An introduction to wood biodegradation

Abstract:
Timbers are susceptible to rapid deterioration by variety of organisms. The wood in living trees and also in used products would start to decay and decompose with the attack of organisms which is termed as the biodegradation of wood. The biodegradation is supposed to be one of the major challenges to incur the heavy economic loss. The fungi and insects are major causes of biodegradation. Wood products are subject to various bio-hazard attacks if preventative measures are not taken. The proper seasoning and / or preservative treatment can reduce the damages and increases the longevity of wood.

1.0 Introduction:
Biodegradation is dependent upon many factors including temperature, microbial population, degree of acclimatization, accessibility of nutrient, cellular transport properties and chemical portioning of growth medium. The cell structure itself and properties of wood has great influence on resisting or enhancing the biodegradation.

The wood is made of cellulose (up to 45%), hemi cellulose (20-30%), lignin (25-30%) and other substances. The main structural component of wood cell is the cellulose. Hemicelluloses are heteropolysachharides. Like cellulose most hemicellulose functions as supporting materials in the cell walls. They are relatively easily hydrolysed by acids (Mohebby 2003). The lignin as the binding agent holds the cellulose together whereas cellulose is more stable than lignin. Lignin fills the space in the cell wall between cellulose, hemi cellulose and pectin components. It is the biopolymer. Lignin is indigestible by mammalian and other animal enzyme, but some fungi and bacteria are able to biodegrade the polymer. Hemi cellulose contains many different sugar monomers.

The primary wall of green plant is made of cellulose; the secondary wall contains cellulose with variable amount of lignin and hemi cellulose.

The micro organism such as fungi causes deterioration of wood by causing decay. The fungi can produce hyphae and different enzymes that deteriorate the cell wall and cause deterioration whereas the insects, termites chew and feed on the sapwood and heartwood and causes great losses.

Timbers are susceptible to rapid deterioration by variety of organisms. Deterioration of wood by decay fungi and insects are the threat to longevity of wood used.
2.0 Causes of biodegradation:

2.1 Decay:
Wood decay is deterioration of wood by primarily enzymatic activities of microorganisms. These microorganisms are primarily the fungi. A wood decay fungus is a variety of fungus which has the ability to digest wood causing it to rot. The decay causes larger damage to timber causing big economic loss.

Fungi:
All rotting of wood is caused by fungal attack. Fungi are microorganisms which live on and within wood and slowly digest the cell wall materials leading to softening and decay. Wood decay fungi obtain nourishment by digesting cell walls, thus causing deterioration of wood.

Decay will occur generally in untreated wood in direct contact with ground, cement or concrete or exposed to a source of moisture such as rain, seepage, plumbing leaks or condensations.

2.2 Conditions necessary for Wood decay:
Although fungal spores are common in the air, they cannot develop and attack unless it gets favorable conditions as follows:

- An adequate supply of oxygen.
- A favorable temperature (15°C to 40°C).
- Moisture in excess of Fiber saturation point (25-30%).
- A suitable source of energy and nutrients (i.e. the wood).
- Absence of antagonistic influence of other fungi

The minimum, maximum and optimum temperature required for growth varies with different decay fungi. Mohebbby (2003) indicate that wood decay fungi require wood Moisture content in excess fiber saturation point to propagate, that fungal growth below fiber saturation point (absence of lumen water) is greatly retarded and that below 20 % wood moisture content their development is completely inhabited. Decay fungi require the free water (lumen water) where as sap stain can occur even with bonded water.

When conditions on a wood surface are favorable for microbial invasion, wood inhabiting fungi of many different species may establish, and start to grow and decay. Heartwood with higher natural durability would be expected to make much resistance and longer to fungal establishment. The growth and decay largely depends on moisture content, durability of wood and the type of decay fungi.

2.3 Types of Decay:

2.3.1 Brown rot:
Brown rot fungi feed on the wood’s cellulose, a component of wood cell wall, leaving a brown residue of lignin. Brown rot is brown because carbohydrates are removed, leaving brownish, oxidized lignin. Infested wood may be greatly weakened. Advanced infestations of brown rot are evidenced by wood more brown in color than normal, tending to crack across the grain. When dried wood previously infested will turn to powder when crushed.
Eventually the decay can cause instability and collapse in houses and other wooden structures.

2.3.2 White rots:
These fungi are able to fragment the major structural polymers of wood and other lignocellulosics- lignin, cellulose, and hemi cellulose and further metabolize the fragments. The hyphae of fungi rapidly invade wood cells and lie along the lumen walls where they secrete the enzyme to depolymerize the hemi cellulose, cellulose and fragmentation of lignin (Kirt T.K. and Dan Culen, 2005). The white rot fungi degrade wood by removing cellulose, hemi cellulose and lignin more or less simultaneously. This is more dangerous and harmful than brown rot since it affects all the contents of cell wall thus causing accidental collapse and damages.

The causal agent for different decay might be different and their affect and damages are also different. These differences are summarized on the following table in brief:

<table>
<thead>
<tr>
<th>Type</th>
<th>Agent</th>
<th>Colour</th>
<th>Texture</th>
<th>Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>White rot</td>
<td>Basidiomycota</td>
<td>Bleaching</td>
<td>Fibrous</td>
<td>all components removed</td>
</tr>
<tr>
<td>Brown rot</td>
<td>Basidiomycota</td>
<td>Brown</td>
<td>fibrous texture lost</td>
<td>primarily carbohydrates lost,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>early, cross-checking</td>
<td>lignin mostly remains</td>
</tr>
<tr>
<td>Soft rot</td>
<td>Ascomycota &amp; Deuteromycota</td>
<td>bleached or brown</td>
<td>-usually on surface, fibrous texture lost, cross checking in some cases</td>
<td>carbohydrates preferred, but some lignin lost too</td>
</tr>
</tbody>
</table>

Source: [http://www.forestpathology.org/fungi.html](http://www.forestpathology.org/fungi.html)

2.4 Damages in wood due to decay:
Toughness and weight loss have been considered the most sensitive indicators of the degree of wood deterioration caused by decay. Other negative affect are observed and experienced due to unexpected changes in the wood properties after infestation. These changes are:
- Weight loss
- Strength loss
- Increased permeability
- Increased electrical conductivity
- Reduction in volume
- Changes in pulping quality
- Discoloration
- Reduction in caloric value

(Source: [http://www.cals.ncsu.edu/course/pp318/profiles/decay/decay.htm](http://www.cals.ncsu.edu/course/pp318/profiles/decay/decay.htm))

3.0 Insects as wood deteriorator:

3.1 Borers:
Some borers can cause considerable destruction to timber especially when the sapwood with lots of moisture contents is
used. These borers are generally beetles which destroy the wood during larval stage by burrowing and producing a network of galleries which may considerably weaken the timber. Some of the important borers are:

- Powder post beetle (Lyctiids),
- Furniture beetle (Anobiids),
- Pinhole borers
- European house borers

3.2 Carpenter ants:
Several species of carpenter ants are capable of damaging wood in building and other structure.

3.3 Termites:
They are more hazardous to wooden building structures and contents. They eat anything with cellulose; hence thrive on anything with cellulose including live and dead wood. They live in colony hence destroy everything by attacking in swarms.

Termites feed wood generally from the inside out, so damage wood is hard to find before severe damage occurs.

Wood eating termites are classified according to their living and feeding habits: dampwood, subterranean and drywood termites.

3.3.1 Dampwood termites:
Dampwood termites as the name suggests, will only infest wood with high moisture content. The colonies of dampwood termites are exclusively wood dwellings with most species not requiring contact with the soil. They always eat across the grain, consuming both spring and summer wood and makes chambers of interconnected galleries inside the wood.

3.3.2 Subterranean termites:
Subterranean termites live largely underground, building their nest in old tree, stumps and root systems and frequently moves outside to search foods. These termites as the food materials can destroy flooring wood to building including roof frames.

3.3.3 Drywood termites:
Dry-wood termites, as their name suggests, are capable of infesting dry, sound wood. They may infest wood structures that are not in contact with the ground. They do not require continuous contact with the ground as they can obtain moisture from the wood in which they feed and live. Dry-wood termites are larger than subterranean termites (7-11 mm), and they construct larger galleries. The examples of dry-wood termites are: Paraneotermes simplicicornis, Incisitermes minor, and Marginitermes hubbardi.
4.0 Control measures:

As “The prevention is better than cure.” the attention should be given to prevent the attack of organisms. This used to be rather cheaper than treatment afterwards in many aspects. To control the termites the insecticides can be sprayed or metal can be put to cover the wood near the ground. Most effectively the wood can be treated with preservatives before final use. The preservative treatment can protect the wood and wooden products from biodegradation.

There are two broad kinds of preservatives available in markets. One is water borne preservatives that solutes with water and has to be impregnated with the help of it. Acid Copper Chromated (ACC), Chromated Copper Arsenic (CCA) are some water borne preservative. The other is oil borne preservative, which solutes in petroleum oils. Coal tar creosote and Pentachlorophenol are the examples of some Oil borne preservative.

The wood that has to use in outside conditions should be treated with appropriate permanent kinds of preservatives so that termites, ants and other wood destroying agents could not attack on it. Similarly the internal used wood, furniture and other products also need appropriate seasoning and wood treatment.

The fungi cannot attack as well as live on well dried wood. They need the free water (water in lumen) for establishment and growth in the wood. The better solution of wood decay problem is to season wood. The kiln seasoned wood does not give favorable condition for fungi. Hence the properly seasoned wood should be used. Moreover, even after well seasoning, sometimes wood could come in contact with water by several means, as the result they will absorb water and swell. In this situation, there remains the chance of fungal infestation. To reduce these undesired damages, the wood needs to be painted or varnished or other appropriate measures should be taken so that the risks could be minimized. Coating such as paints, varnishes, waxes prevent water penetration into the porous cellular structure of wood thus prevent decay and termite attack.

5.0 Conclusions:

- The insects and fungi are the problems that the wood users have been facing since long time. They deteriorate and degrade the physical and chemical (in some instance) properties of wood. The termite and other insects at larval stage cause big economic losses by eating and burrowing.

- The wood decaying fungi degrade the wood and use to incur big economic losses. There damages have been spread more or less all over the world. The decay alone is responsible for bigger losses in the stand and in the wood than fire and other damages combined. The damages due to decay should be kept under control and it can be done by controlling the moisture content of wood via. Kiln Seasoning and so.

- Every year people and nation have been spending lots of money unnecessary to replace and maintain the degraded woods. In these contexts of large economic losses and decreasing resources available, the seasoning and preservative treatment should be given higher priority so that the losses could be minimized and kept under economic threshold.
References:

- [http://www.forestpathology.org/fungi.html](http://www.forestpathology.org/fungi.html)
- [http://www.cals.ncsu.edu/course/pp318/profiles/decay/decay.htm](http://www.cals.ncsu.edu/course/pp318/profiles/decay/decay.htm)
- [http://cals.arizona.edu/urbanipm/insects/termites/drywoodtermites.html](http://cals.arizona.edu/urbanipm/insects/termites/drywoodtermites.html)