Review Article

AnOverview of Leaf Litter Decomposition and Nutrient Dynamics of Multipurpose Tree Species

Abstract:
The multipurpose tree species is a plant species that is purposefully grown so as to provide two or more than two products and their leaf litter decomposition in our ecosystems has a play major role in nutrient dynamics in the atmosphere. Abiological factors such as temperature, rainfall, humidity, moisture, evaporation rate and other seasonal variations affect the rate of leaf litter decomposition. From the this review paper attempt to understand the influence of various soil physical factors like-soil pH, texture, organic matter, chemical factor of leaf litter content like cellulose, hemicelluloses, tannin, lignin and biological factor like major soil fauna and microbes such as algae, actinomycetes, bacteria and fungi communities etc. to stimulating microbial action such as physical breakdown of leaf litter, transfer of organic matter to nutrients, release of CO_2 to the environment etc.

Keyword: Nutrient dynamics, leaf litter, multipurpose tree species, macro-invertebrates.

Introduction:

The dead plant materials such as leaves, bark, needles, flower and twigs that have fallen on the ground are called litter. As the majority of organic matter (OM) produced by plants is returned to the soil as litter, the transfer of nutrients and energy from living biological components to the soil is the important mechanism of nutrient recycling. In the various components of the plant-soil-microorganism mechanism, decomposition processes have a crucial vital role by releasing a complex organic compound into the simple usable form for plants growth and soil fertility. Tree leaf tissue accounted for more than 70% of above ground litter fall in the ecosystems and rest is composed stem, twigs, flower, fruits and other components. The decomposition is a biological disintegration process of dead organic materials whereby mineralization of complex organic matter into simple inorganic form (1). Tree leaf litter decomposition has physical, chemical, and

biological impact and is an important biological process that regulates the complex nutrient content to simple form and net productivity of ecosystems (2). Litter decomposition also affects the soil moisture status, light, and temperature conditionsrequired for the growth of surrounding plants (3), and it impacts the microbial community structure, soil physiochemical properties, and organic matter escapism and content of soil sediments. Generally correlation of main three factors viz. Climatic condition of site, leaf litter quality and soil biota. Out of it climate play dominant crucial role followed by leaf litter quality and soil biota as well as release of nutrient directly correlated to decomposition process (4). Therefore, the main aim of this review paper is to summarize the role of microbes for degradation of leaf litter as well as correlation of leaf litter quality, climatic conditions,soil biota and importance of nutrient dynamics process.

Studies of leaf litter decomposition process:

Leaf litter decomposition plays a very vital and important role for cycling of nutrient in ecosystems, where different types of flora on the basis of quality influenced most significantly. The interaction among soil microbes, climatic conditions and quality of leaf litter will result in the decomposition of litter, in which soil microbes fungi and bacteria is the primary decomposers of leaf litter and broken down into smaller pieces and modified mineralized form into inorganic compounds because microbes feed the organic remains of dead plants materials (5,6). After that the following major processes take place.

1. During the decomposition process soluble materials are moved to lower soil layer for further process.

2. Soil microbe's breakdown the large of piece of leaf litter into smaller ones.

3. Decomposer recognizes the molecules of litter to change the chemical alteration in soil.

During the decomposition process time, Soil fauna, microorganism play a very important role to break the complex compound of leaf litter and change the chemical composition of leaf litter structure and soluble compound (7,5). Atmosphere features, like temperature, rainfall, relative humidity and other seasonal variations may impact the existence of soil microbes and other soil features such as pH, organic carbon, nutrient availability, soil texture and structure that significantly affect the rate of litter decomposition as well as leaf litter quality like litter

structure, roughness, smoothness, waxes structure etc. directly influence the activity of soil communities and process during the decomposition (8). A graphical representation of litter degradation is shown in **Fig. 1**.

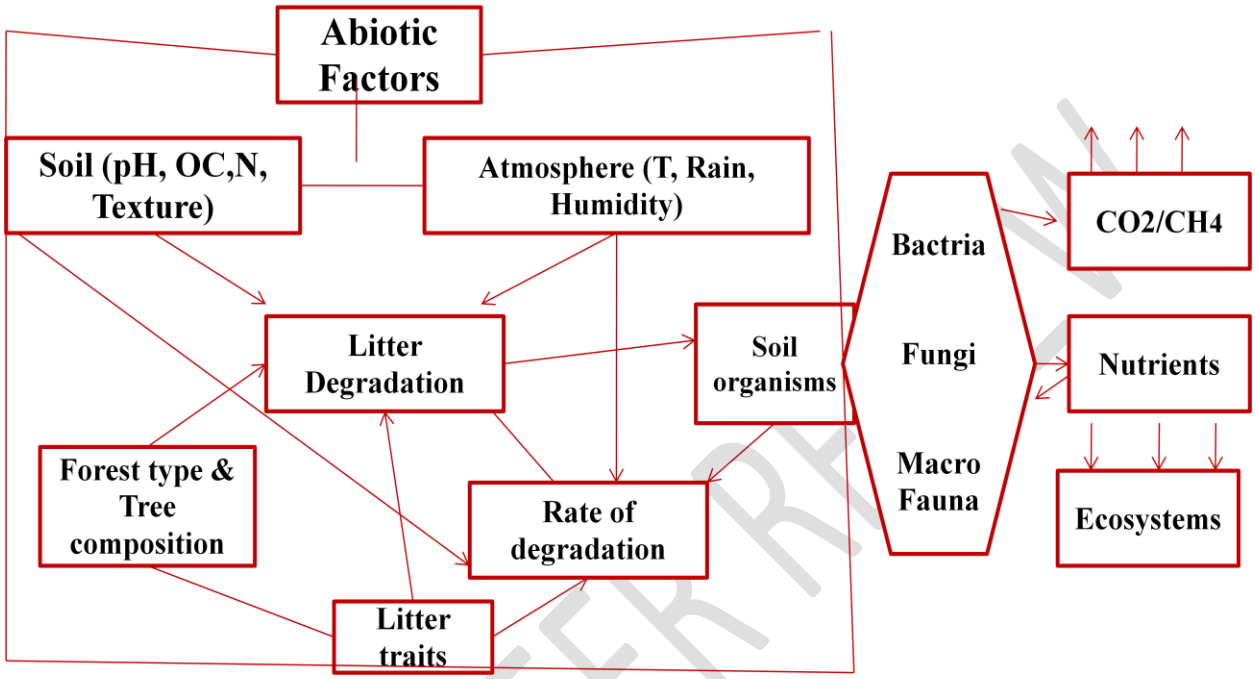

Fig.1 Graphical representation of factors affecting litter degradations.

Factors affecting leaf litter decomposition:

Leaf litter decomposition depends on various biotic such as chemical composition of litter and soil micro organisms and abiotic factors like temperature, relative humidity, rainfall. Both factor directly influenced on mineralization and humification process of structural complex of litter such as lignin, cellulose, hemicelluloses,pectine, starch etc through microorganisms and gradually mineralization of soluble nutrients compounds into soil by leaching process. However, from the above discussion we concluded that the main three leading features are regulating the litter decomposition like leaflitter quality traits, composition of soil microorganism activities and physio-chemical environments etc. (9). In abiotic factor such as temperature is a prime factor in determining the rate of leaf litter decomposition and more sensitive compare to other because abiotic factor like temperature influenced soil temperature and soil temperature directly influenced soil microbial activity rises exponentially. The fresh and old leaf litter position is a readily available substrate for soil microorganisms because leaf litter quality directly

influencethe decomposition process, as it reduces the throughout litter decomposition due to the loss of readily accessible carbon and accumulation of recalcitrant compounds according to (10) also shown in Fig.1.

Role of trees and leaf litter quality:

Tree leaf litter contains have different organic compounds, mainly four important soluble organic material present in litter such as phenolics, hydrocarbons, sugars and glycerides. In which soluble sugar, oligosaccharides and primarily monosaccharide are difficult to metabolize. The above proportions of all compounds are varies with the plant part such as leaves, stems, roots and bark as well as different tree species. The tree leaf litter quality chemical composition like nitrogen, phosphorus, potassium and cell wall components like lignin, cellulose and hemicelluloses etc, directly influence the litter decomposition and nutrient release (5,11). The components account of chief cell wall like lignin content 15 to 40% of total litter quantity. Its may be in extreme cases low as 4% or high as 50%. As well as in addition to lignin, other compound like cellulose, hemicelluloses, pectin are common constituents in tree leaf litter in term of quantity. The account of cellulose (10 to 50%) of litter quantity are linked with β-1-4 bonds and hemicelluloses are polymers of sugar create long chains of molecules organized into fibres (12). The all components such as litter traits-leaf toughness, N,lignin,polyphenol, C/N ratio, lignin: nitrogen ratio etc. directly and indirectly influence the decomposition process and various traits, nitrogen and lignin content of plant litter significantly regulating the decomposition rate (13,14).

Role of soil properties and soil fauna:

Different soil physical and chemical characteristics like soil texture, soil pH, cation exchange capacity, organic matter, nutrients contents, bulk density etc. have a significantly role in leaf litter decomposition process. In decomposition process, soil texture stimulates nutrients and water dynamics, porosity, permeability and soil surface area. According to (15) soil organic matter quality and quantity also play important role to increasing the population density of soil macro-organism, which plays important role in jumble the leaf litter and decomposition rate(16,17). Table 1 shows, the significant role of major soil fauna and microbes such as algae, actinomycetes, bacteria and fungi communities etc. to stimulating microbial action such as

physical breakdown of leaf litter, transfer of organic matter to nutrients, release of CO_2 to the environment etc. (18.,19,20,21). Some soil micro-arthropods includes small invertebrate animals with a exoskeleton and segmented body found on or near the surface of soil and in plant litter. Their population range is between 10^3 m^{-2} in agriculture soils and 10^6 m^{-2} in forest soils. It is a very essential part of the ecosystems due to their significant role in organic compound decomposition process and mineralization activity, nutrient cycling and pedogenesis (22). The labile structural compound like cellulose, sugar, amino acid quickly cleaved and absorbed by exo-enzymes and rapid decay (23).

Role of atmosphere factors:

From the studies of different literature we concluded that the atmosphere factors such as temperature, moisture, humidity, rainfall directly influenced to the chemical component of soil structure and affect the leaf litter decomposition rate in the soil (24). Also reported that the rate of decomposition of leaf litter slow in winter season and faster in rainy seasondue to the presence of sufficient rainfall, soil moisture and microbial load (25).

Table 1: Role of soil fauna and microbes in leaf litter decomposition.

S.no.	Decomposer communities	Roles	References
1.	Soil fauna	Microalgae fix nitrogen and produce organic matter via photosynthesis	(17)
		Increase the surface area of substrate for microbial use	(20)
		Releases soil enzymes, which can help to process root-driven carbon, small organic matter, and fresh aboveground litter, as energy source for bacteria (for example, fungi)	(16,21)
		Augment the nutrient in soil by adding nitrogenous compounds present in their excreta and dead tissue	(21)
2.	Soil microbes	Decompose the fragmented litter and release nutrients	(19)
		Release soil enzymes for the purpose of breaking the larger compounds	(18)

Leaf litter decomposition assessing techniques:

To determination of leaf litter decomposition and decay rate various techniques are used by author like mass balance technique, litter bag technique, Tethered leaves technique and Cohort layered screen technique etc. Mass balance technique are used to evaluate the leaf litter decay on the assumption of constant fraction, k, of the detrital leaf litter quantity decays because mass balance techniques depends on natural litter fall and it is not efficiently explain the role of atmosphere factors like temperature and moisture. In litter bag technique, mess size more than 2 mm and litter bag of 20x20 cm are common and efficient for permit of entry of macrofauna for contact of leaf litter and decay process (26). The another method of leaf litter decay evaluation is tethered leaves techniques. This techniques are similar to the litter bag method. In this method specific leaf litter are tightly packed with nylon thread or monofilament fishing line and permit the leaf intake by macro-invertebrates such as crabs and snails (27). A last Cohort layered screen technique are most appropriate and accurate evaluated of leaf litter decomposition and decay rate. It takes normally three to more years for leaf litter decay studies because there are separate techniques to determination of actual litter fall and decay condition through 1x1 m fiberglass or aluminum window screen with a mesh size of 2-3 mm are used (28).

Conclusion:

Leaf litter decomposition of multipurpose tree species is highly significantly play role in the ecosystem, as it is a most important way of nutrient dynamics, specially C, N and other nutrients elements in the ecosystems. Different multipurpose tree leaf litter decomposition are very high complex process that involves a number of soil physical factors like soil pH, soil texture, humification etc. chemical factors such as composition of leaf litter-cellulose, hemicelluloses, pectin, lignin, chitin etc and last and most important biological factors like atmosphere factor and soil fauna and microbes. However, from the study it is very difficult to understand that the which one the most important for litter decomposition. All the physical, chemical and biological factors inter correlated to each other for appropriate leaf litter decomposition and decay. From the this review paper we focuses on different factors that affect the leaf litter decomposition and decay as well as different techniques emphasized for assessing litter degradation.

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