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Research Article

EXPERIMENTAL DETERMINATION OF THE EFFECT AND CONTROL OF WOOD DESTROYING FUNGI ON ALSTONIA BOONEI USED FOR LIGHT ENGINEERING CONSTRUCTION WORKS

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A B S T R A C T

This research was carried out to experimentally determine the effect and control of wood destroying fungi on *Alstonia boonei* a soft wood used for light construction works. Five samples of *Alstonia boonei* labeled A, B, C, D and E and each of dimension 25mm x 300mm x 300mm were experimentally subjected to varying laboratory and environmental conditions. Samples A, B and C were exposed to moisture in a humid atmosphere for 20 days and it was observed that at the end of the 20th day, the weights of the samples appreciated, meaning that they had absorbed moisture from the surrounding atmosphere. Samples A, B and C were left for additional 40 days in the same humid atmosphere and it was observed that fungi spores had started to germinate on the samples an indication that the humid atmosphere was favourable to them. Gradually the fungi spores became very visible to the naked eyes. The cellulose components of the three samples were broken down by the fungi for food leaving a brown - dark residue of lignin thus leading to weakening of the samples before decay was visible accompanied by a rapid decrease in weight of the samples. Samples D and E were oven dried for 6hours using laboratory controlled temperature of 105^0C. At the end of the 6 hours the weight of D and E which were initially 20.32gm and 19.98gm were reduced to 17.62gm and 17.68gm respectively. The percentage moisture content (% M. C) of sample D and E were found to be 15.88% and 13.01% respectively. This two samples were further treated with a chemical creosote and left in the same humid atmosphere as A, B and C for 60days. At the end of the 60th day, it was observed that both sample D and E were not attacked by any fungi. This research result of our experimental analysis helps to recommend that before using *Alstonia boonei* for light construction works; it should be properly and adequately dried below the moisture content that does not allow for the operation of their fungi that is the moisture content should be less than 19% for air dried wood and 15% or less for oven dried wood. The wood should be properly treated with chemical e.g. Creosote that dislodges the activities of this fungi.

INTRODUCTION

Wood is subject to attack and degradation by biotic agents such as marine borers, insects and micro – organisms like bacteria and fungi. These agents cause a lot of damages to wood which does not allow it to be used to its best advantage, thus reducing its value. These organisms attack wood in a variety of ways; some utilize wood substances for food, some for shelter and others for food and shelter.

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It is no doubt that fungi are the most damaging of all the wood destroying agents.

Alstonia boonei is a soft wood classified under non – durable wood by the international Union of Forest Research Organization after a serious exposure to worse conditions (grave yard test) of this biotic agent. The effect of fungi on *Alstonia* is very devastating. It is important that wood professionals must recognize and understand the nature of these wood attacking organisms to prescribe the appropriate treatment and to assure proper performance of the treated products. Wood when left untreated in many outdoor and even indoor applications becomes subject to degradation by a

variety of natural causes. Some trees possess naturally occurring resistance to decay, but are not in much supply to meet the demand for wood utilization. However, wood products can be protected from attack of decay fungi, harmful insects and marine borers by various treatment processes which greatly increase the life of wood structures, thus reducing replacement costs and allowing more efficient use of our forest resources.

Alstonia boonei, though a soft wood is used for light construction, light carpentry, furniture, interior joinery and many other purposes. However, there has always been a question about how long does it stay in service? While in use for these purposes, considering the fact that it is a soft wood and is susceptible to attack by biotic agents such as fungi, insects and marine borers which leads to its degradation and quick wear out of service. When products from this wood species degrade due to this attack, there is often the need to exploit the forest in order to replace the degraded items or products. This can be controlled if appropriate treatment is given to the wood and its products to fortify them against the biotic agents and ensure proper and good performance. This will also reduce the replacement costs and allow for more efficient use of our forest resources. There is no doubt that these fungi can only attack and decay wood only when conditions are favourable for the attack. Fungi require a temperature ranging between 10 and 32 degree Celsius, the optimum is about 21 to 29 degree Celsius. It therefore implies that, when this wood *Alstonia* is used for an indoor construction or furniture, is bound to be attacked by fungi since the room temperature is between the range of 19 degree Celsius to 24 degree Celsius. *Alstonia* used for indoor construction under normal circumstance is subject to fungi attack because the temperature of the room favours its colonization. Wood is one of the most abundant raw materials ever given to man my God. Therefore, it is very important that it is properly managed and utilized. At least 75 percent of a felled tree should be completely utilized without waste, because it takes a very long time to regenerate itself to a merchantable size. Apart from the waste that may result from logging, converting and processing, wastage of wood also occurs as a result of attack by bio – degrading agents like insects, marine borers and micro – organisms such as bacteria and fungi. These biotic agents cause damage to wood that eventually results in wood waste. It is true that there are species of wood that are naturally durable being resistant to attack by these biotic agents. However, many species are not and as such are prone to attack. *Alstonia* and other species of wood that are not naturally durable can be properly seasoned and treated to resist attack by these biotic agents and so become durable, thereby reducing unnecessary wastage of wood which eventually leads to the unnecessary exploitation of our forest.

This research work is to experimentally determine the effect and control of wood destroying fungi on this soft wood *Alstonie boonei* in service. Noting that while this specie tends to worn - out between 5 to 10 years according to International Union of Forest Research Organization (IUFRO) is as a result of the factors surrounding it which causes it attack by biodegrading agent such as; temperature, humidity, presence of water, etc. These factors are responsible for the attack of this wood specie, hence its deterioration. The effect of these agents on *Alstonia boonei* especially being soft wood is very rapid and very devastating. But can be controlled if these factors responsible for this attack are totally eliminated and the wood is dried to Fibre Saturation Point (F.S.P). Then one is sure of enjoying lasting *Alstonia boonei* in service. However, where these factors cannot be totally eliminated, then, a proper treatment should be given to the wood depending on where it is to be used and what it will be used to accomplish, to ensure its durability in service.

LITERATURE REVIEW

Alstonia boonei is scientifically classified into De wild Authority and Apocynaceae family with other common names; Alstonia, Cheese wood, pattern wood, stool wood. It occurs naturally from Senegal and Gambia to Western Ethiopia and Uganda. According to [world Agroforestry Centre], *Alstonia* is named after Dr. C. Alstonia, a professor of Botany at Edinburgh University. *Alstonia boonei* occurs in primary as well as secondary, moist evergreen to dry deciduous forest up to 1200m altitude. It requires large amount of light and colonizes gaps in the forest. It has plenty of natural regeneration in young secondary forest. In Nigeria, it occurs in moist lowland forest but may extend into drier types, including gentle to steep, rocky hill sites in Liberia. It is most commonly found scattered or in small groups in wet or marshy places that are occasionally inundated [1].

The wood of *Alstonia boonei*, called *Alstonia* in international trade is used for light construction, light carpentry, open boats, moulding furniture, interior joinery, implements, boxes, crates, matches, pencils, sculptures and for veneer and plywood. It is locally popular for the production of house hold implements because of its good working properties and stability. In Ghana, it is used for the production of Asante stools, and in Nigeria for sound boxes of musical instruments of the Yoruba people. The wood is also used as fire wood [1].

Fungi are a major cause of wood degradation. Fungi used to be classified as belonging to the plant kingdom but are now classified in kingdom separate from plant and animals. like animals, fungi are heterotrophic, that is , they must consume digested organic matter rather than manufacture their own food as plant do during photosynthesis, due to their lack of chlorophyll. Fungi secrete digestive enzymes on wood breaking it down into simple substances which they absorb and use as food, thus, bringing about decomposition or degradation of the wood. Fungi reproduce rapidly by means of very minute spores. Air contains quite a number of fungal spores and if wood is in a condition favouring colonization of fungi, it will almost certainly be colonized in a very short time. The spores of fungi, which fulfill the function of seeds are extremely minute and are individually invisible to the naked eyes. On germination, these spores give rise to extremely fine threads, known as hyphae, which permeate the wood and can easily be seen under the microscope. Under very damp conditions, as in an unventilated cellar, these hyphae may proliferate on the surface of the decaying wood and give rise to a visible mass of growth which is known as mycelium. Advanced stages of fungi decay are recognized by a brittle nature and a colour change in the decayed wood. In the early stages, decay is not easy to recognize. Even incipient decay causes loss of strength and is usually accompanied by change of colour. As decay proceeds, wood substance is used up by the fungi and the

wood becomes lighter in weight and begins to shrink. Timber where decay has started is softer than normal wood [2]. Closely allied to the wood destroying fungi are other fungi which give rise to definite discoloration's in wood without noticeably affecting the strength and texture of the material. In accordance to [2], there are a number of wood staining fungi producing a wide range of colour effects but by far the most important is the blue stain or sap stain. In general, it may be said that blue stain should not be considered as a serious defect in material used for ordinary construction purposes. The conditions necessary for the development of decay producing fungi in wood include;

1. Favourable temperature (usually ranging from 10^0C to 32^0C). The optimum is about 21^0C to 29^0C. Wood is basically safe from decay at temperature below 1.6^0C and above 37.7^0C [3].
2. Adequate moisture (fungi will not attack dry wood, that is wood with a moisture content of 19% or less). Decay fungi require a wood moisture content (M. C) of about 30 percent (generally accepted Fiber Saturation Point (FSP) of wood). Thus, air dried wood, usually with moisture content not exceeding 19 percent, and Kiln dried wood with a moisture content of 15 percent or less, may be considered safe from fungal damage [3]. However, percentage moisture content (% M. C) can be determined by the amount of moisture content in a particular wood divided by the oven dried mass of that particular wood multiplied by one hundred [3].

% M. C = (amount of moisture/oven dried mass) x 100
Where,

Amount of moisture = initial mass of wood – oven dried mass.
Fibre Saturation point (F. S. P) is the moisture content of wood when moisture is found only in the cell walls of the wood. This state of complete drying, beyond which a defect such as Shrinkage and warping of the wood occurs.

3. Adequate oxygen - most fungi cannot live in water saturated wood.
4. A suitable substance or a suitable supply of food – wood substance (i. e cellulose, hemicellulose and lignin).

A deficiency in any of these requirements will inhibit the growth of a fungus, even though it may already be well established in the wood. The food required for the nourishment of a wood destroying fungus is supplied chiefly by the actual wood substance. Few, if any, of the decay producing fungi are able to attack all kinds of wood indiscriminately, presumably because of dissimilarities in the chemical composition of different woods [3].

Temperature has an important effect on the growth of fungi, the optimum temperature reported being between 21 and 29 degree Celsius. While cold temperatures check the growth of all fungi in wood, freezing does not actually kill fungi in wood and they soon become active again when the wood thaws out. On the other hand, most of them are soon killed by exposure to high temperatures and a convenient way of sterilizing infected timber is to heat it in a timber drying Kiln. Consequently, sound wood that has been kiln dried or thoroughly air dried is immune to decay unless subjected to wetting or to dampness sufficient to raise its moisture content above the required minimum. Moreover, if wood in which decay is established is dried to moisture content below 20 percent, the development of fungus will be arrested. Wood decaying fungi can be grouped into three (3) major categories: brown rot, white rot and soft rot. Fungi that cause brown rot are able to break down primarily the cellulose component of wood for food, leaving a brown residue of lignin. Wood infested with brown rot can be greatly weakened even before decay is visible. The final stage of wood decay by brown rots can be identified by the dark brown colour of the wood, excessive shrinkage, cross – grain cracking and the ease with which the dry wood substance can be crushed to a brown powder. Brown rot fungi are probably the most important cause of decay of soft wood used in above ground construction. White rot fungi breaks down both lignin and cellulose, have a bleaching effect that may make the damaged wood appear whiter than normal. Affected wood shows normal shrinkage and usually does not collapse or crack across the grain as with brown rot damage. It loses its strength gradually until it becomes spongy to the touch. Sometimes, white rot fungi cause thin, dark lines to form around decayed areas, referred to as zone lines. The wood does not shrink until decay is advanced. White rot fungi usually attack hardwoods, but several species can also cause soft wood decay. Soft rot usually attack green (high moisture) wood, causing a gradual and shallow softening from the surface inward that resembles brown rot. The affected wood surface darkens and this superficial layer, up to 3 to 4mm deep, becomes very soft, giving the decay its name [3].

Wood is universal; it is a raw material that can satisfy almost every requirement. Wood is stronger than steel. Unlike steel, it is also resilient (i.e. the ability for it to return to its original shape after it has been bent, stretched or pressed). This combination of strength and resilience gives wood the ability to absorb the shock of heavy loads providing a greater margin of safety than many other materials [4]. In construction of dwellings, architects consider that wood has more than ten times the insulating capability of steel or aluminium and five times more effective as an insulator than concrete or cinder block [5]. As building material, wood yields an astonishing variety of plywood, plastic and wood fibre products that can meet any engineering specification.

Research Design and Methodology

This research study was carried out in cross River State university of Technology, Faculty of Engineeering, Wood product department laboratory. The wood, Alstonia Boonei was experimentally analysed to determine the effect and control of wood destroying fungi. Five samples of Alstonia wood each measuring 25 x 300 x 300mm acquired from the Calabar timber market were subjected to varying laboratory conditions. The procedure and results of the effects of the various conditions are shown in the table below.

Procedure

1. Five samples of Alstonia wood labeled A, B, C, D and E acquired from the timber market were weighed using the weighing balance to determine the weight of each samples. The weight of each sample is shown on the table below.

Table 1 Weight of Samples

s/n	Sample	Weight (gm)
1	A	20.26
2	B	20.35
3	C	21.03

4	D	20.32
5	E	19.98

2. Sample A, B and C were exposed to moisture in a humid environment for a period of 60days and the three samples absorbed moisture from the surrounding atmosphere. The result is shown on the table below.

Table 2 Weight of sample A,B and C after exposure to moisture in a humid atmosphere after 20days

s/n	Sample	Weight (gm)	Weight after 20 days of exposure to moisture (gm)
1	A	20.26	20.96
2	B	20.35	21.25
3	C	21.03	21.53

From table 2 above, it was observed that after 20 days of exposing sample A, B and C to a humid atmosphere, they absorbed water from the surrounding and there was an increase in weight of these three samples.

3. Sample A, B and C was left for another 40 days in a humid environment. We observed that fungi spores began to germinate on the samples. Gradually, these fungi spores became very visible to the naked eyes as it gave rise to extremely fine threads which is known as hyphae.

Gradually, the cellulose component of sample A, B and C were broken down by these fungi for food leaving a brown residue of lignin. These wood samples were gradually weakened even before decay was visible and there was rapid decrease in weight of the samples. The table below shows the result.

Table 3 Weight of sample A,B and C after 40days being attacked by fungi

s/n	sample	Initial weight (gm)	Weight after 20 days of exposure to moisture (gm)	Weight after 40days being attacked by fungi (gm)
1	A	20.26	20.96	17.96
2	B	20.35	21.25	16.50
3	C	21.03	21.53	18.04

Table 3 above shows clearly that when fungi attack *Alstonia Boonei*, it weakens and reduces the weight of the wood and the strength properties are greatly affected. A change in colour in the three samples to dark brown was also observed. In addition to the colour change, the three samples began to undergo shrinkage gradually and this resulted in a great distortion to the dimensional stability and chemical composition of the wood.

4. Sample D and E were dried for six hours using the oven in the laboratory at a controlled temperature of 105^0C. The result is shown on the table below.

Table 4 Drying of sample D and E at 105^0C for six hours

s/n	Sample	Initial weight (gm)	Oven dry weight after six hours (gm)
1	D	20.32	17.62
2	E	19.98	17.68

5. The percentage moisture content in both sample D and E were determined as shown below.

Sample D:
Initial weight of sample = 20.32gm
Oven dry weight of sample = 17.62gm
Percentage moisture content (% M. C) = (amount of moisture/oven dry weight) x 100%
Where,
Amount of moisture = initial weight – oven dried weight = 20.32 -17.62 = 2.7gm
Percentage moisture content (% M. C) = (2.7/17.62) x 100 = 15.88%
Therefore, sample D was dried to 15.58 percent moisture content.
Sample E:
Initial weight of sample = 19.98gm
Oven dry weight of sample = 17.68gm
Percentage moisture content (% M. C) = (amount of moisture/oven dry weight) x 100%

Where,
Amount of moisture = initial weight – oven dried weight = 19.98 -17.68 = 2.3gm
Percentage moisture content (% M. C) = (2.3/17.68) x 100 = 13.01%
Therefore, sample D was dried to 13.01 percent moisture content.

After drying sample D and E to 15.88% and 13.01% respectively, they were treated with creosote, by a brush method (surface treatment) and exposed for 60days to the same environmental conditions.

RESULT

The research result shows that on exposure of sample D and E which had been dried to a moisture content of 15.88% and 13.01% respectively and treated with Creosote for a total period of 60 days to the same environmental conditions to which sample A, B and C were subjected, sample D and E were not attacked by any fungi.

CONCLUSION

This research study clearly shown that *Alstonia Boonei* specie has only not be durable enough due to its exposure to harsh and unfavourable environmental conditions that are directly responsible for its attack by degrading agents such as marine borers, insects and micro -organisms like bacteria and fungi, hence leading to its deterioration and a complete breakdown while in service. However, if these harsh and unfavourable conditions are controlled to a required state and the wood chemically treated to repel this degrading agents, then *Alstonia Boonei* would not by any means be a problem to wood engineers while considering the choice of wood to use without any fear of fungi attack. Moreover, outside the fact that the presence of water creates an enabling ground for fungi attack, water is an enemy of wood as it is a universal solvent that will dematerialize wood with time. For the purpose of emphasis, soft wood should not be used where hard wood is necessary and required as strength may be the main factor required.

Recommendation

Based on the result and conclusion of this research work, we recommend that *Alstonia boonei* should be properly seasoned, chemically treated and kept free from conditions favourable to biodegrading agent if it is to be used comfortably for various light construction purposes, light carpentry, open boats, furniture, interior joinery, implements, sculpture etc.

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