ISSN: 2277-9655
Impact Factor: 4.116

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

THE DECOMPOSER MICROORGANISMS IN THE ENVIRONMENT AND THEIR SUCCESSION OF SUBSTRATES

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DOI: 10.5281/zenodo.58637

ABSTRACT

Plant litter decomposition is not a purely chemical or physical process, it is basically a biological one resulting from the diverse activities of microorganisms, protozoa and various other soil organisms like insects and worms. The bacteria and fungi play a very significant role in plant litter decomposition and humus formation. The fungi which colonized decaying substrates could use only simple substrates such as sugars and they referred as sugar fungi. Garrett suggested that the root infecting fungi open the way for a sequence of saprophytic sugar fungi, cellulose decomposers and finally lignin decomposers. The initial rates of losses of different components could be ranked as sugar > hemicelluloses> cellulose> lignin. During this succession, the substrates were found to become progressively depleted. This biochemically based succession was believed to be reflected in a taxonomic way as the Phycomycetes to be considered as sugar fungi, the Ascomycetes and Deuteromycetes as cellulolytic and finally Basidiomycetes as lignin decomposers.

KEYWORDS: Plant litter, decomposition, microorganisms, cellulose, hemicelluloses, lignin.

INTRODUCTION

Decompsition and Humification: A central process in the life cycle of all organisms is the decomposition of their dead remains. Plants are no exception to it. Truly speaking, a significant proportion of the net primary production in the biosphere, especially in the terrestrial ecosystems, ends up as accumulations of dead remains of plants at soil surface or below it. These dead remains get decomposed; and the nutrients locked up in the litter as well as a number of new substances formed in the process of decomposition, pass down the soil profile. The significance of this process was recognized long ago.

One may find references to "humus" and its importance in increasing soil fertility in the literature of 18th centuary[1]. Remann[2] established that humus formation is not a purely chemical or physical process; rather, it is basically a biological one resulting from the diverse activities of microorganisms, protozoa and various other soil organisms like insects and worms. Mitscherlich[3] was the first to attribute the decomposition of organic material to bacteria. Since that time, and till the beginning of the twentieth century, the bacteria were considered to be the chief agents responsible for the decomposition of organic matter in the soil. The role of fungi in the formation of the brown substance of the humus was recognized by Scherpe[4]. Dascewska[5] demonstrated experimentally that the Hyphomycetes play a significant role in the decomposition of cellulose and in humification. Singh and Charaya[6] isolated and identified about 40 fungi belonging to Hypomycetes from decomposing wheat crop resedues.

Plant litter decomposition and microorganisms: The fungi play a "predominant" role in the decomposition of plant litter, is now a well-established fact. It is now realised that the plant litter is decomposed by a sequence of events involving physical processes like leaching and mechanical breakdown; as well as through biological processes like microbial degradation which involve several exo-enzymes[7] .
In aerobic environments, the saprobic fungi which can secrete cellulases and other exo-enzymes directly into the environment constitute a major group amongst the decomposer community[8,9,10]. In the aquatic environment also, the decomposition of plant litter is predominantly carried out by the fungi—the fungal biomass being much greater than

the bacterial biomass. Using the rates of incorporation of 14C into ergosterol and that of 3H leucine into protein as indices for estimating fungal and bacterial biomass respectively, Suberkropp and Weyers[11] found higher turnover rates for fungi (11-26 times) as compared to bacteria, in the decomposing leaves in streams thereby further implicating a major role for the fungi in litter decomposition. Dilly[12] studied the culturable bacterial and fungal communities during the decomposition of leaf litter in a black alder forest. Their studies also revealed that fungal communities play a predominant role in litter break down. Earlier, Mamilov[13] had suggested an improved substrate-induced respiration method for differential determination of fungal and bacterial biomass in the soil upon the decomposition of plant remains, suggesting the use of high dose of antibiotics. Extensive use of this method may throw further light on this issue.

In fact, the soil is the home of an indigenous microflora or is merely a resting place for fungal spores floating in the atmosphere. Different workers indicated that many fungi grow and reproduce in the soil. Since then, numerous studies on different aspects of soil microorganisms have been made and it is now almost impossible to bring even the complete list of all such studies under a single cover. There are also numerous articles, reviews and books concerning soil microflora these include[14,15,16,17,18,19,6,20].

Succession of decomposers: Earlier studies on soil fungi were mainly concerned with the compilation of floristic lists. However, gradually the emphasis shifted on studying the ecology of soil mycobiota. The synecological studies led to a survey of substrate relationships of these fungi. Garrett[21] suggested that it is the root-infecting fungi which open the way for a sequence of saprophytic 'sugar fungi', cellulose-decomposers and finally lignin-decomposers in the invaded tissue**.** Later on, Garrett[22] proposed the following very generalised scheme for the succession of fungi on a corpus of plant tissue lying within or upon the soil.

Table 1: Succession of fungi

Senescent tissue	**Dead tissue**		
Stage I a	**Stage I**	**Stage II**	**Stage III**
Weak parasites	Primary saprophytic sugar fungi, living on sugar and carbon compounds similar than cellulose	Cellulose decomposers and associated secondary saprophytic sugar fungi, sharing products of cellulose decomposition	Lignin decomposers and associated fungi

In this scheme, Garrett recognized a 'secondary group' of 'sugar fungi' which do not live on simple carbon sources initially present in the fresh plant tissue, but are dependent upon the hydrolytic products of cellulose-decomposing fungi; and, therefore, appear late in succession in association of these. One of the features that led to the development of substrate-group hypothesis was the observation that the initial rates of losses of different components could be clearly ranked: Sugar > Hemicellulose > Cellulose > Lignin.

During this succession, the substrates were found to become progressively depleted, beginning with sugars and the simpler carbon compounds, continuing with cellulose; and finally with lignin. Similar succession was observe by Charaya and Singh[23], Talbot[24] and Singh[25] during the decomposition of wheat crop residues. This biochemically based succession was believed to be reflected in a taxonomic one in so far as the Phycomycetes (no more recognised as a taxonomic group) came to be considered as 'sugar fungi' *par excellence*; the Ascomycetes and Fungi Imperfecti as cellulolytic; the decomposition of lignin was believed to be primarily the work of the higher Basidiomycetes[26]. The succession of fungus fruiting bodies on herbivore dung experimentally analysed by Harper and Webster[27]. The observations by a number of workers like Saito[28] on beech litter and (Sundaram[29]) on a variety of substrates. Sinha and Dayal[30] on teak lend support to the Garrett's scheme. The succession observed by Chang and Hudson[31]; Singh and Charaya[6] on wheat straw compost also followed this scheme in broadest outline, but the Phycomycetous phase was found to be of very short duration.

On lignicolous substrates, a rather different type of succession was observed by a number of workers like Mangenot[32] on trunks of deciduous trees; Meredith[33] on pine stumps. In general, the substrates were initially found to be colonized by Basidiomycetes and Fungi Imperfecti, the Phycomycetes appearing later. Thus, the general trend of succession was reversed with an initial phase of cellulose and lignin- decomposing fungi. Studies by Caldwell[34] on beech litter also demonstrated that Phycomycetes did not play any significant role in the decomposition of woody substrates. Frankland[35] followed the succession of fungi on decaying petioles of bracken (*Pteridium aquilinum*). The following trend proposed by her had two interesting features : (i) the occurrence of potential lignin-decomposers (Basidiomycetes) and Sphaeropsidales early in the succession and; (ii) the main build up of Mucorales in the end : Hyphomycetes + (Sphaeropsidales ----> Basidiomycetes ---> Phycomycetes). The occurrence of Sphaeropsidales in the early phase of succession was also reported by Hering[36] on leaves of oak, hazel and ash; Macauley[37] on *Eucalyptus* spp. in different environments.

On other substrates, the pattern of succession appears to be one or several waves of Ascomycetes and Fungi Imperfecti following each other. In fact, Chesters[38] embarked upon the idea that the aerial parts of "plant shoot systems are worked over" by weak parasitic and saprobic species, and they arrive at the soil surface much depleted of their nutritional possibilities. Kendrick[39,40] found initial colonization of pine litter by weak parasites. The studies of the saprobic mycobiota of *Saccharum officinarum* by Hudson[41] revealed a primary fungal biota consisting of a number of weak parasites and saprobes followed by *Periconiella* and some imperfect fungi; and finally by numerous imperfect fungi and Ascomycetes. More or less similar pattern was observed by Hogg[42] on leaves of *Fagus sylvatica*; Singh and Charaya[6] on wheat crop resedue, Hudson[43] suggested that for many types of leaf and herbaceous litters, some general correspondence of pattern could be discerned in the observed changes. He proposed the following scheme for the succession of fungi on most plant debris except the lignicolous ones:

Table 2: Succession of fungi

Living tissue	**Senescent**	**Dead**
Parasites: Ascomycetes and fungi imperfecti may be host specific or host restricted	**Common primary saprophytes:** Ascomycetes and fungi imperfecti **Restricted primary saprophytes:** Ascomycetes and fungi imperfecti	**Secondary saprophytes:** 1. Ascomycetes and fungi imperfecti 2. Basidiomycetes 3. Soil inhabitants (Mucorales, Penicillia etc.

Ruscoe[44] found that the leaves of *Nothofagus truncatus* were already heavily colonized by a variety of parasitic and saprobic fungi when they reached the forest floor. Tubaki and Yokoyama[45]) studied the succession on the leaves of *Castanopsis cuspidata* and *Quercus phyllyraeoides*. While confirming the Hudson's scheme, they observed four distinct stages in succession—(i) A group of early colonizers comprising the transient fungi, present on the leaf surface only as detachable propagules, (ii) fungi growing and sporulating actively through out the decay period; and (iii) a group found early in the decay process, but disappearing later; and (iv) a group found at late stages.

Studies by Shearwood and Carroll[46] on *Pseudotsuga meziesti*; Aneja and Mehrotra[47] on *Desmostachya* litter. Singh and Charaya[6] on wheat crop residues, more or less corroborate the pattern of succession proposed by Hudson[43]. On the basis of a scrutiny of the investigations of different workers, Earlier, Charaya[48] studied the mycobiota colonising wheat and paddy straw aboveground, at soil surface (control and waterlogged conditions), and beneath soil surface (control and water-logged conditions). Fungal succession on wheat and paddy roots buried underground were also studied (in control as well as in water-logged conditions). The pattern of succession on both types of roots under both conditions was as suggested by Hudson. On wheat straw also, the succession basically followed the pattern as suggested by Hudson, but allowing for the incorporation of 'secondary sugar fungi' of Garrett[22] at intervals. On paddy straw, however, initial colonisation by the Phycomycetes was observed (though alongwith Ascomycetes and Hyphomycetes); the Phycomycetes disappeared sooner or later. In case of the paddy straw decomposing at soil surface under water-logged conditions, even the Ascomycetes disappeared in the end; the fungal succession in these cases, thus, followed the pattern suggested by Garrett[22]. The study, thus, suggested that the pattern of colonization of a substrate by the mycoflora is largely regulated by the nature of the resource itself[49]. The mycoflora naturally occurring in paddy straw was studied by Singh[50] without any attempt to study the pattern of successive colonization. Selvam[51] studied the microbial colonization of decomposing paddy straw using nylon bag technique. Singh and Charaya[6] also studied the microbial colonization of different components of wheat crop resedues *viz*., wheat internodes, leaves, chaff and mixed straw.

CONCLUSION

The urbanization and industrialization responsible for hudge amount of solid wastes including plant litters and house hold organic wastes, causes environmental problems. Microbes are able to degrade such type of lignocellulosic wastes convert them into products of social welfare such as biogas, enzymes, organic acids etc. This study analysis the biochemical and taxonomic succession of fungi of decomposing plant litters. It is helpful to decide the pattern of colonization of substrates by decomposers and to develop a microbial technology for lignocellulosic waste recycling for safe and clean environment.

ACKNOWLEDGEMENT

I my express my profound sense of gratitude and indebtedness to my esteemed supervisor Professor Dr. M.U. Charaya who with high tenacity,subverted all the snages in the progress of this work and has throughout been a constant source of motivation, imagination and information. I also express my heart-felt gratitude to Professor V.K. Bhatnager, Pro Vice Chancelor, Swami Vivekananda Subharti University, Meerut and Professor Rita Bakshi, Dean Faculty of Science of this University for their ever encouraging suggestions, besides providing me all the necessary facilities to complete this significant work. I express my profound thanks to my friends and colleagues for their co-operation and assistance in this work.

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