditional medicine for conditions like arthritis, asthma, and liver disorders, with ongoing research exploring its neuroprotective, antimicrobial, and cardioprotective potential.

Antipyretic activity- The antipyretic activity of the leaf extract was assessed using a yeast-induced pyrexia model. Treatment with the methanolic extract produced a marked reduction in elevated body temperature, an effect likely associated with the presence of flavonoids, compounds recognized for their ability to suppress lipid peroxidation.

Hepatoprotective Activity- Protective effects of *Vitex negundo* leaf extract against hepatic injury were observed through its ability to counteract CYP2E1-mediated CCl₄ toxicity in human liver cells. These effects are believed to arise from suppression of oxidative lipid damage, regulation of intracellular calcium homeostasis, and inhibition of calcium-regulated proteolytic enzymes.

Insecticidal and Pesticidal Activities- A wide range of insecticidal activities has been attributed to products derived from *V. negundo*, with effectiveness reported against pests infesting stored commodities, mosquito larvae, houseflies, and larvae feeding on tobacco leaves. Of special interest, the essential oil obtained from the leaves has shown marked repellent activity against storage pests (Deshmukh et al., 1982; Prakash & Mathur, 1985; Hebbalkar et al., 1992).

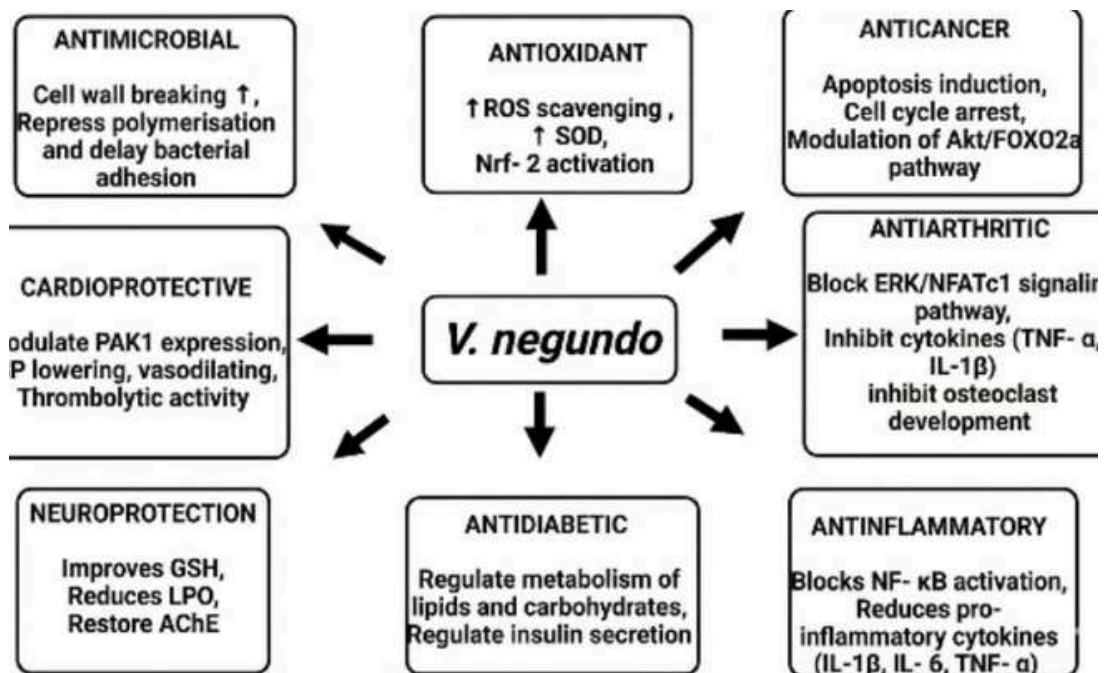
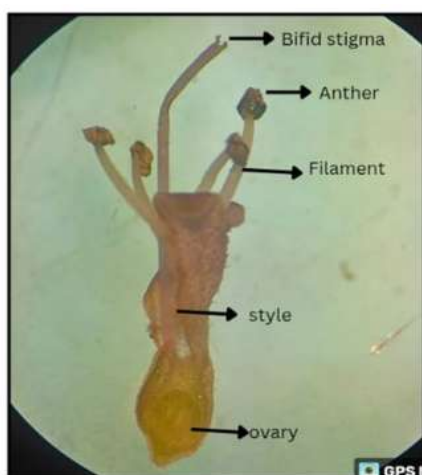


Fig: Vitex negundo L.: (a) Habit showing vegetative parts with leaves and fruiting twig; (b) Inflorescence bearing flowers; (c) Dissected flower showing bifid stigma, anther, filament, style, and ovary.



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DATURA STRAMONIUM: THE DEVIL'S TRUMPET

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INTRODUCTION

Datura stramonium, popularly known as Jimson weed, Devil's trumpet, or Thorn apple, is one of the most intriguing plants found in nature. Belonging to the Solanaceae family, it is widely distributed across tropical and temperate regions of the world, comprising India. This plant has attracted attention for centuries due to its dual nature; serving both as a medicinal herb and a toxic plant. Its striking morphology, combined with its powerful chemical constituents, makes it a theme of great interest in botany, pharmacology, and standard



TAXONOMY AND BOTANICAL DESCRIPTION

Datura stramonium pertains to the Kingdom Plantae, order Solanales, and the family Solanaceae; a family that furthermore includes tomato, potato,

tobacco, and belladonna. The genus *Datura* comprises approximately nine to twelve species, with *D. stramonium* being the most pervasive and far-reaching and thoroughly examined.

Botanically, *D. stramonium* is an erect, branching annual herb that commonly increases between 0.5 and 1.5 meters in height under favourable conditions. Its stems are hollow and pale green to purplish in colour. The leaves are huge and massive, ovate to triangular, with an irregularly toothed or lobed margin, and emit a distinctively pungent odour when crushed; a caution signal evolved to deter herbivores.

The flowers are maybe the plant's most striking feature: huge and massive, trumpet-shaped, white to pale violet blooms that open in the evening and is pollinated primarily by hawk moths. The fruit is a spiny, egg-shaped capsule; the 'thorn apple'; that splits open at maturity to disclose multiple and diverse dark, reniform (kidney-shaped) seeds. It is in these seeds, as well as the leaves and roots, that the plant concentrates its most potent chemical arsenal.

GEOGRAPHIC DISTRIBUTION AND HABITAT

Originally native to Central America and the Caribbean, *Datura stramonium* has attained near-global distribution through human activity; both intentional cultivation and accidental dispersal. Today, it is found across North America, Europe, Asia, Africa, and Australia, thriving in a broad range of disturbed habitats: roadsides, agricultural fields, rubbish grounds, railway embankments, and the margins of human settlements.

This ecological adaptability reflects the plant's exceptional and striking resilience. It tolerates a broad spectrum of soil kinds, withstands balanced drought, and produces copious seeds that can continue feasible in the soil for decades. In agricultural contexts, *D. stramonium* is evaluated a noxious weed, capable of contaminating grain crops such as wheat and millet; with severe implications for food safety, as its alkaloids can persist even through processing.

CHEMICAL COMPOSITION: THE TROPANE ALKALOIDS

The pharmacological attributes of *Datura stramonium* are almost completely attributable to a category of compounds known as tropane alkaloids; chiefly atropine (dl-hyoscyamine), scopolamine (hyoscine), and hyoscyamine. These alkaloids are present throughout the plant, with the supreme and paramount concentrations found in the seeds (up to 0.4–0.6% by dry weight), followed by the leaves, flowers, and roots.

Mechanistically, these alkaloids function as potent competitive antagonists of muscarinic acetylcholine receptors in the parasympathetic nervous system. By blocking these receptors, they generate a constellation of anticholinergic effects: pupil dilation (mydriasis), increased heart rate (tachycardia), inhibition of salivary and sweat secretions, seamless and effortless muscle relaxation, and; at sufficient doses; deep and intense modifications in awareness, hallucinations, delirium, and amnesia.

Scopolamine, in specific, crosses the blood-brain obstacle with greater ease than atropine, making it extremely active in the central nervous system. This attribute underlies both its therapeutic applications and its potential for abuse and toxicity.

MEDICINAL AND THERAPEUTIC APPLICATIONS

Despite its toxic reputation, *Datura stramonium* has a rich history of medicinal application across varied cultural and medical traditions. In Ayurvedic medicine, it has been utilized for centuries under the name *Dhatura* in the management of asthma, bronchospasm, and rheumatic pain. Smoking dried *Datura* leaves; a practice known as stramonium smoking; was once an identified treatment for bronchial asthma in European medicine, predating the arrival of modern bronchodilators.

Contemporary pharmacology has confirmed and refined numerous of these conventional applications. Scopolamine derived from *Datura* species is now an FDA-approved pharmaceutical, broadly used in transdermal patch form for the avoidance of motion illness and post-operative nausea. Atropine remains a vital drug in modern medicine, used to treat bradycardia (abnormally slow heart rate), as a pre-anaesthetic agent, in ophthalmology for pupil dilation, and critically, as an antidote to organophosphate poisoning and nerve agent exposure.

Research is moreover exploring the neuroprotective potential of scopolamine in Alzheimer's disease models, and its quick and fast antidepressant effects; noted in clinical trials; have generated notable scientific interest, potentially opening new paths in the treatment of important and significant depressive disorder.

TOXICOLOGY: A PLANT THAT DEMANDS RESPECT

The therapeutic and toxic doses of *Datura* alkaloids are separated by an extraordinarily narrow margin; a pharmacological actuality that makes this plant notably risky and hazardous. Cases of *Datura* poisoning are reported globally with alarming regularity, emerging from accidental intake, deliberate recreational misuse, and, in rare instances, criminal intent.

The timeless toxidrome of *Datura* poisoning; summarised in the clinical mnemonic as 'blind as a bat, mad as a hatter, red as a beet, hot as a hare, dry as a bone'; captures the hallmark anticholinergic syndrome: serious mydriasis leading to photophobia, delirium and hallucinations, flushing, hyperthermia, and anhidrosis (lack of sweating). In serious instances, the state progresses to seizures, respiratory failure, cardiovascular collapse, and demise.

Critically, the alkaloid information of *D. stramonium* changes substantially between individual plants, plant parts, and growing conditions; making self-dosing or recreational application intrinsically variable and random and extraordinarily hazardous. There is no antidote distinct to *Datura* poisoning; management is largely supportive, with physostigmine used in serious anticholinergic delirium under careful medical oversight.

ECOLOGICAL ROLE AND ENVIRONMENTAL CONSIDERATIONS

From an ecological standpoint, *Datura stramonium* plays a nuanced role in its accepted habitats. Its huge and massive, fragrant flowers serve as significant nectar sources for hawk moths and other huge and massive pollinators, contributing to local pollinator variety. The plant's prolific seed production and chemical defences make it a successful coloniser of degraded and disturbed land; a quality that, while problematic and tough and arduous for agriculture, positions it as a pioneer species in ecological sequence.

However, its status as an invasive weed in numerous regions cannot be missed. In cereal-growing areas across Europe and South Asia, contamination of grain crops with *Datura* seeds poses notable food safety problems. Regulatory organizations in the European Union have established maximum alkaloid limits in cereal products specifically in response to this danger, highlighting the plant's capability to intersect with human food systems in consequential ways.

CONCLUSION

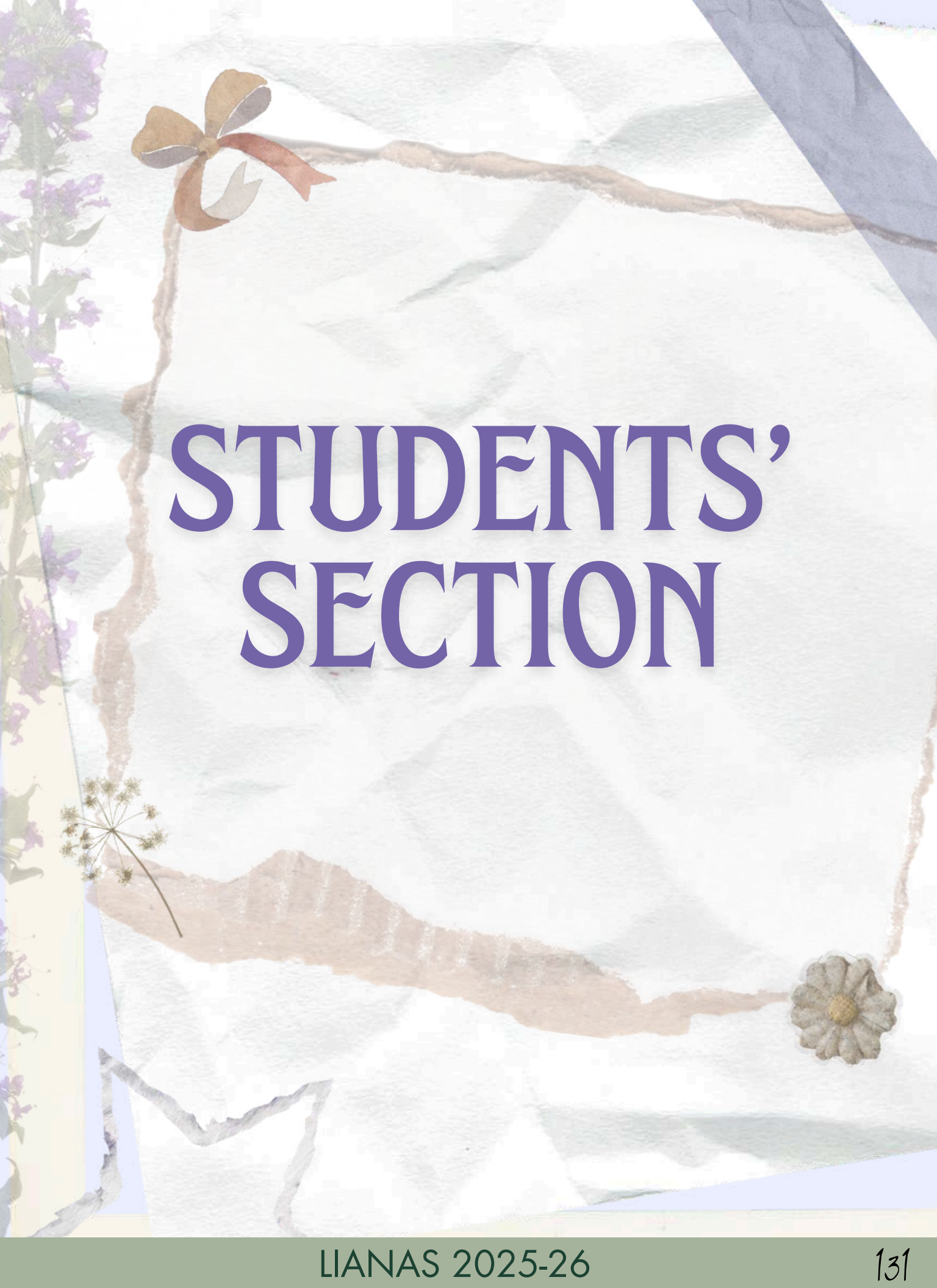
Datura stramonium is an outstanding instance of nature's duality; offering both healing potential and serious risks. Its rich phytochemical composition makes it valuable in traditional and usual and modern medicine, while its toxicity necessitates responsible handling and application. The plant serves as a reminder that natural substances, though profitable and useful, must be used with knowledge and caution. Continued inquiry on *Datura stramonium* may further unlock its potential in the domain of pharmacology while guaranteeing safe and effective applications.

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STUDENTS' SECTION

PRESIDENT'S NOTE

"Look deep into nature, and then you will understand everything better." — Albert Einstein

It is a privilege to address you through this edition of LIANAS 2026 as the President of Vasundhara, the Botanical Society of Daulat Ram College.

Nature has always been humanity's greatest teacher. The quiet resilience of plants, their intricate structures, and their role in sustaining life remind us how deeply connected we are to the natural world, a connection that Vasundhara continues to nurture by fostering curiosity, collaboration, and a deeper appreciation for the fascinating world of plants. As President, I remain committed to fostering an environment that encourages exploration, learning, and appreciation for plant sciences.

Over the past year, Vasundhara has continued to serve as a platform for students passionate about botany. Through academic discussions, activities, and collaborative initiatives, students were able to engage with plant sciences beyond the classroom.

Serving as the President of Vasundhara has been both an honour and a learning experience. It has been inspiring to witness the creativity and dedication of our members, and I remain committed to strengthening the society's efforts in fostering curiosity and appreciation for plant sciences.

I would like to express my sincere gratitude to our faculty members for their guidance, to the non-teaching staff for their support and to the dedicated team members and students whose enthusiasm and efforts have contributed to the growth of society.

I hope that Vasundhara continues to inspire students to observe, question, and appreciate the remarkable diversity of the plant world.



SUJATA

FROM THE STUDENT'S EDITORIAL DESK



ANSHITA CHAUHAN
EDITORIAL HEAD

Dear Readers and Contributors,

Bringing Lianas 2025-26 to life has been a journey of creativity, teamwork, and growth. What once felt like a distant idea became possible through the dedication and passion of an incredible team.

This magazine is more than a collection of articles it is a reflection of the curiosity, ideas, and voices within our department.

To all our writers, artists, photographers, and volunteers, thank you for making this vision a reality.

Happy reading!



AIMAN KHAN
EDITORIAL SECRETARY

Dear Readers,

Bringing this magazine together has been a journey of teamwork, dedication, and shared vision. As Editorial Secretary, I have witnessed the effort and care each contributor invested- from thoughtful writing to meticulous coordination.

A heartfelt thank you to everyone who supported the editorial process and ensured that every detail was completed on time.

I hope this issue makes you reflect with the beauty of the botanical world.

STUDENT'S EDITORIAL BOARD



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FROM

THE

DESK

OF

Botanical

Poets

धरा और देश की गरिमा बचाना भी आसान नहीं होता

-ऐमन खान



धरती माँ का सबका बोझ उठाना भी आसान नहीं होता,
धूप, तपिश और पतझड़ सहना भी आसान नहीं होता।
हम पूजते हैं मिट्टी को मगर, स्वार्थ में उसे छलते हैं,
प्रकृति की इस मूक पीड़ा को समझ पाना भी आसान नहीं होता,
धरा और देश की गरिमा बचाना भी आसान नहीं होता ॥

गंगा की निर्मल धारा का विष पीना भी आसान नहीं होता,
मैली होकर भी सबको जीवन देना भी आसान नहीं होता।
पुकारते हैं 'पावन माँ' उसे, पर इसमें जहर घोलते हैं,
नदी के इन बहते आँसुओं को पोंछना भी आसान नहीं होता,
धरा और देश की गरिमा बचाना भी आसान नहीं होता ॥

हिमालय की बर्फीली चोटियों पर अडिग रहना भी आसान नहीं होता,
चीर कर सीना वनों का, विकास सहना भी आसान नहीं होता।
प्रकृति ही आधार है इस पावन राष्ट्र की अस्मिता का,
उजड़ते हुए उपवनों की चीख सुनना भी आसान नहीं होता,
धरा और देश की गरिमा बचाना भी आसान नहीं होता ॥

केसरिया बाने में खुद को सदा सजाना भी आसान नहीं होता,
मातृभूमि की रक्षा में सर्वस्व लुटाना भी आसान नहीं होता।
मिट्टी का कर्ज चुकाने को जो वीर सीमा पर मरते हैं,
तिरंगे की उस ऊँची शान को थामना भी आसान नहीं होता,
धरा और देश की गरिमा बचाना भी आसान नहीं होता ॥

PILOTS OF THE PLANET

-MANASVI DABRAL



The voices of the youth speak loud and free,
'The climate is changing but why aren't we?'
While the ozone abyss is extending copiously,
We breathe the air where Carbon dies oxidatively.
The voices of the youth speak loud and free,
'The soil is changing but why aren't we?'
Our trees have held the ground since eternity,
It's us who can protect the branches growing besides gravity.
The voices of the youth speak loud and free,
'The fauna is changing but why aren't we?'
Our Lions once ruled the forest without a fee,
now they pay the cost of life taken away, mercilessly.
The voices of the youth speak loud and free,
'The flowers are changing but aren't we?'
Our Ghost Orchids are about to set sail in the extinction sea,
Let us be the one to save them from this vile sorcery.
The tyrants can demolish mountains and change the course of rivers,
yet, we'll stand together with our nature that shivers,
The rich can build walls in the forest and put buildings in the cities,
yet, we'll stand together to fight with a gentle ferocity,
after all, it reminds us of the pilots of our Earth,
who join the roots of vibrant biomes with a strong girth,
who without the request of reciprocation,
guide our homeostasis to a biotic exploration.
The voices of the youth speak loud and free,
'We have changed but the conundrums aren't over completely',
perhaps, we might write endless odes for a biosphere glee,
and this is going to endure until we attain a blooming tapestry.

क्या धर्म यही सिखलाता है ?

-सुजाता



आँख खुली जब इस सृष्टि में
लगी यह कितनी प्यारी थी,
नन्हें नन्हें होंठों से फिर
गूँज उठी किलकारी थी।
धर्म जात और भेद प्रथा से
मैं तब तक अनजान थी,
मैं मानव थी,
मानवता ही मेरी पहचान थी।

आँख खुली जब धीरे धीरे
भेद समझ में तब आया।
वो नर है, वो नारी है,
वो राजा, रंक या भिखारी है।
कुछ तेरा है, कुछ मेरा है,
हर दो पग भूमि के आगे
पड़ा पाप का घेरा है।
मानव को बड़ा बेदर्द यहाँ देखा,
मानवता से बड़ा धर्म का देखा।

अनचाहे जय-जयकार सुनी वैभव की,
न कि जन, धर्म के गौरव की।
इतिहास के कोरे पन्नों पर
कितना रक्त बिखराता है।
क्या धर्म यही सिखलाता है ?
धर्म के आडंबरों पर,
त्यज दिया अपना ईमान,
मानवता की नींव पड़ी,
मानव बन जा तू इंसान।
अगर धर्म का मर्म यही
कि क्या तेरा है, क्या मेरा है,
तो क्या धर्म सही सिखलाता है ?





Nature in Focus



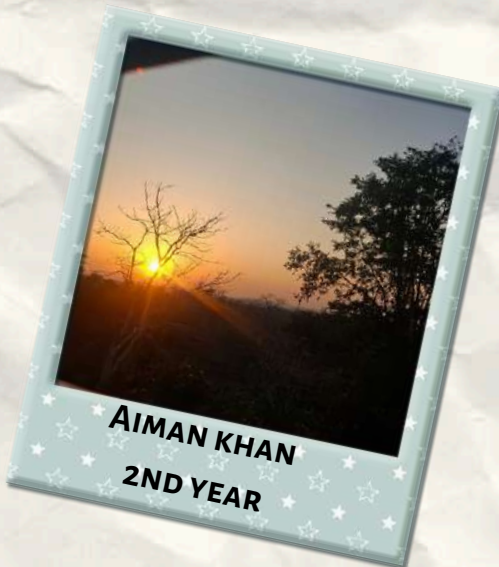
DEBASRITA DAS
3RD YEAR



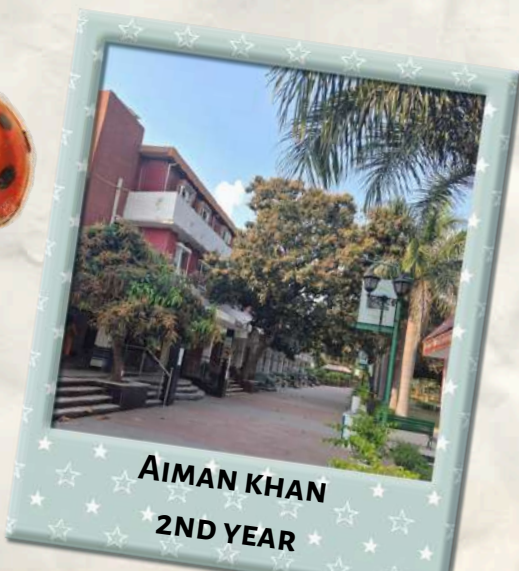
DEBASRITA DAS
3RD YEAR



AIMAN KHAN
2ND YEAR



AIMAN KHAN
2ND YEAR



AIMAN KHAN
2ND YEAR



PALAK PANDEY
2ND YEAR



Nature in Focus



PALAK PANDEY
2ND YEAR



AQSA
3RD YEAR



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Nature in Focus



**SAVNI
3RD YEAR**



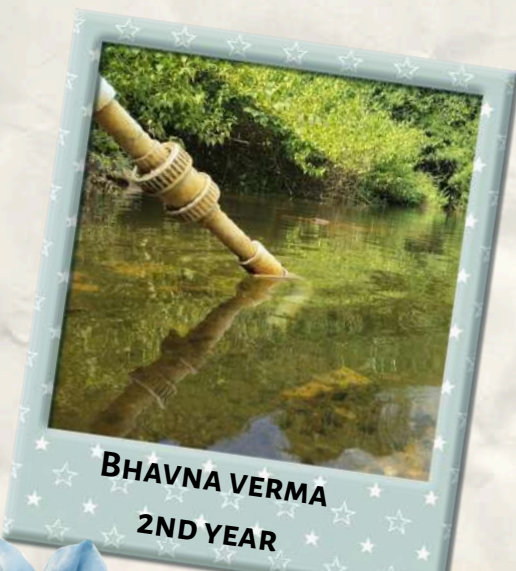
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**SAVNI
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**AQSA
3RD YEAR**



**BHAVNA VERMA
2ND YEAR**



**BHAVNA VERMA
2ND YEAR**



Nature in Focus



ABOUT

VASUNDHARA

THE BOTANICAL ASSOCIATION

Daulat Ram College is a distinguished educational institution in Delhi, founded in 1960 by the visionary educationist Late Shri Daulat Ram Gupta. The college offers undergraduate programmes in Arts, Commerce, and Science, along with postgraduate studies in Arts. It also provides add-on courses in foreign languages, enriching students' academic and professional skills. At present, the college comprises 19 departments and has a student strength of around 4,200.

The Botany Department of the college, established in 1968, is among the prominent departments of the University in the domain of plant and life sciences education. In recognition of its academic excellence and contributions to research and teaching, the department was awarded the prestigious "Star Status" by the Department of Biotechnology, Government of India in 2013.

Beyond academics, the department actively encourages students to explore their creativity and talents. Through its Botanical Association "Vasundhara," it organizes a range of inter-college competitions and co-curricular activities during "Orchidz," the department's annual botanical event, providing students with a vibrant platform to learn, engage, and showcase their abilities.

VASUNDHARA UNION



Dr. Meenam Bhatia
Teacher in charge



Dr. Asmita Gupta
Staff Advisor

CORE UNION



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Class Representative III year



Manasvi
Class Representative II year



Aparna
Class Representative I year

INAUGURAL CEREMONY



VASUNDHARA
THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY

Cordially invites you to the

INAUGURAL TALK

on

"Intruders in Plant World"

SPEAKER:

Prof. Gyaan Prakash
Sharma

Department of
Environmental Science,
University of Delhi



15 October 2025

11:00AM
ONWARDS

LAB A
DEPARTMENT OF BOTANY



Vasundhara's inaugural ceremony was held on 15th October 2025. The event began with a warm welcome address by the association members, followed by the auspicious lamp-lighting ceremony. Moving ahead, Staff Advisor Dr. Asmita Gupta Ma'am introduced our distinguished speaker and invited him to deliver the talk.

Prof. Gyaan Prakash Sharma, Department of Environmental Science, University of Delhi, addressed the audience on the topic "Intruders in Plant World." He shared valuable insights on invasive plant species, their ecological threats, and the need for effective management strategies. His discussion emphasized how these intruders impact biodiversity and the importance of scientific approaches to tackle them.

The session concluded with an interactive exchange of ideas, followed by the closing proceedings of Vasundhara for the academic year.

VASUNDHARA INAUGURAL





VASUNDHARA ACTIVITIES

VASUNDHARA
THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY
DAULAT RAM COLLEGE
UNIVERSITY OF DELHI

presents

ACTIVITY 1	ACTIVITY 2	ACTIVITY 3
Flora Photography Competition	Best Out of Waste competition	Mandala Art/ Botanical drawing competition
MODE OF CONDUCT: ONLINE	MODE OF CONDUCT: HYBRID	MODE OF CONDUCT: OFFLINE

DATE: 25 November 2025
TIME: 2:00-3:00pm
VENUE: Botany Department

RULES

1. Participants can choose any one of the two activity (MANDALA ART OR BOTANICAL CANVAS- Botanical drawing competition)
2. Bring your own colours; sheets will be provided.
3. Submit 1 Geo-Tagged photo and same photo in regular mode of your entry
4. Top 3 entries will get certificates.
5. Selected entries will get featured on social media account of Vasundhara

Staff Advisor: Dr. Asmita Gupta Teacher in charge: Dr. Meenam Bhatia Principal: Prof. Savita Roy

VASUNDHARA
The Botanical Association
Department of Botany
Daulat Ram College
University of Delhi

PRESENTS

Activity 1
LEAF PAINTING COMPETITION

Activity 2
STONE PAINTING COMPETITION

GUIDELINES

- Participants are required to prepare their material at home submit online pictures within designated date and time.
- Offline submission is required on 14th January 2026
- Do not use edited or downloaded images from the internet.
- Upload clear photographs of the completed artwork (no blur).
- Late submissions will not be accepted.
- Deadline to fill the form: 11th January 2026

Rewards: Exciting prizes and certificates

Staff Advisor: Dr. Asmita Gupta Teacher In-charge: Dr. Meenam Bhatia Chief Patron: Shri Mukul Gupta Principal: Prof. Savita Roy

VASUNDHARA
THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY
IN COLLABORATION WITH
THE GARDEN COMMITTEE
DAULAT RAM COLLEGE
UNIVERSITY OF DELHI

Presents

ACTIVITY
"Grow what you throw"

Date: 15 January 2026
Venue: Botanical Garden

GUIDELINES

- Collect clean and dry waste plastic Containers
- Cut plastic into pot shapes
- Make drainage holes at the bottom
- Fill pots with soil and compost
- Sow seeds lightly and cover with soil
- Water gently

★ **Patron**
Shri Mukul Gupta

Principal: Prof. Savita Roy Teacher in charge: Dr. Meenam Bhatia Vasundhara Staff Advisor: Dr. Asmita Gupta Garden committee convenor: Dr. Pratibha Kumar

VASUNDHARA
The Botanical Association
Department of Botany
Daulat Ram College
University of Delhi

In collaboration with

ENSURE IAS
Presents
CAREER COUNSELLING SESSION ON A to Z of UPSC

SPEAKER
Mr. Siddhartha Kumar
• Senior UPSC CSE Faculty and Mentor.

Venue: Conference hall
Date: 19 January 2026
Time: 10:30 am Onwards
Students from all departments may attend

Patron Shri Mukul Gupta **Principal** Prof. Savita Roy **Teacher in charge** Dr. Meenam Bhatia **Staff Advisor** Dr. Asmita Gupta

VASUNDHARA ACTIVITIES



VASUNDHARA

THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY
DAULAT RAM COLLEGE
UNIVERSITY OF DELHI



ACTIVITY 1
Poster making Competition
MODE OF CONDUCT: OFFLINE

Duration: 1 hour
Theme : **Vasant Panchami: A floral tribute**
Sheet Size: A3 (will be provided)
-Participation: Individual or Team (Maximum 3 members per team)
-Background: Must reflect elements related to the theme

ACTIVITY 2
Poetry Competition
MODE OF CONDUCT: OFFLINE

Theme : **Nature and Nationalism**
-Poems must be based on the given theme
-No offensive or inappropriate language
-Plagiarism will lead to disqualification

General Instructions:-
-Participants can register for one or both competitions
-All entries must follow the theme.
-Final decision of judges will be binding
-Participants should bring their own colours

Chief Patron:
Shri Mukul Gupta

Principal:
Prof. Savita Roy

Teacher in charge:
Dr. Meenam Bhatia

Staff Advisor:
Dr. Asmita Gupta



VASUNDHARA

The Botanical Association
Daulat Ram College
University of Delhi

In collaboration with
Evolution Educare
presents
Career Counselling Session
on
**Career Options for Botany Graduates:
UPSC Examination and Beyond**



Dr. Abhishek Kumar
Founder of Evolution Educare
Head of Academic Affairs
Mentor

Date: 29th January 2026
Time: 11:00 AM onwards
Venue: Conference Hall

Chief Patron:
Shri Mukul Gupta

Principal:
Prof. Savita Roy

Teacher-in-Charge:
Dr. Meenam Bhatia

Staff Advisor:
Dr. Asmita Gupta



VASUNDHARA

THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY

In collaboration with
Garden Committee
Is Organising a Workshop
on
KOKEDAMA
AN INTRODUCTION TO LIVING ART





Speaker: Ms. Neha Verma
Founder of Bloomtastic Greens



Reconnect with nature
—one moss ball at a time.

- Limited Seats
- First 30 students only
- All Materials Provided

Date: 28th January 2026
Time: 12:30 PM onwards
Venue: Conference Hall, Botanical Garden

Chief Patron:
Shri Mukul Gupta

Principal:
Prof. Savita Roy

Vice Principal:
Prof. Preeti Malhotra

Teacher-in-Charge:
Dr. Meenam Bhatia

Staff Advisor:
Dr. Asmita Gupta

Garden Committee Convener:
Dr. Pratibha Kumari



VASUNDHARA

The Botanical Association
Department of Botany
Daulat Ram College
University Of Delhi

(under the Aegis of IQAC)
Is Organizing
INTERNATIONAL SYMPOSIUM
On
Environmental Biotechnology and Water Sustainability (ISEBWS-2026)
In Hybrid mode





Dr. Raj Morya
Postdoctoral Researcher, Environmental Biotechnology Laboratory, INRAE, Narbonne, France



Dr. Pankaj K. Gupta
Ramanujan Fellow, IIT Delhi, and Adjunct Assistant Professor, University of Waterloo, Canada

Scan to register

Date : 11th February, 2026
Venue: Conference Hall
Time: 10:30 am onwards



Short Oral presentation only for 4th year Dissertation students.
last date for abstract submission: 9th February
[link for abstract submission](https://forms.gle/P4aySiRbSy5fHplY5)

Chief Patron
Shri Mukul Gupta

Principal
Prof. Savita Roy

Vice Principal
Prof. Preeti Malhotra

IQAC convener
Prof. Padmashree Mudgal

Teacher-in-charge
Dr. Meenam Bhatia

Convener
Dr. Asmita Gupta

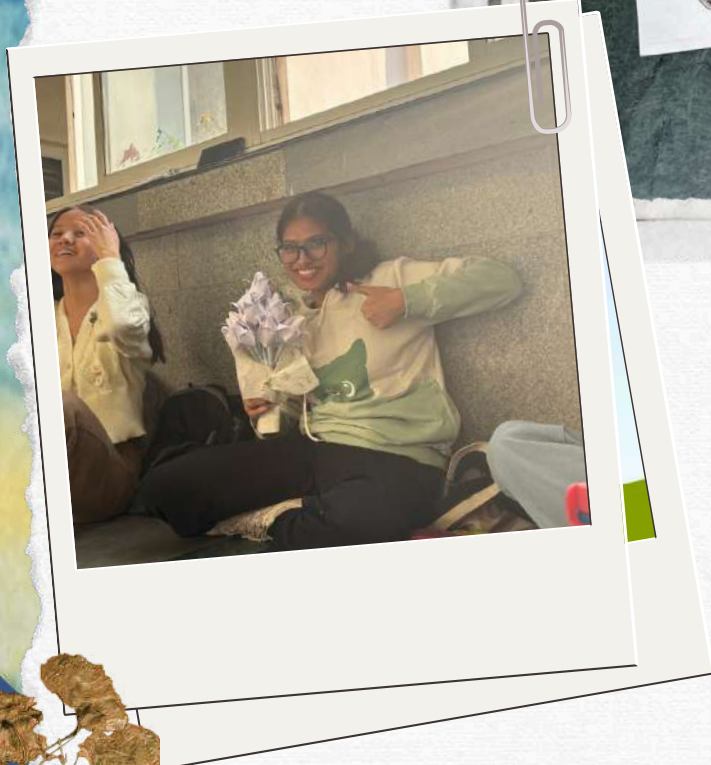
Co-convener
Dr. Pratibha Kumari

MANDALA COMPETITION





BEST OUT OF WASTE



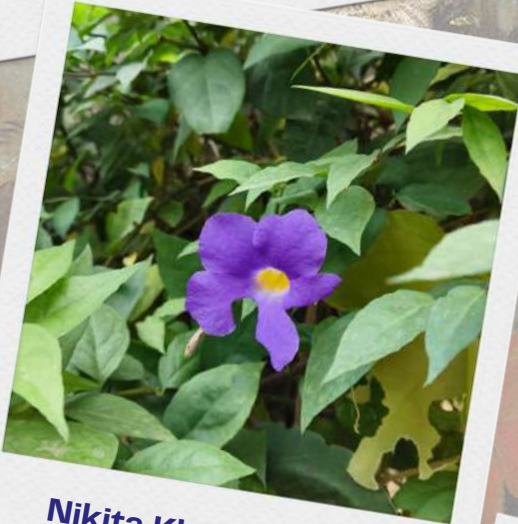
FLORA PHOTOGRAPHY COMPETITION



Sakshi Jha 1st year



Nikita Khatri 1st year



Nikita Khatri 1st year



Suhani Dua 3rd Year



Manju 2nd year



Manju 2nd year





LEAF PAINTING AND STONE PAINTING COMPETITION



ENSURE IAS CAREER COUNSELLING SESSION 1



GROW WHAT YOU THROW

 **VASUNDHARA**
THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY
IN COLLABORATION WITH
THE GARDEN COMMITTEE
DAULAT RAM COLLEGE
UNIVERSITY OF DELHI
Presents
ACTIVITY
"Grow what you throw"

Date: 15 January 2026
Venue: Botanical Garden

GUIDELINES

- Collect clean and dry waste plastic Containers
- Cut plastic into pot shapes
- Make drainage holes at the bottom
- Fill pots with soil and compost
- Sow seeds lightly and cover with soil
- Water gently

★ **Patron**
Shri Mukul Gupta

Principal: Prof. Savita Roy Teacher in charge: Dr. Meenam Bhatia Vasundhara Staff Advisor: Dr. Asmita Gupta Garden committee convenor: Dr. Pratibha Kumar







KOKEDAMA WORKSHOP



Kokedama is a traditional Japanese form of living art in which plants are grown in a hand-shaped ball of soil wrapped with moss, instead of a conventional pot. Literally meaning “moss ball”, it embodies the principles of simplicity, balance, and harmony with nature. Rooted in Japanese aesthetics, Kokedama encourages mindful interaction with plants while promoting sustainable and minimalistic gardening. Suitable for both indoor and outdoor spaces, it beautifully blends art, nature, and well-being, allowing individuals to reconnect with nature one moss ball at a time.



VASANT PANCHAMI ACTIVITIES

**VASUNDHARA**
THE BOTANICAL ASSOCIATION
DEPARTMENT OF BOTANY
DAULAT RAM COLLEGE
UNIVERSITY OF DELHI



ACTIVITY 1
Poster making Competition
MODE OF CONDUCT: OFFLINE

ACTIVITY 2
Poetry Competition
MODE OF CONDUCT: OFFLINE

DATE: 23 January 2026
TIME: 1:30-2:30pm
VENUE: Botany dept.

Duration: 1 hour
Theme : **Vasant Panchami: A floral tribute**
Sheet Size: A3 (will be provided)
-Participation: Individual or Team (Maximum 3 members per team)
-Background: Must reflect elements related to the theme

Theme : **Nature and Nationalism**
-Poems must be based on the given theme
-No offensive or inappropriate language
-Plagiarism will lead to disqualification

General Instructions:-
-Participants can register for one or both competitions
-All entries must follow the theme.
-Final decision of judges will be binding
-Participants should bring their own colours



Chief Patron: Shri Mukul Gupta
Principal: Prof. Savita Roy
Teacher in charge: Dr. Meenam Bhatia
Staff Advisor: Dr. Asmita Gupta

POETRY



POSTER MAKING





EVOLUTION EDUCARE CAREER COUNSELLING SESSION II

evolution  **VASUNDHARA**  

The Botanical Association
Daulat Ram College
University of Delhi

In collaboration with
Evolution Educare
presents
Career Counselling Session
on
**Career Options for Botany Graduates:
UPSC Examination and Beyond**


Dr. Abhishek Kumar
Founder of Evolution Educare
Head of Academic Affairs
Mentor

 Date: 29th January 2026
 Time: 11:00 AM onwards
 Venue: Conference Hall





INTERNATIONAL SYMPOSIUM ON ENVIRONMENTAL BIOTECHNOLOGY AND WATER SUSTAINABILITY (ISEBWS-2026)

VASUNDHARA
The Botanical Association
Department of Botany
Daulat Ram College
University Of Delhi
(under the Aegis of IQAC)
Is Organizing

INTERNATIONAL SYMPOSIUM
On
**Environmental Biotechnology and Water
Sustainability (ISEBWS-2026)**

In Hybrid mode

Dr. Raj Morya
Postdoctoral Researcher, Environmental
Biotechnology Laboratory, INRAE,
Narbonne, France

Dr. Pankaj K. Gupta
Ramanujan Fellow, IIT Delhi, and
Adjunct Assistant Professor,
University of Waterloo, Canada

Scan to register

Date : 11th February, 2026
Venue: Conference Hall
Time: 10:30 am onwards

Short Oral presentation only
for 4th year Dissertation
students.
last date for abstract
submission: 9th February
[link for abstract submission](https://forms.gle/P4aySiRbSy5fHPLy5)
<https://forms.gle/P4aySiRbSy5fHPLy5>

Shri Mukul Gupta
Chief Patron

Prof. Savita Roy
Principal

Prof. Preeti Malhotra
Vice Principal

of. Padmshree Mudgal
IQAC convenor

Dr. Meenam Bhatia
Teacher-in-charge

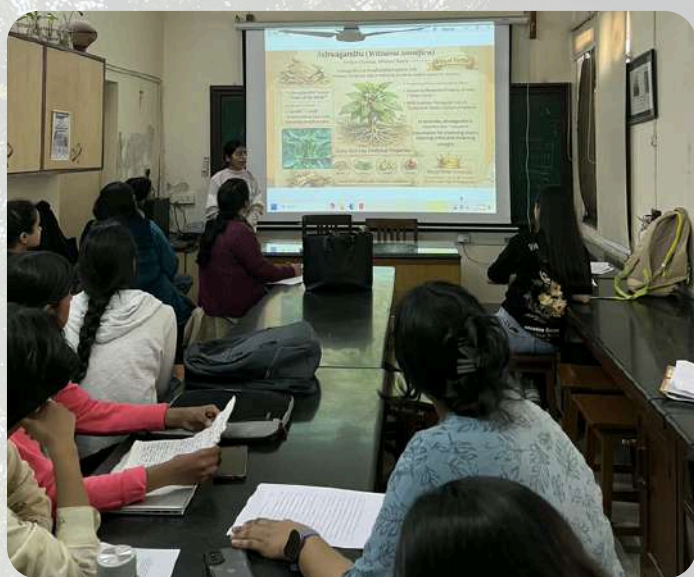
Dr. Asmita Gupta
Convenor

Dr. Pratibha Kumari
Co-convenor



**ENVIRONMENTAL
BIOTECHNOLOGY AND
WATER
SUSTAINABILITY**





GLIMPSES OF BOTANICAL GARDEN

ACHIEVEMENTS





DEPARTMENT OF BOTANY

FACUTLY MEMBERS



Dr. Meenam Bhatia
Teacher in charge



Dr. Meenakshi Sharma



Dr. Basanta Kumar Das



Dr. Sunita George



Dr. Vidhi Choudhary



Dr. Priyanka Rathore



Dr. Remya Krishnan



Dr. Aradhna Yadav



Dr. Asmita Gupta
Staff Advisor



Dr. Pratibha Kumari



Dr. Shagun Danda



Dr. Kamlesh Kumari



Dr. Neha Mann



Dr. Dipti Tong



Dr. Ekta



Dr. Sonia



Ms. Mamta



Ms. Utkarsh



Dr. Jhilmil

LABORATORY STAFF



Mr. Suresh Kumar
Lab Assistant



Mr. Ramesh Nagar
Lab Assistant



Mr. Satish Kumar Chauhan
Lab Assistant



Mr. Mahender Pal
Lab Assistant



Mr. Ranbir Mann
Lab Attendant



Mr. Niraj
Lab Attendant



Mrs. Geetanjali
Lab Attendant



Mr. Koushi Giri
Lab Attendant



LIANAS, The Annual Publication of the Botanical Association, stands as a vibrant platform where faculty members and students come together to share their scientific insights and creative perspectives. Lianas 2025–26 brings together a diverse collection of scientific articles, research work, and highlights of the Association’s activities, centred around the pressing theme of Biodiversity Conservation, Environment and Sustainability. Through thoughtful contributions and scholarly exploration, this publication reflects the collective commitment of our academic community towards understanding, preserving, and sustaining the natural world.



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