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Natural resistance of ten selected Nigerian wood species to subterranean termites' attack

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Abstract

Natural resistance of some wood species used prominently in the Nigerian construction industries to termite was examined in this study. Wood samples were collected from a Sawmill in Akure and cut to stakes of 35 × 35 × 450 mm which were to be buried half way in the soil, their density was determined and classified across three density classes; high, medium and low. They were exposed to subterranean termites attack for 48 weeks (12 months) in a termitarium. Monthly visual estimation of the stakes was done in accordance with ASTM D 3345/1980 rating scale and gravimetric weight loss assessment carried out after 6 and 12 months of exposure. Results showed that there was significant difference ($p<0.05$) in the resistance of the species to *Macroterms sybhylinus* a native of subterranean termites identified on the site. It was discovered that species in higher density classes exhibited greater resistance and density was found to have a higher correlation coefficient of 0.91 with loss in weight after the exposure period. Other factors such as presence of toxic extractives and age could also be responsible for higher resistance. This study proved the inevitability of protection strategies for all the wood species regardless of density class using appropriate technologies to ensure a longer service life and sustainable management of our forest resources.

1. Introduction

It is a common practice among builders to buy wood and use directly for construction work without going through preservative treatment process. This could be as a result of lack of knowledge about the natural durability status of some of the Nigerian wood species, users only rely on experience acquired over the years but which is no longer reliable because of dwindling supply of mature timber from the forest. Wood as a biological product undergoes various physiological changes in the process of growth. According to [1], most fast grown wood species tend to deteriorate rapidly under biological and physical influences. Sapwood of most wood species have low durability. The durability of most heartwood is enhanced by the presence of toxic extractives which vary with different species and determine their level of durability. Natural resistance is the inherent ability of some wood species to resist the attack of bio-deteriorating agents without treatment with chemical preservatives. The natural resistance exhibited by some species is the resultant effect of the presence of extractives in the heartwood region. [2] revealed that the sapwood of all known tree species is very susceptible to decay, regardless of any natural resistance of the heartwood. Unless sapwood is entirely removed or impregnated with preservatives, decay is likely to occur even in durable species [3].

The term 'natural durability' therefore refers to the degree of resistance of untreated wood to bio-deteriorating agents. The natural durability of wood can only be appreciated through adequate knowledge of physiological processes of tree growth. As trees get older and larger, the storage cells in the center at the bottom begin to die resulting to a gradual transformation of the sapwood region to heartwood. Trees with more toxic natural chemicals deposited during the transformation have very durable heartwood that is highly resistant while some may be moderately resistant than others.

[4] classified the durability of wood into different classes; very durable, durable, moderately durable, non-durable and perishable. Wood species belonging to the perishable class are not generally suitable for use in construction works and cannot withstand damp environment or last long when in contact with the ground. Wood is exposed to numerous biological degradations in different environments and biological degradations occur when a log, sawn product, or final product is not stored, handled, or designed properly [5].

Bio-deterioration has been one of the major problems of wood in service which has been addressed mainly by impregnation with appropriate chemical preservatives depending on the area of use. Conventional wood impregnation methods (water or oil-borne preservatives) are based primarily on the use of toxic chemicals [6]. For environmental concerns however, there has been restrictions on the utilization of conventional chemical treatments as a result of their impact on human health. Wood treated with Copper chrome arsenate, Creosote oil and Pentachlorophenol requires a careful handling and utilization [7]. Frequent or prolonged inhalation of sawdust of treated wood and skin contact with creosote or pentachlorophenol-treated wood is hazardous which restricted their use for residential, industrial or commercial interior. [8] asserted that one goal of wood preservation industry should be to exploit the natural defence mechanisms of durable wood species.

Therefore, this study examined the natural resistance of these timbers in an accelerated condition of exposure to subterranean termites which is most prevalent in the tropical and sub-tropical environments.

2. Materials and Methods

This study was carried out at the Timber graveyard of the Federal University of Technology, Akure, Nigeria. FUTA (Lat. 7°17′N, Long 5°10′E), lies in the tropical rainforest zone of Nigeria with mean annual temperature of 20°C; elevation 350m; relative humidity 85-100% during the rainy season and 60% during the harmattan period. The soil of the study area is classified as ferruginous tropical soil (Alfisol) on crystalline rock of basement complex. The soil belongs to the Egbeda series;[9]. The soil is a characteristic red laterite rich in Iron and aluminum which favours termite activity

Wood samples of *Diospyrous nigerica* (Ebony), *Lophira alata* (Iron wood), *Celtis zenkeri* (Ita), *Khaya grandifoliola* (Mahogany), *Bligha sapida* (Ishin), *Alstonia congensis* (Ahun), *Cola gigantia* (Oporoporo), *Pachystelia brevipes* (Osan igbo), *Terminalia superba* (Afara) and *Terminalia ivorensis* (Idigbo) were selected for the study. They were obtained from boards of mixed conversion which contained both sapwood and heartwood. Stakes of 35 × 35 × 450 mm were prepared for the tests. The wet samples were weighed and the green weight was recorded as T_1 before oven-drying. Samples were oven-dried to a constant weight at 103 ± 2^0Cfor 24 hrs and the constant weight was recorded as T_2.

Density of the samples was determined and classified as high density, medium density and low density (High density >700kg/m^3, Medium density >450kg/m^3 and Low density <450kg/m^3). Five replicates were produced for each wood species making a total of fifty samples. The samples which were meant solely for natural durability test were later transferred to the timber graveyard site. The foraging activities of the termites were instigated by spreading wood shavings on the graveyard site 7 days before planting the wooden stakes. The stakes were pegged at a depth of 225 mm into the soil and the distance between each stake was 900 mm. Monthly visual observation was conducted and the samples were rated as specified in ASTM D 3345-74 standards [10] and a gravimetric method was used to assess weight loss due to termite damage after 6 and 12 months.

ASTM rating scale for visual estimation is shown below:

10 = Sound, surface nibbles permitted.

9 = Light attack

7 = Moderate attack penetration

4 = Heavy attack, 30 – 40% of the wood cross-section eaten up by termites

0 = Failures, over 50% of the wood cross-section eaten up by termites

3. Results and Discussion

The result of the mean gravimetric assessment (weight loss) and ASTM rating values for the selected indigenous wood species with their estimated mean density values is shown in Table 1. Wood species in the high density class recorded lower gravimetric values with a correspondingly higher ASTM values. *Lophira alata* (Iron wood) recorded a mean weight loss of 1.39 and 8.93 % at the end of the 6 and 12 months exposure to termites respectively. *Diospyros* spp. (Ebony) in the same density class recorded a higher weight loss of 18.03 and 19.73 % and a non-significant (p>0.05) weight loss as Ironwood. The higher weight loss of 19.73 recorded for Ebony was as a result of the inclusion of sapwood in the wood during conversion. *Celtis zenkeri. and Bligha sapida.* could maintain their integrity for only 6 months as they recorded failure after 12 months of exposure to termites' attack.

Wood species in the medium density class; Mahogany and Osan Igbo recorded weight loss values of 47.03 % and 82.83 % after 6 and 12 months respectively while the low density class recorded mean weight loss of 100 %. Although there was significant difference between the ASTM values among the medium and low density species, they fall within 0 – 0.8 ratings showing that they were totally degraded at the end of the 12 – month field test. From the scatter plot shown in Figure 2, it could be observed that there was a strong correlation (0.91) between density and weight loss revealing that with increasing wood density values, weight loss decreases. This higher weight loss value was observed to be due to the presence of sapwood which was rapidly degraded during the first six months leaving the heartwood which finally recorded 19.13 % weight loss. The mean ASTM rating of Ironwood and Ita were 8.0 and 9.5 respectively (Figure 3a) showing that they were still sound during the first six months but Ita had reached a heavy attack stage at the end of the 12th month leaving Ironwood and Ebony at the moderate attack stage (Figure 3b).

The result of density test for the ten selected wood species shown in Table 1 revealed classification into three density classes: Ebony, Ekki, Ita and Isin were in high density class with values of 811.10, 734.75, 653:36 and 609.29 kg/m^3 respectively; Mahogany and Osan Igbo in medium density group had 596.51 and 499.38 kg/m^3 while Afara, Oporoporo, Ahun and Idigbo had 452.76, 434.62, 395.35 and 304.61 kg/m^3 respectively. The result of regression analysis used in examining the relationship between weight loss values and wood density shown in Figure 2 revealed that weight loss and wood density are inversely related but with a strong correlation coefficient (R^2 = 0.91). This relationship showed that as the density value increases, weight loss decreases and it implies that high density wood samples will show a correspondingly low weight loss. From these results, higher density wood species tend to perform better compared to medium and low density species.

Table 1. *Gravimetric and ASTM values assessment after 6 and 12 months of field exposure.*

Scientific names/density class	Trade names	Density (Kg/m^3)	Weight loss% (mean + Se) after 6 months	Weight loss (%) (mean + Se) after 12 months	ASTM Ratings (mean + Se)after 6 months	ASTM Ratings (Mean + Se) After 12 months
High density						
Diospyros spp	Ebony	811.10	18.03±0.97 ^{b}	19.73 ± 1.05^b	8.08±0.18^a	7.00 ± 0.40^a
Lophira alata	Ekki/ Iron wood	734.75	1.39 ± 0.12^a	8.93 ± 0.62^a	9.52±0.07^a	7.60 ± 0.30^a
Celtis zenkeri	Ita	653.36	5.09 ± 0.21^a	31.49 ± 0.89^b	9.68±0.11^a	3.80 ± 0.32^b
Blingia sapida	Isin	609.29	18.04±0.80 ^{b}	57.07 ±1.08 ^{d}	8.00±0.31^a	0.00 ± 0.00 ^{d}
Medium density						
Khaya grandifoliola	Mahogany	596.51	18.60±0.80 ^{b}	47.03 ± 1.24^c	6.76±0.35 ^{a}	0.80 ± 0.27^c
Pachystela brevipes	Osan igbo	499.38	30.34±0.69 ^{b}	82.83 ± 0.99^e	2.88±0.35 ^{b}	0.80 ± 0.27^c
Low density						
Cola gigantia	Oporoporo	452.76	100.00±0.00 ^{d}	100.00 ± 0.00^f	1.80±0.33 ^{b}	0.00 ± 0.00^d
Terminalia superba	Afara	434.62	48.76±0.82 ^{c}	100.00 ± 0.00^f	2.24±0.36 ^{b}	0.00 ± 0.00^d
Alstonia congensis	Ahun	395.35	100.00±0.00 ^{d}	100.00 ± 0.00^f	2.24±0.36 ^{b}	0.00 ± 0.00^d
Terminalia ivorensis	idigbo	304.61	100.00±0.00 ^{d}	100.00 ± 0.00^f	1.40±0.33 ^{b}	0.00 ± 0.00^d

*Means with the different alphabet in a column are significantly different

It could be observed that the resistance of the wood species varies with the density, which means density appears to have a greater influence on the natural resistance. Previously, [11] reported that no strong correlation exist between wood density and termite resistance but this study however revealed that natural resistance of wood to termites depends largely on density which is a measure of wood hardness since the mode of termites attack is biting and chewing. Although natural resistance of indigenous wood species may not solely depend on density, the factor of variability in the presence of toxic extractives may also be taken into consideration [5]. It should be noted from these results that species in the higher density class were attacked in the long run and were rated as being moderately attacked showing that they are not completely resistant. This confirmed the assertion that no wood is completely immuned from the attack of termites, only the degree of resistance varies ([12, 13]. Most of the species in the middle and lower density class were completely degraded before the end of the 12-month field test revealing that preservative treatment or any other protection technology is necessary to enhance their longer life in service.

A general overview of the species performance is shown in Figures 3a and 3b. This result revealed that most of the wood species in medium and low density class only lasted less than eight weeks (2 months) on the field. Most of the high density species especially Ironwood and *Celtis* could however be accounted as sound with surface nibbles at the twenty-fourth week despite the mixed conversion method used. This however does not imply that their sapwood were durable. Although the high density species generally had a better resistant to termites, a longer service life could also be enhanced through the use of chemical preservatives. Wood extractives contain both the organic and inorganic components. [14] and [5] stated that the organic components of extractive influence some wood properties such as colour, odor, taste, decay resistance, density, hygroscopicity, and flammability.

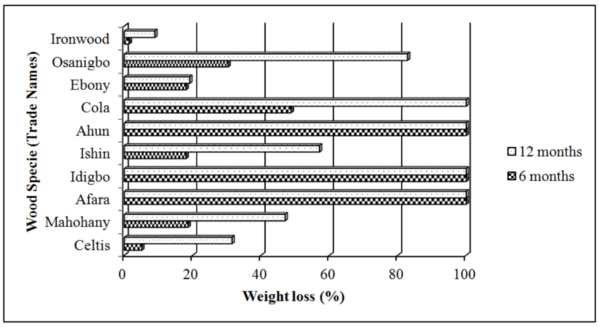

Figure 1. *Mean weight loss of the individual wood species at 6 and 12 months of field test.*

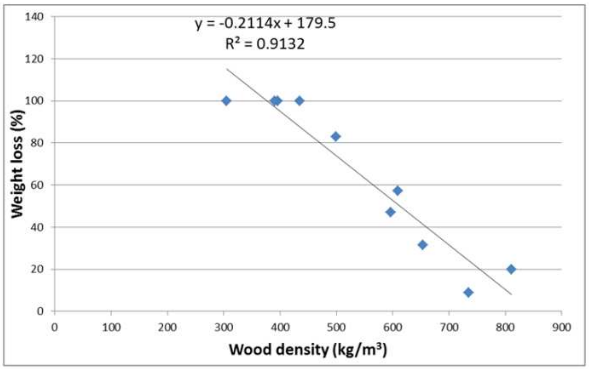

Figure 2. *Relationship between weight loss and wood density of the wood species.*

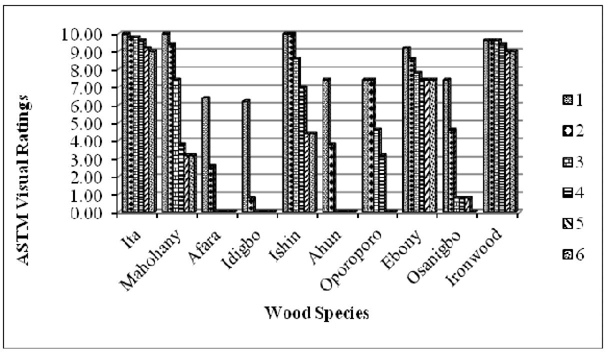

Figure 3a. *Mean ASTM rating of the wood species at first 6 months of field exposure to termites.*

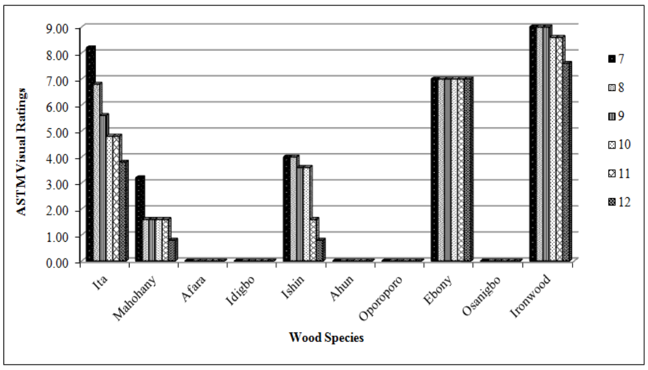

Figure 3b. *Mean ASTM rating of the wood species at 12 months of field exposure to termites.*

4. Conclusion

This study has shown that most of the indigenous wood species examined in this study are not naturally resistant to the ravaging attack of subterranean termites. It also revealed that density plays a major role in the natural resistance of wood to termites attack. Density which is a measure of weight and hardness of the wood has correlation with its resistance to termites' attack. The results indicate that the mixed conversion method popularly used in Nigeria makes it imperative for all wood species of all density classes to be treated with preservatives before use to preserve the wood integrity in service. It is therefore recommended that these species be protected to ensure a longer service life through suitable protection technologies which will help in ensuring sustainable use of wood.

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