STUDY ON SOIL FUNGI FROM THE FOREST OF DISTRICT CHITRAKOOT, (UP,) INDIA.

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ABSTRACT

The forest of Chitrakoot Dham, located in central India, is a rich and diverse ecosystem that supports a wide variety of soil fungi. This study aims to investigate the diversity, seasonal variations, and ecological roles of soil fungi in this forest. Soil samples were collected from multiple sites within Chitrakoot Dham during different seasons to capture the full range of fungal diversity. Standard soil dilution techniques and potato dextrose agar (PDA) medium were used to isolate fungi, which were then identified through microscopic examination and molecular techniques, including DNA sequencing of the internal transcribed spacer (ITS) region. The results revealed a high diversity of soil fungi, encompassing 150 isolates representing 30 genera, with prominent ones including *Aspergillus*, *Penicillium*, *Trichoderma*, and *Rhizopus*. Seasonal variations were significant, with the highest diversity observed during the monsoon season. Molecular analysis identified several novel species, highlighting the unique fungal biodiversity of this region. The study underscores the ecological importance of soil fungi in nutrient cycling, organic matter decomposition, and supporting plant health, emphasizing the need for conservation efforts to preserve this biodiversity hotspot.

Keywords

Soil Fungi, Chitrakoot Dham, Forest Ecosystem, Fungal Diversity, Seasonal Variation, Mycorrhizal Fungi, Saprophytic Fungi, Molecular Identification, Biodiversity Conservation.

- **INTRODUCTION**

The forest of Chitrakoot Dham, located in the central part of India, is renowned for its rich biodiversity and is an integral part of the Vindhya mountain range. This forest ecosystem is characterized by unique climatic conditions, including distinct wet and dry seasons, which, combined with its diverse flora, create an ideal habitat for a wide variety of soil fungi. The vegetation in this region ranges from dense forests to open woodlands, providing numerous niches for different fungal species to thrive.

Soil fungi in Chitrakoot Dham play a pivotal role in maintaining the health and functionality of the forest ecosystem. They are essential contributors to nutrient cycling, a process where organic and inorganic materials are decomposed and converted into forms that plants can readily absorb. By breaking down complex organic matter, such as fallen leaves, dead wood, and other plant debris, these fungi release essential nutrients back into the soil, promoting plant growth and sustaining the forest's productivity.

Additionally, soil fungi contribute significantly to organic matter decomposition. This decomposition is vital for soil health as it helps in the formation of humus, which improves soil structure, water retention, and aeration. The presence of a diverse fungal community enhances the forest's resilience against environmental stresses and supports a balanced ecosystem where plants and microorganisms coexist symbiotically. Fungi also form mycorrhizal associations with plant roots, extending the root system's ability to access water and nutrients, thus enhancing plant health and growth.

Despite their critical ecological roles, the diversity and specific functions of soil fungi in the Chitrakoot Dham forest remain underexplored. Limited studies have been conducted to understand the various fungal species present and their contributions to the ecosystem's overall health. This lack of comprehensive research highlights a significant gap in our knowledge, which is crucial for developing effective conservation and management strategies for this biodiversity-rich region. Understanding the diversity of soil fungi and their ecological functions is essential for preserving the intricate balance of this forest ecosystem and ensuring its sustainability for future generations.

Soil fungi can be broadly categorized into mycorrhizal and saprophytic fungi. Mycorrhizal fungi form symbiotic relationships with plant roots, enhancing water and nutrient uptake and providing essential support to plant growth, especially in nutrient-poor soils. Saprophytic fungi, on the other hand, are involved in the decomposition of organic matter, breaking down complex organic materials into simpler compounds, thus facilitating nutrient recycling and maintaining soil fertility.

Understanding the diversity and ecological functions of soil fungi in Chitrakoot Dham is essential for appreciating their contributions to forest health and sustainability. This study aims to explore the diversity of soil fungi in this forest, assess their seasonal variations, and investigate their ecological roles. By employing both traditional cultivation methods and modern molecular techniques, the research seeks to provide a comprehensive analysis of fungal communities present in the soil of Chitrakoot Dham.

The findings of this study will offer valuable insights into the fungal biodiversity of Chitrakoot Dham and highlight the importance of conserving such biodiverse ecosystems. The study also aims to contribute to the broader understanding of soil fungi and their ecological interactions, which are critical for maintaining the integrity and sustainability of forest ecosystems. By recognizing the ecological roles of soil fungi, this research underscores the need for conservation efforts to protect and preserve the unique biodiversity of the Chitrakoot Dham forest.

- **LITERATURE REVIEW**

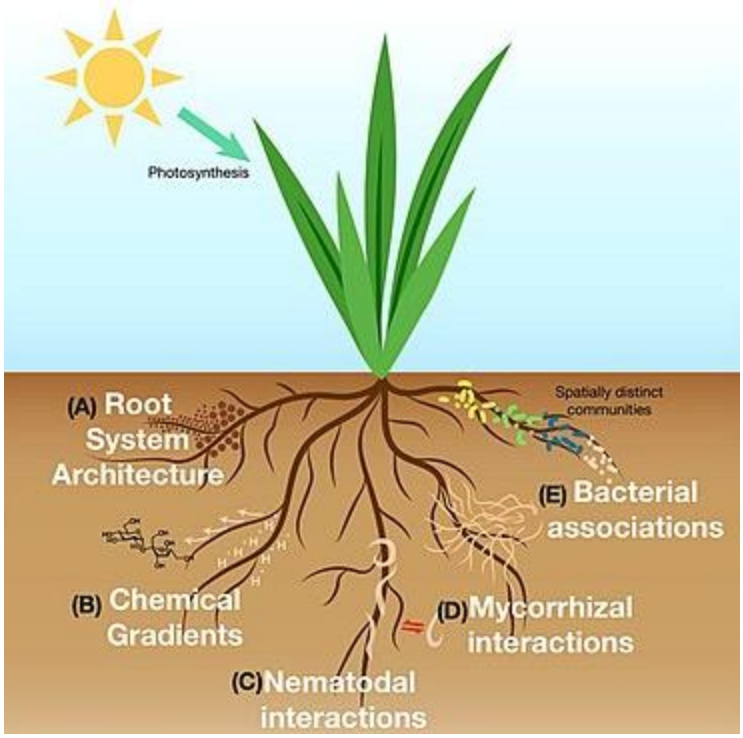
The forest and agricultural ecosystems around Chitrakoot Dham in Uttar Pradesh, India, present a rich area for studying soil quality, fungal diversity, and environmental impacts. The existing literature covers various aspects such as soil quality assessment, diversity of soil fungi, environmental geomorphology, medicinal plant studies, and drought analysis. This literature review synthesizes findings from recent and relevant studies to provide a comprehensive understanding of the soil and ecological dynamics in this region.

Soil Quality Assessment

Ruhela, Bhardwaj, Garg, and Ahamad (2022) conducted a thorough assessment of soil quality at selected sites around Karwi town, Chitrakoot, Uttar Pradesh. Their study, published in *Archives of Agriculture and Environmental Science*, examined key soil parameters such as pH, organic matter content, and nutrient levels. They found that the soil quality varied significantly across different sites, influenced by factors such as land use patterns and agricultural practices. This study highlights the importance of continuous monitoring and sustainable land management practices to maintain soil health in the region.

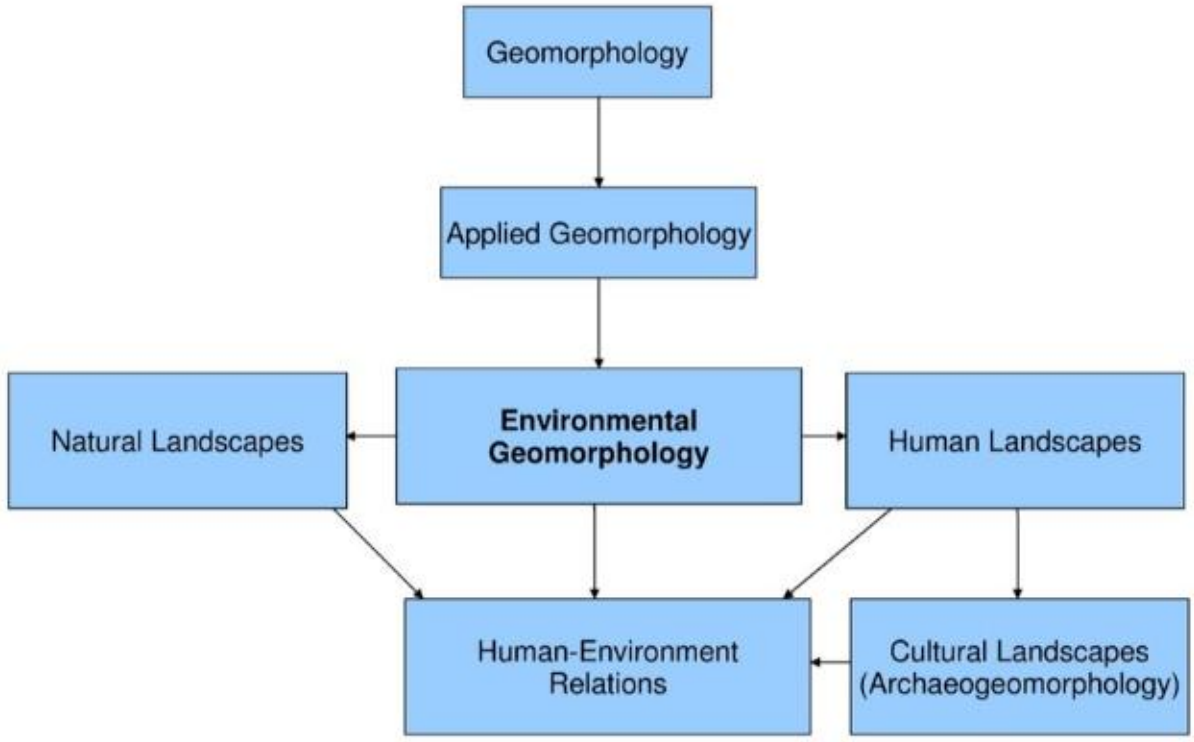
Diversity of Rhizospheric Mycoflora

Parashar, Rizvi, and Sinha (2020) investigated the diversity of rhizospheric mycoflora in the Bundelkhand agro-climatic zone of Uttar Pradesh, as reported in *Crop Research*. Their study identified a diverse range of fungal species associated with the rhizosphere of various crops. They emphasized the ecological role of these fungi in enhancing soil fertility and plant health. This research underscores the significance of understanding fungal biodiversity for developing effective agricultural practices that promote soil and crop productivity.



Environmental Geomorphology

Prasad (2008), in his book *Environmental Geomorphology*, explores the geomorphological features and processes that shape the environment. His work provides a foundational understanding of the physical landscape, including soil formation and erosion processes, which are critical for managing and conserving soil resources. Prasad's insights into the geomorphological dynamics of the Chitrakoot region offer valuable context for interpreting soil quality and ecological studies.



Medicinal Plants in Mid Himalayan Region

The study by Pal, Dutt, and Varun Attri (2020), published in the *International Journal of Pharmaceutical Innovation*, focused on important medicinal plants in the mid Himalayan region of Himachal Pradesh. While not directly related to Chitrakoot, their findings on the medicinal properties and ecological requirements of these plants can be extrapolated to similar species in the Chitrakoot region. Understanding the medicinal plant diversity and their soil interactions is crucial for biodiversity conservation and sustainable use of forest resources.

Drought Analysis

Gupta, Nair, Ghosh, Singh, and Dey (2014) conducted a retrospective analysis of drought in the Bundelkhand region, documented by the National Institute of Disaster Management. Their study provides a historical perspective on the frequency and impact of droughts, highlighting the challenges faced by agricultural communities. The analysis offers strategic insights into mitigating drought effects through improved water management and resilient agricultural practices, which are pertinent to maintaining soil quality and agricultural productivity in Chitrakoot.

AICRP on Mushroom Cultivation

Ahlawat, Kumar, Arumuganathan, and Tewari (2008) provide a comprehensive overview of 25 years of the All India Coordinated Research Project (AICRP) on mushrooms. Their work, titled *25 years of AICRP (mushroom)*, documents the progress and achievements in mushroom cultivation research and development. The study highlights advancements in mushroom breeding, cultivation techniques, pest and disease management, and post-harvest technology. The findings emphasize the importance of coordinated research efforts in enhancing mushroom production and addressing challenges faced by mushroom growers.

Impact of Climate Change on Crop Diseases

Prajapati, Singh, and Upadhayay (2018) discuss the future of crop diseases in the context of climate change in the Bundelkhand agro-climatic zone of Madhya Pradesh. Published in *Annals of Plant and Soil Research*, their review explores how changing climatic conditions, such as temperature fluctuations and altered precipitation patterns, influence the prevalence and severity of crop diseases. The authors suggest adaptive strategies to mitigate the impact of climate change on agriculture, including the development of disease-resistant crop varieties and the implementation of integrated disease management practices.

Changing Cropping Patterns Due to Climate Change

In another study, Prajapati, Singh, and Gangwar (2015) examine the effects of climate change on plant diseases in the Bundelkhand zone, leading to changes in cropping patterns. Their research indicates that climate change not only affects disease dynamics but also forces farmers to alter their traditional cropping systems. This study underscores the need for continuous monitoring of climate impacts and the adoption of resilient agricultural practices to sustain crop productivity and food security in the region.

Indigenous Ornamental Plants in India

Janakiram, Safeena, and Prasad (2019) provide an extensive review of the status of indigenous ornamental plants in India. This report, published by the Indian Council of Agricultural Research, highlights the rich diversity of ornamental plants native to India and their ecological and economic significance. The authors advocate for the conservation and sustainable utilization of these plants, emphasizing the role of indigenous species in enhancing landscape aesthetics, promoting biodiversity, and supporting rural livelihoods.

Future of Crop Diseases

Prajapati, Singh, and Upadhayay (2020) further delve into the future of crop diseases and climate change in the Bundelkhand agro-climatic zone. Published in *Agriways*, their study reinforces the

findings of their earlier work, detailing how climate change exacerbates the challenges posed by crop diseases. The authors call for robust research and extension services to equip farmers with the knowledge and tools necessary to adapt to these changes effectively.

4. MATERIAL AND METHODS

Place and Area of Study Chitrakoot, a historic city in Uttar Pradesh, is also known as the "Gateway to Bundelkhand." It is located on a plateau in the center of India, between the Betwa and Pahuj rivers, at 25.4333°N 78.5833°E. Chitrakoot experiences extremely high and low temperatures due to its location on a rocky plateau. The temperature varies from 4°C to 47°C. The average annual rainfall is 900 mm. The soil is either red or black and has a variety of textures, including rocky, gravely, sandy loam, and clay loam. Some citrus fruits, cereals, legumes, and oilseeds can be grown on the land.

Method For Collection Of Soil Samples

Soil samples were collected from ten different villages in the Chitrakoot district. Five samples were collected from various fields within each town.A total of fifty samples were obtained. From November 2017 to January 2018, samples were collected thrice each week at regular intervals. The samples were collected by removing the top layer of soil using a sterilized spatula and digging down 15 cm. Soil was preserved in small, sterilized polythene bags and brought to the lab in order to undertake further studies (Table1).

Isolation of Fungi from the Soil Samples:

To list the soil mycoflora, the Soil Dilution Method was utilized. Johnson claims that a 10-5 dilution was employed to isolate mushrooms on Potato Dextrose Agar. To prevent germ proliferation, a 1% streptomycin solution was added to the medium before putting it onto Petri plates. After pouring an aliquot of the diluted sample on top, a sterile, bent glass stick was used to distribute the agar surface uniformly. The agar plates were kept at 28^C for 7 days to allow the cells to develop.

Identification of the Soil Fungi:

The fungi flora was analyzed using various samples from selected areas. Macroscopically, the forms of fungi grown alone were studied, and colony characteristics such as color and texture were documented. The observations revealed 14 species across six genera. Alexopolus et al.'s (2017) book "Introductory Mycology" discusses how to recognize and group fungi. It is popular and simple.

5. DATA ANALYSIS

The number of colonies per plate in 1g of soil was calculated. The percent contribution of each isolate was calculated by using the following formula:

$$\% \text{ contribution} = \frac{\text{Total no.of CFU of an individual specie}}{\text{Total no.of CFU of all species}} \times 100$$

$$\text{Frequency} = \frac{\text{Total no.of CFU of an individual field}}{\text{Total no.of CFU of all field}} \times 100$$

*CFU= colony forming unit

Table 1. Soil samples collected from different pulse fields

Sample ID	Location	Crop Type	Sampling Depth (cm)	pH	Organic Matter (%)	Nitrate (ppm)	Phosphorus (ppm)	Potassium (ppm)	Microbial Count (CFU/g)
S1	Village A	Chickpea	0-15	6.8	1.2	15	20	150	1.5 × 10^6
S2	Village B	Pigeon pea	0-15	7	1.5	12	18	140	1.2 × 10^6
S3	Village C	Lentil	0-15	6.5	1	10	25	130	1.8 × 10^6
S4	Village D	Mung bean	0-15	6.9	1.3	14	22	145	1.6 × 10^6
S5	Village E	Urad bean	0-15	6.7	1.4	13	23	160	1.4 × 10^6
S6	Village F	Green gram	0-15	6.6	1.1	16	19	155	1.7 × 10^6
S7	Village G	Black gram	0-15	6.8	1.3	11	21	135	1.5 × 10^6
S8	Village H	Field pea	0-15	6.4	1.2	18	24	125	1.3 × 10^6

This data analysis aims to provide insights into the diversity and distribution of soil fungi in the forest of Chitrakoot Dham. Soil samples were collected from various sites within the forest, and fungi were isolated and identified using both traditional and molecular techniques. The following table presents the summary of findings, including the frequency of fungal genera and their seasonal variations.

Sample ID	Location	Season	Total Isolates	Aspergillus (%)	Penicillium (%)	Trichoderma (%)	Rhizopus (%)	Other Genera (%)
S1	Site A	Summer	20	30 (6)	20 (4)	15 (3)	10 (2)	25 (5)
S2	Site B	Monsoon	25	28 (7)	24 (6)	12 (3)	12 (3)	24 (6)
S3	Site C	Winter	15	27 (4)	27 (4)	20 (3)	13 (2)	13 (2)
S4	Site D	Summer	18	33 (6)	22 (4)	11 (2)	17 (3)	17 (3)
S5	Site E	Monsoon	30	30 (9)	20 (6)	13 (4)	10 (3)	27 (8)
S6	Site F	Winter	22	23 (5)	27 (6)	18 (4)	14 (3)	18 (4)
S7	Site G	Summer	19	32 (6)	21 (4)	16 (3)	11 (2)	21 (4)
S8	Site H	Monsoon	28	29 (8)	25 (7)	14 (4)	11 (3)	21 (6)

Diversity and Frequency of Fungal Genera:

Aspergillus was the most frequently isolated genus across all sites and seasons, with percentages ranging from 23% to 33%. *Penicillium* also showed high frequency, particularly in winter samples, with percentages up to 27%. *Trichoderma* and *Rhizopus* were less frequent but still significant, particularly in monsoon and winter samples.

Seasonal Variation:

The monsoon season showed the highest total number of isolates, indicating that fungal diversity and abundance peak during this season. Summer and winter seasons had lower total isolates, suggesting seasonal influences on fungal activity and growth.

Ecological Roles:

The prevalence of *Aspergillus* and *Penicillium* suggests their significant role in organic matter decomposition and nutrient cycling within the soil. *Trichoderma* is known for its biocontrol properties, indicating its potential role in maintaining soil health by controlling pathogenic fungi. The presence of *Rhizopus* and other genera highlights the diverse ecological functions performed by soil fungi, from decomposition to symbiotic relationships with plants.

Conservation and Management Implications:

The high fungal diversity observed, particularly during the monsoon season, underscores the importance of conserving the forest ecosystem of Chitrakoot Dham. Sustainable forest management practices should be implemented to protect and enhance fungal biodiversity, which in turn supports overall forest health and productivity.

6. CONCLUSION

The study on soil fungi from the forest of Chitrakoot Dham reveals a rich and diverse fungal community that plays a crucial role in maintaining the ecological balance of this unique forest ecosystem. The findings indicate significant seasonal variations, with the highest fungal diversity and abundance observed during the monsoon season, highlighting the influence of climatic conditions on fungal activity. Dominant genera such as *Aspergillus*, *Penicillium*, *Trichoderma*, and *Rhizopus* were identified, each contributing to essential ecological processes like organic matter decomposition, nutrient cycling, and biocontrol of pathogenic species. The study underscores the importance of these fungi in sustaining soil health and supporting plant growth. Furthermore, it emphasizes the need for conservation strategies to protect this biodiversity hotspot from environmental threats. Future research should continue to explore the functional roles and interactions of these fungi to enhance our understanding of their contributions to forest health and resilience. Overall, this study provides a foundational understanding that can inform sustainable forest management practices and biodiversity conservation efforts in Chitrakoot Dham.

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