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10. Wood Decaying Fungi: A Positive Impact on Nature

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10.1 Information:

Wood consists of complex chemical constituents primarily cellulose (about 40-50% of the dry weight of wood), hemicelluloses (about 25-40%) and/or lignin (about 20-35%). Cellulose is a polysaccharide composed of linear chains of glucose molecules. All plants have cellulose as the primary cell wall component. Cellulose is the most common organic compound on earth and makes up roughly 50% of wood.

Lignin is a complex insoluble polymer of phenolic compounds and relatively resistant to decay. It plays a key role in the carbon cycle as the most abundant aromatic compound in nature providing a protective matrix in the cell wall. This amorphous and insoluble polymer is not susceptible to hydrolytic attack in contrast to cellulose. Certain fungi are responsible for lignin degradation (Kirk and Farrell, 1987).

The basidiomycetes are the only organisms capable of efficient depolymerization and mineralization of lignin. Wood contains very low levels of nitrogen. The lignin component plays role as barrier to wood decay because lignin is a complex aromatic polymer that preventing easy access of enzymes.

In addition to these points, wood often contains potentially fungitoxic compounds which are deposited in the heartwood. In broad-leaved trees the toxic compounds are usually tannins that cross-link proteins and making the plant cells resistant to decay (Taylor et al., 1989).

In contrast, conifers contain a range of phenolic compounds such as terpenes, stilbenes, flavonoids and tropolones. The most toxic of the tropolones are the thujaplicins which act as uncouplers of oxidative phosphorylation.

Fungi which grow on wood are sometimes called "lignicolous" fungi. Lignicolous fungi belong to ascomycetes and basidiomycetes. They have the ability to degrade cellulose and lignin, the major components of wood. The ability of wood decay is often judged negatively on our part because these fungi cause economic loss (Bruce, 1992; Eaton and Hale, 1993). Wood decay fungi create unique cavities on trees which provide shelter to various birds.

A large number of birds prefer cavities or holes for their nesting on trees produced by wood decay process by wood rotting fungi (Table 10.1 and Figure 10.1). Forest trees and valuable landscape trees can be infected and rotted by these fungi. Each year a large amount of timber is lost on account of decay by fungi in forests.

Different species of fungi are responsible for different lever of decay of wood in tree. Some species are restricted to sapwood and will not affect the heartwood. Decomposition refers to the process by which tissues of dead plant break down into simpler forms of matter. Such a breakdown is essential for ecosystyem function because it is the basis for recycling limited chemical compounds as well as freeing up limited physical space in the environment.

Fungi are the main decomposer organisms responsible for wood decay. Wood decay fungi require free water i.e. moisture content of wood must be above 28% to decay. Dry wood will not decay. If you add water to dry wood, the cell walls absorb water up to a moisture content of about 28%. Without moisture, the fungus cannot be active or grow and become dormant or die.

Wood decay is generally classified into two main groups- white rots and brown rots based on wood residue left behind following fungal digestion. Two more other types include "dry rot", which is a form of brown rot caused by water conducting decay fungi, and "soft rot", referring to decay caused by certain Ascomycetes.

The main wood-inhabiting group of basidiomycetes is commonly known as the polypores. Most polypores are saprophytic and utilize dead wood as their food source. These fungi commonly appear as hard, tough, corky, leathery or woody structures of various shapes and sizes.

Polypores are mostly wood inhabiting fungi that are able to utilize components of wood as their primary source of energy for growth and reproduction.

Table 10.1: Tree rotting fungi found at Kulik Wildlife Sanctuary, Uttar Dinajpur, West Bengal (Mandal, 2019).

Name of Wood decay fungi	***Family***	***Decay types***
Antrodia malicola (Berk. & M. A. Curtis) Donk	*Fomitopsidaceae*	*Brown rot*
Trametes hirsuta (Wulfen) Lloyd	*Polyporaceae*	*White rot*
Trametes versicolor (L.) Pilat	*Polyporaceae*	*White rot*
Auricularia auricula-judae (Bull.) Wettst.	*Auriculariaceae*	*White rot*
Pleurotus ostreatus (Jacq. ex Fr.) P.Kumm.	*Pleurotaceae*	*White rot*
Marasmius luteolus Berk. & M.A. Curtis	*Marasmiaceae*	*Brown rot*

Name of Wood decay fungi	***Family***	***Decay types***
Phloeomana alba (Bres.) Redhead	*Porotheleaceae*	*White rot*
Oxyporus populinus (Schumach.) Donk	*Schizoporaceae*	*White rot*
Marasmius calvus Berk. & Broome	*Marasmiaceae*	*Brown rot*
Marasmius armeniacus Gilliam	*Marasmiaceae*	*Brown rot*
Hydnellum caeruleum (Hornem.) P. Karst	*Bankeraceae*	*White rot*
Inonotus glomeratus (Peck) Murrill	*Hymenochaetaceae*	*White rot*
Hericium coralloides (Scop.) Pers	*Hericiaceae*	*White rot*
Ganoderma lucidum (Curtis) Kummer	*Ganodermataceae*	*White rot*
Coprinopsis lagopus (Fr.) Redhead, Vilgalys & Moncalvo	*Psathyrellaceae*	*Brown rot*

Wood rotting fungi are defined as "those which can bring about significant weight loss and structural change in woody tissues". Wood decay by fungi is typically classified into 3 types according to their mode of attack and general appearance of the decayed wood (Figure 10.3).

- Brown-rot fungi
- White-rot fungi
- Soft-rot fungi

10.2 Brown-Rot Fungi:

Brown-rot fungi are predominantly members of the Basidiomycota including common species such as *Schizophyllum commune*, *Fomes fomentarius* (the "hoof fungus" of Scottish birch woods) and dry rot fungus *Serpula lacrymans*. Many of the brown-rot fungi produce bracket-shaped fruit bodies on the trunks of dead trees, but the characteristic feature of these fungi is that the decaying wood is brown and shows brick-like cracking due to uneven pattern of decay causing the wood to split along lines of weakness.

The wood decayed by brown rot fungi is typically brown in appearance and it is degraded via both non-enzymatic and enzymatic systems. A series of cellulolytic enzymes are employed in the degradation process by brown rot fungi, but no lignin degrading enzymes are typically involved. Brown-rot fungi degrade the cellulose and hemicellulose of wood leaving the lignin intact as a brown framework. Six percent (6%) of wood-decay fungi cause brown rots.

All these fungi are members of the basidiomycota. They include dry-rot fungus (*Serpula lacrymans*) and brown cubical rot of birch (*Piptoporus betulinus*).

For degredation, cellulase enzymes produced by brown-rot fungi have little impact on the cellulose. This breakdown is actually an oxidation process in which hydrogen peroxide is formed. Hydrogen peroxide is strong oxidiser and readily causes generalized decay of cellulose of wood leaving the lignin intact with the general cell shape. Brown-rot fungi can delete up to 65% of the weight of the timber. Wood decay tends to spread from cell to cell fast in the timber or inside the wood. In the advanced stage, timber often forms cube like appearance.

10.3 White-Rot Fungi:

White-rot fungi are more numerous than brown-rot fungi. They include both Ascomycota, such as *Xylaria* spp., and Basidiomycota e.g. *Armillariella mellea*.

The white-rot fungi seem to use conventional cellulase enzymes for wood decay but they are extremely efficient in their use of nitrogen. For example, the nitrogen content of *Coriolus versicolor* is about 4% when the fungus is grown on laboratory media of Carbon-to-Nitrogen ratio, 32:1, but only 0.2% when grown on a medium of C: N, 1600:1.

White-rot fungi might also benefit from the growth of nitrogen-fixing bacteria in wood. White-rot caused by the two major root-rot pathogens of trees, the honey fungus (*Armillaria mellea*) and butt rot (*Heterobasidion annosum*) and also by many saprotrophic fungi including turkey tail mushroom (*Coriolus versicolor*).

White rot fungi are typically associated with hardwood decay and normally has a bleached appearance and this may either occur uniformly leaving the wood a spongy or stringy mass or it may appear as a selective decay or a pocket rot (Highley and Micales, 1990).

The most remarkable feature of white-rot fungi is their ability to degrade lignin completely in wood. Lignin is a complex polymer composed of three types of phenyl-propane unit (six-carbon rings with three-carbon side chains) bonded to one another in at least 12 different ways. It requires a multitude of enzymes to degrade lignin.

The process of degradation is complex, but essentially the white-rot fungi produce only a few enzymes such as glucose oxidase, lignin peroxidase, manganese peroxidase and laccase and these generate strong oxidants, which virtually “combust” the lignin framework.

The major enzyme that initiates ring-cleavage is laccase, which catalyses the addition of a second hydroxyl group to phenolic compounds. The ring can then be opened between two adjacent carbon atoms that bear the hydroxyl groups. This process occurs while the ring is still attached to the lignin molecule.

10.4 Soft-Rot Fungi:

Soft rot fungi typically attack higher moisture, and lower lignin content wood and can create unique cavities in the wood cell wall.

They are the characteristic decay fungi of fence posts, telegraph poles, wooden window frames, the timbers of cooling towers, and wood in estuarine or marine environments. Less is known about the soft rot degradative enzyme systems.

The diffusion of these enzymes creates a characteristic pattern of decay, seen as rhomboidal cavities within the cell wall.

These persist even when the fungi have died, leaving the characteristic signature of rot fungus. The soft-rot fungi have little or no effect on lignin, which remains more or less intact. Some are common decomposers of cellulose in soil (e.g. *Chaetomium* species).

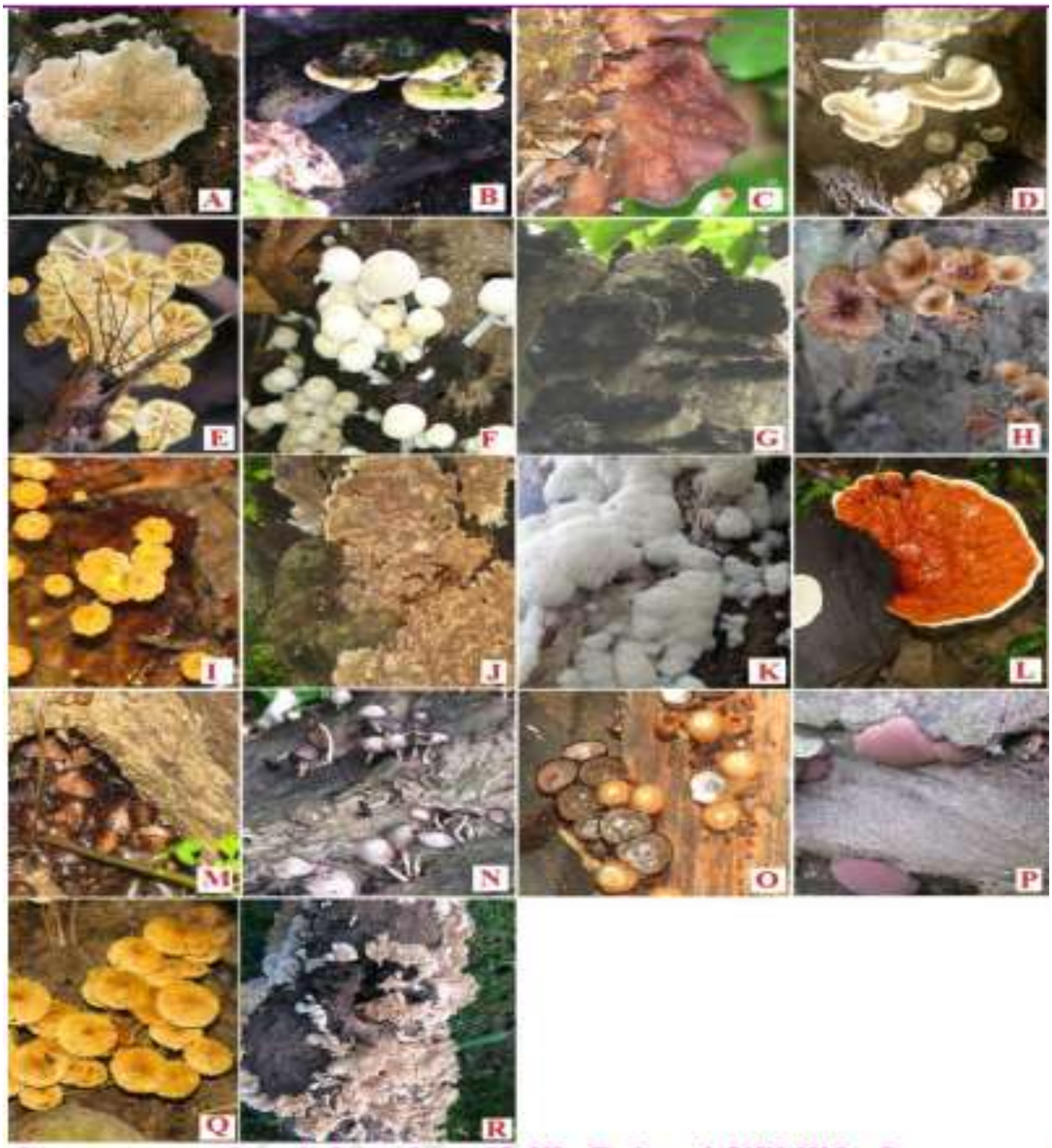

Figure 10.3: Wood decay fungi found at Kulik Raiganj Wildlife Santuary, West Bengal: A- *Antrodia malicola*; B- *Trametes hirsute*; C- *Auricularia auricula-judae*; D- *Pleurotus ostreatus*; E- *Marasmius luteolus*; F-*Phloeomana alba*; G- *Oxyporus populinus*; H- *Marasmius calvus*; I- *Marasmius armeniacus*; J- *Inonotus glomeratus*; K- *Hericium coralloides* ; L- *Ganoderma lucidum*; M- *Coprinellus micaceus* ; N- *Coprinopsis lagopus*; O- *Cyathus striatus*; P- *Daldinia concentric*; Q- *Armillaria mellea*; R- *Schizophyllum commune*.

Figure 10.2: Appearance of wood and wood decay by different groups of fungi A- Brown-rot; B- White-rot; C- Soft-rot.

10.5 Positive Impact of Wood Decaying Fungi:

- Wood decay fungi are the pioneer recyclers of wood in ecosystems. Without these fungi, wood would never be decayed.
- Wood decay fungi include many edible fungal species such as *Pleurotus ostreatus, Grifola frondosa,* and *Laetiporus sulphureus*.
- Wood decay fungi are used as myco-medicinals. Preparations made from species such as *Ganoderma lucidum* and *Trametes versicolor* are the mycological equivalent of herbal medicinal.
- Wood decay fungi create unique cavities on trees which provide shelter to various birds. A large number of birds prefer cavities or holes for their nesting on trees produced by wood decay process by tree rotting fungi.
- Wood decay fungi are screened for pharmaceutical and industrial compounds.
- Wood decay fungi are favorite subjects for photographers and other artists.

10.6 References:

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