Microbial succession in decomposition of plant organic matter

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Introduction

- Microbial community structure and activity reflect changes of biotic (soil biota) and abiotic (climate, soil chemistry, and litter quality) factors as well as ecosystem functioning.
- In particular, the complex environmental characteristics of a given site influence the pool of microbial species at the regional scale, while litter quality affects the dynamics of microorganisms coming from that pool at the local scale.
- The roles of biotic and abiotic factors change over time as the litter is sequentially decomposed. As the chemical composition of litter changes, the associated microbial community and extracellular enzyme activities also change.
- The differential response of microbes to the changing litter chemistry is the basis for sorting microbes into specific guilds.
- More specifically, a nutritious organic substrate is connected to a wide range of nonspecialized microbes, while recalcitrant organic substrates are decomposed only by a limited number of taxa, which can break the resistant organic structures.
- Fungi have long been considered the main microbial decomposers catalyzing the decomposition of complex substrates.

- However, the role of bacteria in decomposition has also been recently highlighted.
- Particularly, *Actinobacteria*, *Proteobacteria*, *Firmicutes*, and *Bacteroidetes* produce extracellular enzymes and are active in substrate degradation.
- Moreover, *Actinobacteria* are able to produce lignolytic enzymes and secondary metabolites and form filaments, which are strategies similar to those of fungi.
- It is widely accepted that microbial communities define main litter decomposition phases in response to the changing chemical characteristics of the remaining material.
- The initial phase is characterized by a rapid decomposition rate in which soluble compounds are decomposed, followed by a slow phase during which complex, highly recalcitrant molecules such as cell wall polysaccharides are degraded.
- In the initial phase, a zymogenous (allochthonous) microbial community, originated in the leaf surface, is predominant.
- The slow phase is dominated by autochthonous, soil-originated communities.

- With regard to fungi, the typical succession consists of (a) Zygomycetes (sugar fungi), (b) Ascomycetes, and (c) Basidiomycetes capable of degrading cellulose and lignin.
- Despite the limited information available on bacterial communities, at least Pseudomonas and Bacillus have been mentioned as present in stage a, as well as Actinomycetes and cellulolytic bacteria for stage b.
- The influence of climate on microbial succession is another little known aspect of litter decomposition dynamics, particularly in semi-arid regions where water availability is a key factor limiting microbial activity.

Table 30.4 : General trend of fungal succession

Senescent tissue		*Dead Tissue*	
Stage 1a	*Stage 1b*	*Stage 2*	*Stage 3*
Weak parasites	Primary saprophytic sugar fungi living on sugars and carbon compounds simpler than cellulose (mucoraceous phycomycetes)	Cellulose decomposers and associated secondary saprophytic sugar fungi sharing products of cellulose decomposition (ascomycetes and some mucorales)	Cellulose and lignin decomposers, and other associated fungi (basidiomycetes and others)

Primary colonizers

Secondary colonizers

Trend of succession

Factors influencing microbial succession

Litter Quality:

- Structural and chemical properties of litter make up its quality. However, it is less specific term reflecting decomposition rate.
- The higher number of fungal taxa was reported from decomposing litter of *Cupressus torulosa* than *Pinus roxburghii* litter decomposing in respective forests of Kumaon Himalaya.
- In contrast, the litter of bryophytes are decomposed at a very slow rate because of presence of lignin like complex chemicals in its thalli.

Temperature:

- Temperature governs the growth and microbial activity in its natural habitats.
- At different elevations temperature differs.
- It is found that species diversity and fungal counts on oak leaf litter were markedly affected by the environment changes brought about by the native leaf litter.
- The pattern of fungal species occurring on litter changed with the progress of decay of substrate.

Aeration:

- In the pores of soil, sufficient amount of oxygen is present which is required by aerobic flora.
- In water-logged conditions where O_2 becomes a limiting factor aerobic microorganisms will be absent, and only anaerobic microorganisms will grow and decompose the organic matter.
- Soil texture affects aeration and the later affects microorganisms.

Soil pH:

- Soil pH is governed by the presence of cations and anions.
- Certainly these affect microbial growth.
- For example, actinomycetes prefer to grow above soil pH 7, bacteria below 7, and fungi between pH 5 to 6.

Inorganic Chemical:

- The concentration of already available inorganic substances also affect the rate of decomposition of added matter on soil.
- In addition after decomposition from humus the elements N, P, K, Na, Mg, Ca, etc. are released in soil.
- Some amount is taken up by the growing microorganisms and the remainder is made available to plants.

- **Moisture:**
- Soil moisture varies according to water holding capacity (WHC) of a given soil.
- However, water is required to carry out the physiological processes.
- Rai and Srivastava (1982) have found the half life of litter in a tropical mixed dry deciduous forest about 173 days.
- Moisture plays a critical role in determining the activity of microorganism in decomposition.

Microorganisms Associated with Organic Matter Decomposition:

Cellulose Decomposers:

- **Fungi:** Altemaria, Aspergillus, Chaetomium, Coprinus, Fomes, Fusarium, Penicillium, Rhizopus, Trichoderma, Trametes, Verticillium, etc.
- **Bacteria:** Bacillus, Cellulomonas, Clostridium, Corynebacterium, Cytophaga, Pseudomonas, Vibrio, etc.
- **Actinomycetes:** Micromonospora, Nocardia, Streptomyces, Streptosporangium, etc.

Hemicellulose Decomposers:

- **Fungi:** Alternaria, Aspergillus, Chaetomium, Fusarium, Glomerella, Penicillium, Trichoderma, etc.
- **Bacteria:** Bacillus, Cytophaga, Erwinia, Pseudomonas, etc.
- **Streptomycetes:** Streptomyces, etc.

Lignin Decomposers:

- **Fungi:** Agaricus, Armillaria, Clavaria, Clitocybe, Coprinus, Ganoderma, Phaliota, Pleurotus, Polyporus, Poria, Trametes, Ustulina, etc.
- **Bacteria:** Species of Arthrobacter, Flavobacterium, Micrococcus, Pseudomonas, Xanthomonas, etc.