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# NUTRIENT BUDGET LITTER DECOMPOSITION OF MULTIPURPOSE TREES IN FOREST ECOSYSTEM

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**ABSTRACT**

Litterfall is an important channel through which the organic matter decomposition cycle connects the soil and plant components in an ecosystem. It serves as a temporary nutritional sink as well as an input-output system. Due to its significant contribution to nutrient fluxes, elements affecting the development and breakdown of litter have a significant impact on the ecosystem's long-term productivity. The quantity and quality of litter vary depending on the following: stocking numbers, tree management, floristic composition, stand age, and environmental conditions. The quality and quantity of litter vary according on the following factors: environment, floristic composition, stand age, tree management, and stocking levels. They thereby modify the rates of nutrient turnover and degradation. Thus, species selection can control the release of plant nutrients into the soil and their subsequent recycling through plant uptake. The ways in which multipurpose trees absorb, store, and recycle nutrients change greatly depending on the quality of their litter. It is, therefore, vital to have a good understanding of the tree species influences on many components of soil organic matter dynamics and nutrient cycling including the effects of litter or green manure addition on soil nutrient dynamics.
***Keywords* :** Litterfall, ecosystem, nutrient cycle, organic matter, decomposition, multipurpose trees, soil.

## Introduction

For the preservation of biodiversity, nutrient replenishment, nutrient input and output, the nutrient cycle that controls the buildup of soil organic matter, and other ecosystem activities, litterfall is a crucial component of any forest ecosystem. Plant debris that has been separated from a living plant is found in the layer on the soil's surface. Litter decomposition rate is influenced by a number of climatic conditions, including temperature, humidity, rainfall, and seasonal fluctuations. Microbial decomposition releases carbon dioxide, which is highly helpful to the decomposition of litterfall. Microbes and plants aid in the decomposition of litter, the cycling of nutrients, and the mineralisation process. The dynamics of the forest ecosystem are greatly influenced by the abundance of litter present on the forest floor. Litter decomposition illustrates the beneficial role of a forest ecosystem in the nutrient budget. The organisation of soil fauna and microbial communities have an impact on the pace of litter breakdown at different stages of decomposition. (Krishna and Mahesh, 2017; Giweta, 2020 and Bezkorovainaya, 2005). One important route that connects the soil and plant components in an ecosystem is litterfall. It serves as a temporary nutritional sink as well as an input-output system. The long-term productivity of the ecosystem is significantly impacted by factors controlling the generation and decomposition of litter, owing to its significant involvement in nutrient fluxes. The quantity and quality of litter vary depending on the following: stocking numbers, tree management, floristic composition, stand age, and environmental conditions. Thus, in a managed tropical system, species selection can influence nutrient cycle. The ways in which multipurpose trees absorb, store, and recycle nutrients change greatly depending on the quality of their litter. Therefore, it is crucial to comprehend how different tree species affect the dynamics of soil organic matter and nutrient cycling, as well as how adding litter or green manure affects these processes (Krishna and Mahesh, 2017; Giweta, 2020 and Brady and Weil, 2010).

### Multipurpose trees

The purposeful maintenance and management of trees and shrubs for numerous desired uses, products, and/or services; in a multiple-output land-use system, the cultivation or retention of these is typically driven by economic considerations. (Klein and Dutrow 2000; Santa Regina and Tarazona, 2001).

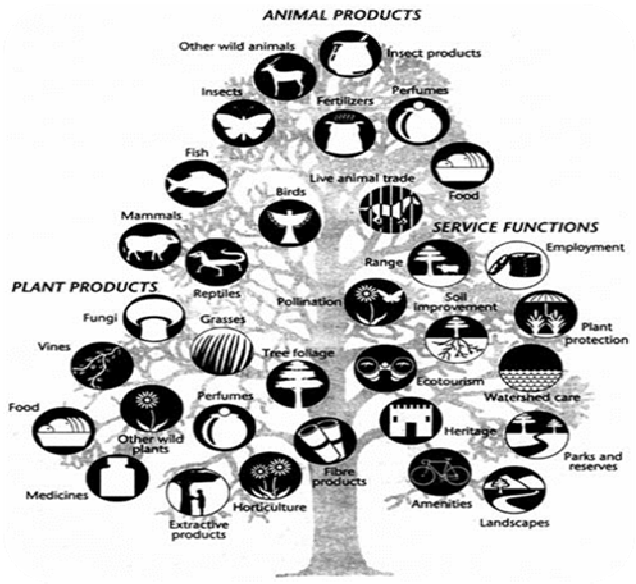


**Fig. 1:** Multipurpose tree (Source: Madhu Verma, 2018)

**Table 1 :** Role of MPTS

| **Protective role of MPTS** |
|---|
| Stabilization of environment |
| Soil improvement |
| Live fences |
| Wildlife habitat |
| Pest and weed control Watershed protection and rehabilitation of degraded lands. |
| **Productive role of MPTS** |
| Wood - timber, building material, pulp, paper etc. |
| Bark - raw as fuel, dyes, and tannins. |
| Energy Raw - wood fuel Processed - charcoal, gases or liquid fuels, resin, oil paint, varnishes |
| Leaf - fodder, oil, silk, medicines, dyes, food |
| Root - fiber, fuel wood, dyes, chemical extractives. |
| **Socio-economic benefits** |
| Improved human and animal nutrition and health |
| Employment opportunities and income generation |
| Foreign exchange and import substitution |
| Rehabilitation of degraded lands |
| Counter seasonality, year along products and employment |
| Risk reduction and lobour saving |

Source: Pathak, 1992

### What is litter?

The dead plant material (leaves, branches, and other plant components) that is dispersed over the forest floor or soil is called litter. It is composed of both subterranean and above-ground biomass (Vesterdal, 1999; Wedderburn and Carter, 1999) Leaf is by far the most common component.

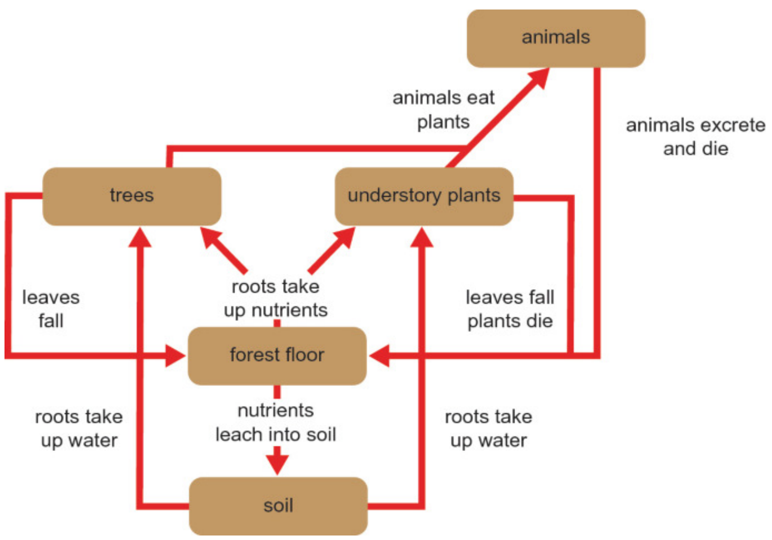


**Fig. 2:** Nutrient cycling in an ecosystem
*Source: Huntley, B.J., 2023*

**General composition of compounds**

Simple sugars, cellulose, and hemicellulose are examples of carbohydrates. Lignin is connected to cellulose. grow as the percentage of wood increases. immune to deterioration. The intermediate complexity of fats and oils. mostly connected to seeds (Isaac and Nair, 2005). Proteins are the primary source of nutrition, along with amino acids, amines, and other $N_2$ molecules.

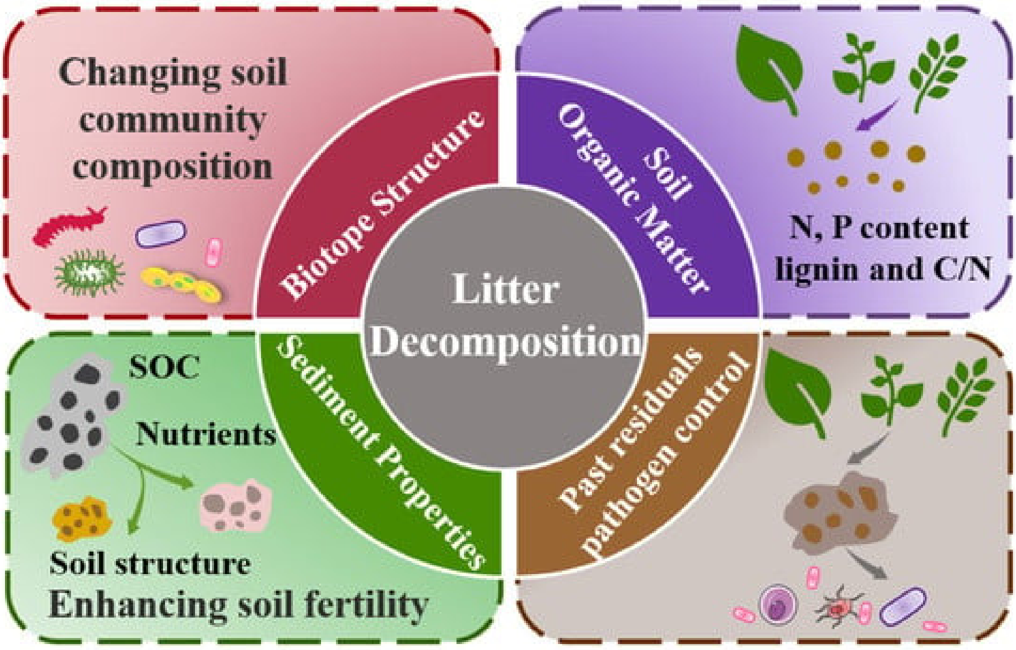


**Fig. 3:** The role of plant litter in ecosystem functioning (Source: Zhou, X *et al*., 2023)

**Decomposition of organic compounds**

Sugars, starch, simple protein, Crude protein, Hemicellulose, Cellulose, Fats, waxes, Lignin (Crawford, 1981; Jin *et al*., 1990 and Eriksson *et al*., 1990).

**Factors affecting litterfall**

Basal area and stand age, Species attributes, Species composition/ ecosystem, Season/climate, Management interventions (Giweta, 2020; Berg *et al*. 1993; Couteaux *et al*. 1995; Cadish and Giller 1997; Bohlen *et al*. 1997 and Dechaine *et al*. 2005)

**Basal area and stand age**

It is known that the age structure and basal area are important factors in determining litterfall (Giweta, 2020). Basal area and yearly litterfall are present in early emerging stands.

**Species attributes**

It is crucial to consider species-related changes in litterfall quantity and periodicity. (Giweta, 2020) Eg: Deciduous Vs Evergreen, $N_2$ fixing trees etc.

**Species mixtures**

The creation of litters coincides with that of biomass. Due to their inherent productivity advantage over monospecific stands, mixed species stands are likely to produce more litter (Giweta, 2020).

**Season/climate**

Specifically for deciduous plants, falling leaves is a sporadic occurrence. Adheres to a bimodal or unimodal pattern (Giweta, 2020). The most prevalent type of litterfall pattern is unimodal for tropical species.

**Reasons for peak litter fall during a particular season**

Senescence of leaves due to stress from moisture and/or temperature. Warm weather, unfavorable surroundings, and seasonal variations in soil salinity (Giweta, 2020).

**Management interventions**

Thinning, pruning and fertilization. As a result, thinning reduces litterfall rates, but canopy closure quickly increases them again. Agroforestry typically involves pruning the laterals, and the trees that are pruned typically produce less litter (Giweta, 2020). Also modifies the periodicity of leaf fall. As fertilization increases the creation of leaf biomass, it may also increase litterfall.

## Litter decomposition

Litter decomposition is the process by which biotic and abiotic forces break down the accumulation of litter on the forest floor into simpler molecules (Mishra *et al.*, 2004; Chapman and Koch 2007 and Lira *et al.*, 2007).

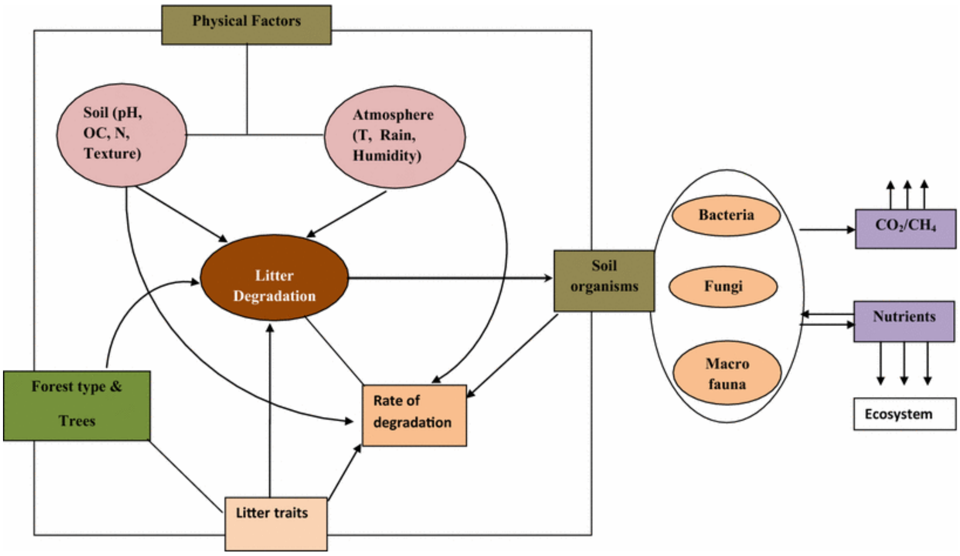


**Fig. 4:** Litter decomposition

Source: Krishna, M.P, 2017

## Three important ecosystem effects of decomposition

Returns to atmosphere the majority of C fixed by NPP (Lira *et al.*, 2007). Provides the majority of the yearly fertiliser need for plant uptake (Mishra *et al.*, 2004). The initial stage of the development of organic matter in soil, which influences soil properties: $H_2O$ retention and CEC (Chapman and Koch, 2007).

## Plant litter decomposition

Water leaching eliminates soluble elements, such as nutrients and simple C compounds. (Chapman and Koch, 2007). Fragmentation: primarily caused by macrofauna in the soil, which redistributes decaying organic debris without altering its chemical composition (Lira *et al.*, 2007). Chemical modification: as microorganisms decompose organic matter molecules, chemistry is changed. (Mishra *et al.*, 2004).

## Humus

A dark-coloured, amorphous substance that resembles jelly and is made up of leftover organic materials that soil microbes find difficult to break down. (Krishna and Mahesh, 2017) Humification is the process of humus formation. Composed of two primary biological reaction types: synthesis and breakdown.

## Litter quality

The physical and chemical properties of litter play a crucial role in controlling its breakdown. The C components, cellulose and hemicellulose, break down quickly (Krishna and Mahesh, 2017). Lingitin is resistant to enzyme degradation and poses a significant hindrance to its breakdown. A favourable association with disintegration (Giweta, 2020). Phenolic substances, such as tannins, attach to proteins and soluble organic nitrogen to create robust complexes.

**Fig. 5:** Litter quality

**Ecosystem characteristics**

The quality of the location has a considerable influence on decay rates (Krishna and Mahesh, 2017). Tropics: Higher decay rate coefficient and quick nutritional turnover. So, nutrients are found in the biomass of trees (Giweta, 2020). Temperate areas: slow down the breakdown process.

**Moisture and temperature**

Climate plays a significant influence, particularly with regard to temperature and moisture. A greater reduction in litter mass is observed during the wet season (Krishna and Mahesh, 2017; Giweta, 2020). Elevated temperature encourages microbial activity, which in turn accelerates the pace of decomposition.

**Soil micro and macro faunal activity**

Compared to temperate environments, tropical ecosystems have a higher rate of decomposition due to their more diversified soil flora and fauna (Dilly *et al.*, 2004). The population of soil fauna may decrease if native vegetation is removed. Site-specific changes in soil biota activity result in notable differences in litter decomposition rates (Schaefer and Schauermann 1990 and). Drilosphere systems predominate in decomposition where soil-moisture regimes are suitable.

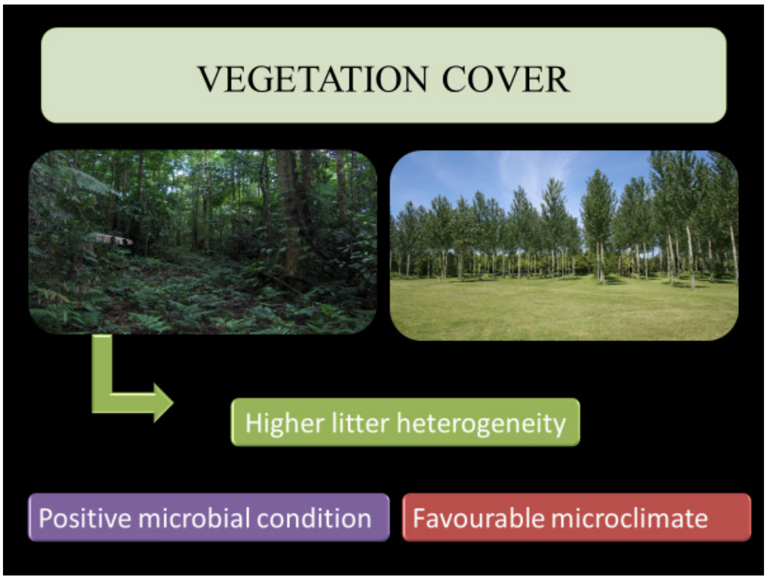


**Fig. :** Vegetation cover

**Soil fauna -** Microalgae fix nitrogen and produce organic matterviaphotosynthesis (Crawford DL, 1988). Increase the surface area of substrate for microbialuse (Gonzalez G, *et al*. 2001). Releases soil enzymes, which can help to processroot-driven carbon, small organic matter, and freshaboveground litter, as energy source for bacteria (forexample, fungi) (Schinner F, 1996; Gonzalez G and Zou X, 1999). The nutrient in soil by adding nitrogenouscompounds present in their excreta and dead tissue

**Soil microbes -** Decompose the fragmented litter and releasenutrients (Laganiere *et al.*, 2010). Release soil enzymes for the purpose of breaking the larger compounds (Brady and Wei, 2010)

**Nutrient release from decomposing litter**

30–50% of the leaf biomass decomposes in the first three to four months due to the rapid process(Guo and Sims 1999). Slower than the last one, most likely because the remaining mass had more resistant components accumulated in it. It continuously distributes nutrients slowly.

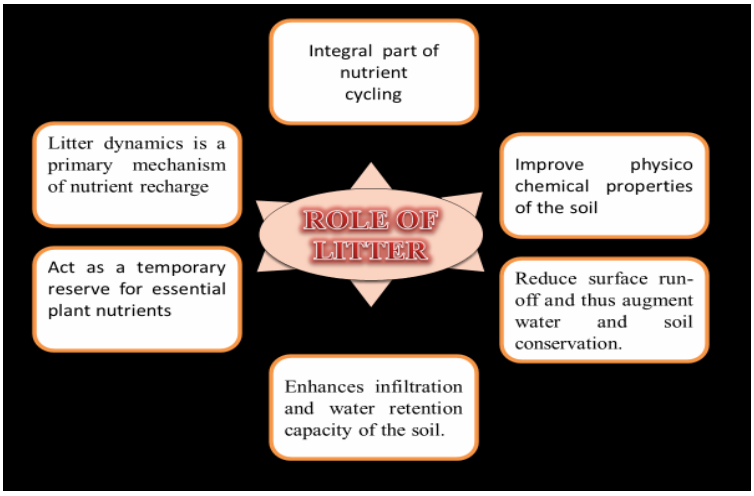


**Fig. 7:** Role of litter

## Conclusion

The biogeochemical cycling is significantly influenced by litter dynamics, which also provides the majority of the necessary materials needed for stand growth, particularly after canopy closure. This is particularly crucial in the majority of artificial forests and zero-input agroforestry systems. In managed tropical land use systems, the linkages between litter production and decay are complicated and influenced by a variety of factors, including location, climate, plant type, disturbance, and other productivity-related factors. The degree to which land managers can control litter dynamics is largely determined by these effects. Numerous management techniques can increase how effectively nutrients are absorbed and used by plants.

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