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Role Of Fungi in Organic Matter Decomposition and Nutrient Cycling in Soil

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ABSTRACT

Fungi play a fundamental role in maintaining soil fertility and ecosystem functioning through the decomposition of organic matter and the regulation of nutrient cycling. They contribute to the breakdown of complex organic compounds, including cellulose, hemicellulose, lignin and other plant-derived materials, through specialised extracellular enzymes and biochemical processes. These activities facilitate the release, transformation and recycling of essential nutrients such as carbon, nitrogen and phosphorus. Different fungal groups, particularly saprotrophic and mycorrhizal fungi, perform complementary functions in soil ecosystems by influencing organic matter decomposition, nutrient acquisition and carbon storage. Fungal communities also contribute to soil aggregation, microbial interactions and the maintenance of biological diversity. The present study examines the role of fungi in organic matter decomposition and nutrient cycling through a review of existing scientific literature. It adopts a descriptive and qualitative research approach based on secondary data, with particular emphasis on fungal diversity, enzymatic mechanisms, nutrient transformations and environmental influences. The study highlights that fungal activity is essential for maintaining soil biological processes and ecosystem stability. It further establishes that environmental changes, agricultural practices and alterations in soil microbial communities can influence fungal functioning and nutrient availability. Understanding fungal ecological processes is therefore important for improving soil health, sustainable agriculture and long-term ecosystem management.

Keywords: Soil Fungi, Organic Matter Decomposition, Nutrient Cycling, Soil Microbiology, Fungal Biodiversity, Saprotrophic Fungi, Mycorrhizal Fungi, Soil Fertility, Carbon Cycling, Soil Health.

1. INTRODUCTION

Soil is a complex biological system that supports plant growth, regulates nutrient availability and maintains essential ecological processes. Its productivity and long-term sustainability depend considerably on the interactions between physical, chemical and biological components. Among the biological components, fungi perform essential ecological functions by decomposing organic materials, transforming nutrients and maintaining soil structure. They are widely distributed across terrestrial ecosystems and occur in agricultural fields, forests, grasslands and other natural environments. Their extensive hyphal networks enable

them to explore soil particles and organic substrates, making them important contributors to soil biological activity.

Organic matter decomposition is a fundamental ecological process through which dead plant materials, animal remains and other organic residues are broken down into simpler compounds. This process facilitates the release of nutrients that can subsequently become available to plants and other microorganisms. Fungi are particularly effective decomposers because they produce extracellular enzymes capable of degrading complex organic substances. Their decomposition activities involve cellulose-degrading enzymes, hemicellulases, lignin-modifying enzymes, proteases and other biochemical compounds. These enzymes allow fungi to utilise a wide range of organic materials that may be difficult for other microorganisms to decompose.

Fungal decomposition is particularly important in ecosystems where plant-derived organic matter contains substantial amounts of lignin and other structurally complex compounds. Saprotrophic fungi contribute significantly to the breakdown of leaf litter, woody materials, roots and other organic residues. Their enzymatic systems influence the rate at which organic materials are transformed and the extent to which nutrients are released into the soil environment. Eichlerová et al. (2015) demonstrated that the enzymatic systems involved in decomposition are associated with the ecology and taxonomy of saprotrophic fungi, indicating that different fungal groups possess distinct decomposition capacities.

Fungi also contribute to nutrient cycling through their interactions with plants and other soil microorganisms. Mycorrhizal fungi establish associations with plant roots and facilitate the acquisition of nutrients, particularly phosphorus and nitrogen. In return, plants provide these fungi with photosynthetically derived carbon compounds. Such relationships contribute to nutrient exchange and influence the movement of carbon between plants, fungi and soil organic matter. Frey (2019) highlights the importance of mycorrhizal fungi as mediators of soil organic matter dynamics, demonstrating that their ecological functions extend beyond direct nutrient transfer to plants.

Carbon cycling is another important dimension of fungal activity. During decomposition, fungi utilise organic carbon for energy and growth, releasing a portion through respiration while incorporating another portion into fungal biomass and metabolic products. Some fungal-derived compounds can contribute to soil organic matter formation and stabilisation. However, fungal activities do not always increase soil carbon storage because decomposition can also accelerate carbon mineralisation. The overall outcome depends on fungal community composition, substrate availability, environmental conditions and interactions with other microorganisms.

Nitrogen and phosphorus cycling are similarly influenced by fungal activity. Organic nitrogen-containing compounds are decomposed through enzymatic processes, releasing nitrogen in forms that can subsequently undergo microbial transformation and become available to plants. Fungal hyphae can also transport nutrients across soil microsites and facilitate access to nutrient sources beyond immediate root zones. Organic acids produced by

microorganisms, including fungi, may influence the mobilisation of nutrients associated with soil minerals and organic matter.

Fungal communities are sensitive to environmental conditions, including soil moisture, temperature, pH, nutrient availability and land-use practices. Changes in these factors can influence fungal diversity, metabolic activity and the composition of microbial communities. Baldrian et al. (2022) emphasise the importance of understanding fungal communities under global environmental change, particularly because changes in environmental conditions can modify the ecological processes responsible for decomposition and nutrient cycling.

2. NEED OF THE STUDY

The study of fungal involvement in organic matter decomposition and nutrient cycling is necessary because soil fertility depends heavily on the continuous transformation and recycling of nutrients. Plant residues, animal remains and other organic materials accumulate in soil, but their contribution to soil fertility depends on the activities of decomposer organisms. Fungi are among the most important organisms responsible for these transformations because of their capacity to produce extracellular enzymes and utilise complex organic substrates.

Modern agricultural practices, excessive chemical fertiliser application, intensive land use and environmental changes can influence soil microbial communities and their ecological functions. Understanding fungal activities can help explain how biological processes contribute to nutrient availability and long-term soil productivity. It can also provide a scientific foundation for developing sustainable soil management practices that support natural nutrient recycling.

Another important requirement is to understand the relationship between fungal biodiversity and soil health. Different fungal species possess different ecological characteristics and decomposition abilities. Changes in fungal community composition may therefore influence the breakdown of organic materials, carbon storage and nutrient mobilisation. Studying these relationships can improve understanding of ecosystem functioning and environmental sustainability.

3. PROBLEM STATEMENT

Organic matter decomposition and nutrient cycling are essential processes for maintaining soil fertility, but their effectiveness depends significantly on the biological activities of microorganisms. Among these microorganisms, fungi perform specialised functions in the decomposition of complex organic materials and the transformation of nutrients. Despite their ecological importance, the contribution of different fungal groups to soil nutrient dynamics is influenced by several biological and environmental factors that remain complex.

One major problem concerns the variability in fungal decomposition activities. Different fungal species possess different enzymatic capabilities, substrate preferences and ecological adaptations. Consequently, the decomposition of cellulose, lignin, proteins and other organic compounds does not occur uniformly across soil environments. Changes in fungal community composition may influence the rate of organic matter breakdown and the availability of essential nutrients.

4. LITERATURE REVIEW

Eichlerová et al. (2015) examined the enzymatic systems involved in organic matter decomposition and established their relationship with the ecology and taxonomy of saprotrophic fungi. Their research highlights that different fungal species possess distinct enzymatic capabilities depending on their ecological characteristics and substrate preferences. Saprotrophic fungi produce extracellular enzymes that facilitate the breakdown of structurally complex organic materials, including cellulose, hemicellulose and lignin. These biochemical processes are essential for converting plant residues into simpler compounds that can undergo further microbial transformation. The study is particularly relevant to soil nutrient cycling because the efficiency of decomposition influences the release and availability of nutrients. It also demonstrates that fungal diversity is closely connected with the functional diversity of decomposer communities. Therefore, understanding fungal taxonomy and enzymatic characteristics is important for evaluating the ecological contribution of fungi to organic matter decomposition.

Baldrian (2017) examined the diversity, complexity and dynamics of forest soil microbial communities, with particular emphasis on fungal populations. The study highlights that forest soils contain highly diverse microbial communities that perform interconnected ecological functions. Fungi contribute to organic matter decomposition, nutrient transformation and interactions with plants and other microorganisms. Their distribution and activity are influenced by environmental conditions, substrate availability and ecological relationships within soil ecosystems. The research also emphasises that soil microbial communities are dynamic rather than static, with their composition changing in response to seasonal and environmental conditions. This perspective is important because fungal functioning cannot be understood independently of the wider microbial environment. The study establishes the importance of fungal diversity in maintaining forest ecosystem functioning and demonstrates the need to examine microbial interactions when analysing soil biological processes.

Fierer (2017) discussed the complexity of soil microbiomes and the challenges associated with understanding their ecological functioning. The study emphasises that soil contains highly diverse microbial communities whose activities are influenced by environmental conditions and interactions among microorganisms. Fungal communities contribute to several essential soil processes, including organic matter decomposition, nutrient transformations and plant-microbe interactions. However, predicting the functioning of soil microbiomes remains challenging because microbial diversity does not always translate directly into predictable ecological outcomes. Different organisms may perform overlapping functions or respond differently to environmental disturbances. The research is significant for the present study because it establishes the importance of understanding microbial community composition alongside functional processes. It also highlights the relevance of advanced molecular and ecological approaches for studying fungal diversity and its contribution to soil nutrient cycling.

Averill and Hawkes (2016) investigated the influence of ectomycorrhizal fungi on soil carbon cycling and demonstrated that these fungi can slow certain processes of soil carbon

decomposition. Their contribution is particularly important for understanding the relationship between mycorrhizal associations and carbon storage. Ectomycorrhizal fungi receive carbon from their host plants and utilise it to support their growth and nutrient acquisition activities. Their interactions with other decomposer organisms can influence the accessibility of organic substrates and the overall rate of carbon turnover. The study draws attention to the fact that mycorrhizal fungi do not simply function as nutrient-absorbing organisms; they can also influence soil organic matter dynamics. Their ecological effects depend on interactions with saprotrophic fungi, nutrient availability and environmental conditions. This research provides an important basis for examining the relationship between fungal communities and soil carbon stabilisation.

Lindahl and Tunlid (2015) examined the potential of ectomycorrhizal fungi to participate in organic matter decomposition while distinguishing their ecological functions from those of saprotrophic fungi. Their discussion highlights that ectomycorrhizal fungi possess certain biochemical capabilities that allow them to access nutrients from organic matter. However, their primary ecological strategy is associated with nutrient acquisition through symbiotic relationships with plants rather than unrestricted decomposition of organic materials. This distinction is important because different fungal groups may influence soil organic matter through different mechanisms. Saprotrophic fungi primarily obtain energy by decomposing organic substrates, whereas ectomycorrhizal fungi depend substantially on plant-derived carbon. The study contributes to understanding the complexity of soil nutrient cycling and indicates that fungal groups must be evaluated according to their ecological strategies and interactions.

Treseder and Lennon (2015) examined the fungal traits that influence ecosystem dynamics on land. Their research provides a broad understanding of how fungal characteristics contribute to terrestrial ecological processes. Fungal traits such as growth rate, resource acquisition, enzyme production, stress tolerance and reproductive strategies influence their ecological performance. These characteristics determine how fungi respond to environmental conditions and interact with other organisms. The study is relevant to organic matter decomposition because fungal species differ in their ability to utilise particular substrates and obtain nutrients from soil. It also highlights that fungal communities influence ecosystem processes through their biomass, metabolic activities and interactions with plants. Understanding these functional traits is important for predicting how soil ecosystems respond to environmental changes and disturbances.

Clarholm, Skyllberg and Rosling (2015) investigated the role of organic acids in releasing nutrients from metal-stabilised soil organic matter through their proposed unbutton model. Their research provides an important biochemical explanation of how organic compounds can influence nutrient availability in soil. Organic matter may become associated with mineral surfaces and metal compounds, limiting its immediate accessibility to microorganisms. Organic acids can interact with these mineral associations and facilitate the release of nutrients and organic compounds. This mechanism is relevant to fungal activity because fungi can produce organic acids during metabolism, potentially influencing nutrient

mobilisation and organic matter accessibility. The study therefore demonstrates that nutrient cycling involves interactions between biological processes and soil chemical properties. It also highlights the importance of considering mineral-organic matter interactions when examining the decomposition and transformation of soil organic materials.

Fernandez and Kennedy (2016) revisited the Gadgil effect and examined whether interactions between different fungal ecological groups influence carbon cycling in forest soils. Their research focuses on the interactions between ectomycorrhizal and saprotrophic fungi and their implications for organic matter decomposition. Competition for nutrients and resources can influence the growth and activity of these fungal groups. Such interactions may modify decomposition rates and affect the movement of carbon through soil ecosystems. The study is important because it demonstrates that the ecological functions of fungi are shaped not only by their individual enzymatic capacities but also by interactions among microbial groups. Understanding these relationships is essential for predicting the effects of changes in fungal community composition on soil carbon dynamics and ecosystem functioning.

Frąc et al. (2018) examined fungal biodiversity and its importance for soil health. Their work highlights the multiple ecological functions performed by fungi in agricultural and natural soils. Fungal communities contribute to organic matter decomposition, nutrient transformation, plant growth and soil structural development. The study emphasises that fungal biodiversity is an important component of healthy soil ecosystems because different species perform complementary ecological functions. Some fungi are particularly effective in decomposing plant residues, while others establish beneficial associations with plant roots and improve nutrient acquisition. Changes in fungal diversity can therefore influence soil biological activity and ecosystem stability. The research is particularly relevant to sustainable agriculture because maintaining diverse fungal communities can support natural nutrient cycling and improve the biological condition of cultivated soils.

Frey (2019) reviewed the role of mycorrhizal fungi in regulating soil organic matter dynamics. The study emphasises that mycorrhizal fungi influence carbon and nutrient transformations through their relationships with plant roots and other soil organisms. These fungi receive carbon from plants and use it to support hyphal growth and nutrient acquisition. Their activities can influence the decomposition of organic materials, the formation of microbial residues and the stabilisation of soil carbon. The research demonstrates that mycorrhizal fungi should be considered important regulators of soil organic matter rather than merely organisms responsible for nutrient transfer to plants. Their effects vary according to fungal functional groups, plant characteristics, soil properties and interactions with decomposer microorganisms. The study provides a useful conceptual foundation for understanding the relationship between fungal symbiosis and nutrient cycling.

Baldrian et al. (2022) examined fungal communities in soils under global environmental change. Their research highlights the sensitivity of soil fungal communities to changing environmental conditions and the consequences for ecosystem processes. Climate-related changes in temperature, moisture and vegetation patterns can influence fungal diversity, community composition and metabolic activity. These changes may affect the decomposition

of organic matter and the availability of essential nutrients. The study is significant because it connects fungal ecology with broader environmental challenges. It suggests that changes in fungal communities can influence soil ecosystem functioning and the stability of nutrient cycling processes. Understanding these responses is important for predicting how terrestrial ecosystems may respond to environmental disturbances and developing appropriate strategies for maintaining soil biological diversity.

Tunlid et al. (2022) examined the mechanisms through which ectomycorrhizal fungi decompose soil organic matter and discussed the consequences for organic nitrogen uptake and soil carbon stabilisation. Their research highlights that ectomycorrhizal fungi possess biochemical systems that enable them to access nitrogen from organic substrates. Such processes are important in forest ecosystems where nitrogen availability may limit plant productivity. The study also discusses the relationship between organic matter decomposition and carbon stabilisation, demonstrating that fungal nutrient acquisition can influence the transformation of soil organic materials. The research provides an important contribution to understanding the ecological complexity of mycorrhizal fungi. It indicates that nutrient cycling and carbon dynamics are interconnected processes that depend on fungal functional characteristics and their relationships with plants and soil microorganisms.

5. METHODOLOGY

The present study adopts a descriptive and qualitative research design based entirely on secondary data. It examines the role of fungi in organic matter decomposition and nutrient cycling through a critical analysis of existing scientific literature. The primary sources include peer-reviewed journal articles and published scholarly research concerning fungal ecology, soil microbiology, enzymatic decomposition, mycorrhizal associations and soil carbon dynamics.

The selected literature provides the conceptual and scientific foundation for understanding the biochemical and ecological mechanisms associated with fungal activity. The collected information is organised into thematic categories, including fungal biodiversity, organic matter decomposition, extracellular enzyme production, carbon transformation, nitrogen and phosphorus cycling, and environmental influences. Qualitative content analysis and descriptive interpretation are used to identify recurring scientific findings and examine relationships among fungal communities and soil processes. No laboratory experiments, soil sampling, microbial isolation, field observations or primary statistical investigations have been undertaken. Accordingly, the findings are based on the synthesis and interpretation of existing scientific research.

6. RESULTS AND DISCUSSION

The analysis of the reviewed literature establishes that fungi perform multiple interconnected functions in soil ecosystems. Their contributions extend from the decomposition of complex organic materials to nutrient mobilisation, carbon transformation and the maintenance of soil biological structure. The findings are discussed through major ecological and biochemical dimensions.

6.1 Fungal Diversity and Organic Matter Decomposition

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Fungal biodiversity is a major determinant of decomposition processes in soil because different fungal groups possess different substrate preferences, enzymatic capabilities and ecological adaptations. Saprotrophic fungi are particularly important because they obtain energy and nutrients by decomposing dead organic materials, including leaf litter, plant residues, woody substances and other organic compounds.

Their hyphal networks penetrate organic substrates and facilitate the distribution of extracellular enzymes. These enzymes break down complex compounds into smaller molecules that can be absorbed and metabolised by fungal cells and other microorganisms.

Different fungal species possess different decomposition capabilities. Some are particularly effective in cellulose degradation, whereas others can modify lignin-rich materials. Eichlerová et al. (2015) demonstrate the relationship between fungal taxonomy, ecological characteristics and enzymatic systems involved in decomposition.

Baldrian (2017) and Frąc et al. (2018) further highlight that fungal biodiversity contributes to the functional complexity of soil ecosystems. Therefore, the maintenance of diverse fungal communities is important for ensuring the continuous decomposition of organic matter under different environmental conditions.

6.2 Enzymatic Mechanisms Involved in Decomposition

The decomposition of organic matter by fungi is largely facilitated by extracellular enzymes. These enzymes are secreted into the surrounding environment, where they act on complex organic compounds and convert them into simpler substances.

Cellulases are responsible for breaking down cellulose into smaller carbohydrate units. Hemicellulases act on hemicellulose, which forms an important component of plant cell walls. Lignin-modifying enzymes, including laccases and peroxidases, contribute to the transformation of lignin-rich materials. Proteases facilitate the breakdown of proteins into smaller nitrogen-containing compounds.

These enzymatic processes make organic nutrients more accessible to microorganisms and contribute to the recycling of essential elements. The production of particular enzymes depends on fungal species, substrate characteristics and environmental conditions.

Table 1: Major Fungal Enzymes and Their Functions in Organic Matter Decomposition

Enzyme	Principal substrate	Ecological function
Cellulase	Cellulose	Breaks down plant cell-wall carbohydrates
Hemicellulase	Hemicellulose	Decomposes complex plant polysaccharides
Laccase	Lignin-related compounds and phenolics	Facilitates oxidative transformation of complex organic materials
Lignin peroxidase	Lignin	Supports the breakdown of structurally complex aromatic compounds
Manganese peroxidase	Lignin-related compounds	Facilitates oxidative modification of lignin
Protease	Proteins	Releases smaller nitrogen-containing

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		compounds
Chitinase	Chitin	Decomposes fungal and other chitin-containing materials
Phosphatase	Organic phosphorus compounds	Releases inorganic phosphate through hydrolysis

6.3 Role of Fungi in Carbon Cycling

Carbon cycling represents one of the most important ecological functions of soil fungi. Plant-derived organic materials enter soil through leaf litter, root residues, dead vegetation and other biological inputs. Fungi contribute to the transformation of these materials through decomposition, respiration and biomass production.

During decomposition, fungi utilise organic carbon to support cellular metabolism and growth. A proportion of the carbon is released into the atmosphere through respiration, while another proportion becomes incorporated into fungal biomass and metabolic products. Fungal residues can subsequently contribute to soil organic matter formation.

However, the relationship between fungal activity and soil carbon storage is complex. Some fungal activities accelerate carbon decomposition, whereas others may contribute to the formation or stabilisation of soil organic matter. Mycorrhizal fungi can influence carbon dynamics through plant-derived carbon inputs and interactions with decomposer communities.

Averill and Hawkes (2016) highlight that ectomycorrhizal fungi can slow certain soil carbon cycling processes. Fernandez and Kennedy (2016) further demonstrate the importance of interactions between fungal ecological groups in regulating carbon decomposition. These findings indicate that soil carbon dynamics depend on the balance between decomposition, microbial processing and carbon stabilisation.

6.4 Fungal Contribution to Nitrogen and Phosphorus Cycling

Nitrogen and phosphorus are essential nutrients required for plant growth and microbial functioning. Fungi contribute to the cycling of these nutrients by decomposing organic materials and facilitating nutrient acquisition.

Nitrogen occurs in soil organic matter through proteins, amino compounds and other nitrogen-containing substances. Saprotrophic fungi produce enzymes such as proteases that facilitate the breakdown of these compounds. The resulting products can undergo further microbial transformations, contributing to nitrogen mineralisation and the availability of inorganic nitrogen forms.

Mycorrhizal fungi play an additional role by acquiring nitrogen from soil organic and inorganic sources and transferring nutrients to associated plants. Tunlid et al. (2022) highlight the mechanisms through which ectomycorrhizal fungi access organic nitrogen and the consequences for soil carbon stabilisation.

Phosphorus is frequently present in soil in organic forms and in association with mineral compounds. Fungi can contribute to phosphorus mobilisation through phosphatase production

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and the release of organic acids. These mechanisms can increase the availability of phosphorus for microbial uptake and plant nutrition.

Table 2: Contribution of Fungi to Major Nutrient Cycling Processes in Soil

Nutrient	Fungal mechanism	Ecological significance
Carbon	Decomposition of plant residues and organic substrates	Supports carbon transformation and soil organic matter dynamics
Nitrogen	Protease activity and acquisition of organic nitrogen	Facilitates nitrogen mobilisation and plant nutrition
Phosphorus	Phosphatase production and organic acid release	Improves phosphorus mobilisation and availability
Sulphur	Decomposition of sulphur-containing organic compounds	Contributes to sulphur transformation and recycling
Potassium	Weathering-related processes and mobilisation from mineral and organic sources	May improve nutrient accessibility in certain soil environments

6.5 Mycorrhizal Fungi and Soil Nutrient Dynamics

Mycorrhizal fungi establish symbiotic relationships with plant roots and perform important functions in nutrient acquisition. Their hyphal networks extend beyond the immediate root zone and explore soil spaces that may not be accessible to roots alone.

These networks can facilitate the uptake of phosphorus, nitrogen and other nutrients. In exchange, plants provide carbohydrates and other carbon compounds generated through photosynthesis. This relationship supports plant growth and contributes to nutrient movement within soil ecosystems.

Mycorrhizal fungi also influence organic matter dynamics. Frey (2019) highlights their role in mediating soil organic matter processes, while Lindahl and Tunlid (2015) distinguish their nutrient-acquisition strategies from the primary decomposition activities of saprotrophic fungi.

The relationship between mycorrhizal and saprotrophic fungi is particularly important. These groups may compete for nutrients and resources, and their interactions can influence decomposition rates. The Gadgil effect describes the possibility that ectomycorrhizal fungi suppress saprotrophic decomposition under certain conditions through competition and resource-related mechanisms.

Consequently, the influence of mycorrhizal fungi on soil nutrient cycling extends beyond their direct association with plant roots. They also affect the ecological relationships that regulate carbon and nutrient transformations.

6.6 Fungi and Soil Structure

Fungi contribute to soil structural development through their extensive hyphal networks and interactions with organic and mineral particles. Hyphae can physically connect soil particles,

helping to form and stabilise soil aggregates. These aggregates influence soil porosity, water retention, aeration and resistance to erosion.

Fungal biomass and decomposition products can also contribute to the formation of organic binding materials that influence soil structure. Mycorrhizal fungi, particularly those producing extensive external hyphae, can contribute to the organisation of soil aggregates.

Frąc et al. (2018) identify fungal biodiversity as an important component of soil health. Their findings support the importance of maintaining fungal communities for sustaining soil biological and structural functions.

6.7 Environmental Factors Influencing Fungal Activity

Fungal activity is influenced by several environmental factors, including temperature, soil moisture, pH, organic matter availability and nutrient conditions. These factors regulate fungal growth, enzyme production, community composition and decomposition rates.

Temperature influences metabolic activity and the functioning of extracellular enzymes. Soil moisture affects hyphal growth, nutrient diffusion and the accessibility of substrates. Excessively dry conditions can restrict fungal activity, while prolonged water saturation can create oxygen limitations and alter the composition of fungal communities.

Soil pH also influences fungal diversity and the availability of nutrients. Different fungal species possess different pH tolerances, resulting in variations in community composition across soil environments.

Global environmental change can modify these conditions and influence fungal ecological functions. Baldrian et al. (2022) highlight the importance of examining fungal communities under changing environmental conditions. Their work suggests that changes in soil environments may affect decomposition processes and nutrient cycling through alterations in fungal diversity and activity.

Table 3: Environmental Factors and Their Influence on Soil Fungal Activities

Environmental factor	Influence on fungal communities	Possible effects on soil processes
Temperature	Influences growth and metabolic activity	Alters decomposition rates and enzyme functioning
Soil moisture	Regulates hyphal growth and substrate accessibility	Affects organic matter decomposition and nutrient movement
Soil pH	Influences fungal diversity and physiological activity	Modifies nutrient availability and microbial composition
Organic matter availability	Determines the supply of energy and carbon substrates	Influences fungal biomass and decomposition activity
Nutrient availability	Affects fungal growth and nutrient-acquisition strategies	Modifies nutrient mobilisation and microbial interactions
Land-use practices	Alters soil structure, substrate inputs and microbial habitats	Can change fungal diversity and soil biological functioning

Climate change	Modifies temperature, moisture and vegetation conditions	Influences fungal community composition and carbon-nutrient cycling

6.8 Fungal Interactions and Soil Ecosystem Stability

Soil fungi interact with bacteria, plants, soil fauna and other microorganisms. These interactions influence decomposition, nutrient availability and ecosystem stability. Fungal communities can compete with other microorganisms for nutrients and organic substrates, while some interactions may facilitate complementary nutrient transformations.

The balance between saprotrophic and mycorrhizal fungi is particularly important in forest ecosystems. Saprotrophic fungi decompose dead organic materials, while mycorrhizal fungi obtain nutrients through their associations with plants and may also influence the activity of decomposer organisms.

Fernandez and Kennedy (2016) highlight the importance of interguild interactions in regulating carbon cycling. Similarly, Fierer (2017) emphasises that the complexity of soil microbiomes makes it necessary to examine microbial interactions rather than treating individual microbial groups in isolation.

Maintaining fungal biodiversity can therefore support ecosystem stability by ensuring the presence of organisms capable of performing different ecological functions. Disturbances that reduce fungal diversity may affect decomposition efficiency, nutrient availability and the overall functioning of soil ecosystems.

7. CONCLUSION

Fungi perform essential ecological functions in soil through organic matter decomposition, nutrient mobilisation and the regulation of carbon and nutrient cycling. Their ability to produce extracellular enzymes enables them to break down complex organic materials, including cellulose, hemicellulose and lignin, thereby facilitating the transformation of organic residues into simpler compounds. Saprotrophic fungi contribute directly to decomposition, while mycorrhizal fungi support plant nutrient acquisition and influence soil organic matter dynamics.

The present study establishes that fungal activities contribute to carbon transformation, nitrogen and phosphorus mobilisation, soil aggregation and ecosystem stability. It also highlights that fungal biodiversity, enzymatic characteristics and interactions among microbial groups influence the effectiveness of these processes. Environmental factors such as temperature, moisture, pH and land-use practices can modify fungal communities and their ecological functioning.

The study concludes that maintaining diverse and functional fungal communities is important for sustaining soil fertility, improving nutrient availability and supporting long-term ecosystem productivity. Sustainable agricultural practices, organic residue management and reduced soil disturbance can help preserve favourable conditions for soil microorganisms. A better understanding of fungal ecology and biochemical processes can contribute to improved soil management, environmental conservation and sustainable agricultural development.

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