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Resistance to Termite Attack Properties of *Azadirachta indica* Wood from the Savannah Ecological Zone of Ghana

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Abstract:- The continued increase in human population and demand for wood for different structural applications has prompted intensive research into the suitability of various types of timber species that will be suitable for various utilization. For the appropriate use of wood for engineering purposes, its properties must be established for use. This study evaluated the durability properties of neem (*Azadirachta indica)* wood. Samples for this study were harvested from the natural forest at the Du-West / Peplime community of the Upper West region of Ghana. Specimens were extracted from the logs using quarter sawing. The natural resistance of *neem* wood was carried out using samples along (Axially) and across (Radially) the bole of the tree. Prepared specimens were oven-dried, weighed until there was no variation in weight of two successive weighs, and then subjected to a field termite exposure test for a period of six months, after which, they were exhumed and cleaned, dried, and re-weighed. The result of this study showed that the weight loss assessment of the heartwood was lower while that of the sapwood of all the trees under study was higher. However, One-way ANOVA conducted between the heartwood and sapwood showed no significant variation even though the sapwood recorded a higher mass loss than the sapwood. The average mass loss for the heartwood of all the trees under study was 5.90% and that of the sapwood was 7.71% revealing a high resistance of *neem* wood to termite attack and also placing *it* in the Durable class.

I. INTRODUCTION

Insufficient supply of wood raw materials is one of the main global hindrances to the growth and sustainability of the furniture industry. Many lesser-known-species (LKS) that could play a supplementary role to the scarce commercial timbers for furniture production are available in tropical forests (Antwi-boasiako & Boadu, 2016). However, the industry continuously suffers timber shortages leading to the collapse of some businesses. A study conducted by Aguma and Ogunsanwo (2019) reported that the shortage of raw wood materials has led to some wood processing and furniture production companies either becoming non-operational or not operating at full capacity. It has also caused some firms, as well as individuals, to lose their jobs and income. As a result of these negative effects, the need for alternative wood has become a major priority for stakeholders in the wood industries (Cionca et al., 2006). The extent to which manufacturers patronize LKS as alternatives to the commercial timber specie is low because the biological durability and other properties of the timber are unknown, which this study sought to ascertain. According to Eslyn and Highley (1976), wood is a natural polymer consisting basically of cellulose, hemicelluloses, and lignin in a matrix that gives structural support to the living tree and some resistance against microbial manifestation or attack. Eslyn and Highley (1976) reported that lignin is a heterogeneous polymer of phenyl propane units and is highly resistant to some decay fungi. Nevertheless, other organisms have developed high resistance to attack for one or more of the polymers in the wood cell wall. Some wood species have evolved to produce extractive compounds that can protect the wood and these are the main sources of decay resistance in all species. Wood is a natural, sustainable, and organic composite material, it can be affected by several wood-deteriorating agents under suitable climate exposure conditions, which may threaten the long-term performance of timber structures in their service life (Verbist et al. 2019). The biological degradation of wood has a role in carbon cycling in nature, and wood being an organic material is subject to several types of degradation agents (or factors) under suitable climate exposure conditions (Marais et al., 2022). Wood-destroying insects are not ubiquitous like fungi and bacteria, they can however live and degrade wood from the inside for several years before detection. Control of wood moisture is not always enough to limit its occurrence. The main risk factor remains the local hazard, therefore geographical distribution of their occurrence (Marais et al., 2022). According to the EN 350 standard, wood durability is the "resistance of wood to destruction by wood-destroying organisms". Wood durability can greatly vary depending on the species, the age of the tree (from which the wood is derived), the geographical origin of the tree species, and the growing conditions (Mazela & Popescu, 2017). The microbial degradable carbohydrates and polar hydroxyls in wood absorb moisture, making wood susceptible and attractive material for active biological agents such as termites, molds, fungi, and beetles in the environment (Råberg et al., 2005). The severity and intensity of mold growth are highly dependent on the environmental conditions and the type of wooden material chosen for a particular work or a particular location (Vidholdova et al., 2015). Natural durability may be of high advantage to the living tree because fungal or insect attacks through wounds that subjects' heartwood will tend to progress at a slower pace in durable woods than in nondurable woods. Knowledge about the natural durability of wood species can provide useful information on their possible end-uses as well as important predictions on product service life (Gambetta et al., 2004).

Several highly effective wood preservatives in recent times have been banned in many countries as they pose a threat to human health and the environment. strategic approaches for increasing wood durability are being sought to improve the durability of wood (Brischke, 2020). Due to high price of wood preservatives and their harmful nature to users when improperly handled, disposal of the leftover chemicals after treatment of the wood with these preservatives turns out to be a problem for all living organisms on the earth. When preservatives are improperly disposed of, they get into water bodies which causes health challenges to mankind and also poses a threat to aquatic animals (Hasan et al., 2018). Direct soil contact is one of the most severe exposure situations wood can be subjected to since in-ground wood is almost permanently wet and in direct contact with wood-degrading organisms such as fungi, insects, and bacteria, which in turn become well-established and can proliferate through readily available nutrient sources (FAO, 1986). With these backdrops in processing and efficiently utilizing wood, it is, therefore, beneficial to make use of wood species that are naturally durable and resistant to wood deteriorating organisms as well as resistant to weathering to minimize the devastating and replicative effects of the preservatives if not avoided when used in preserving the wood.

Fig 1. above shows the specimen being mounted at the Demonstration field to determine the level of natural resistance of neem to termites and other biodegradation factors at the Kwame Nkrumah University of Science and Technology test site.

II. MATERIAL AND METHODS

➢ *Research Design*

The research design used for this work was an experimental type. Why because the study involved the causal relationship resulting from the manipulation of the research factors of determining the behavior of samples at various sections (Butt, Middle, and Top) parts of the three trees and to ascertain the heterogeneous characteristics of the neem tree and the effect on the various durability properties of the neem tree.

➢ *Collection of neem Samples,*

Three matured ***Azadirachta indica*** trees were harvested from a natural forest at the Du-west community in December 2020. The three trees were purposefully selected based on the diameter of the tree, straightness of the trunk, as well as defects-free trunk were marked and fell. Measurements of 12m in length and 1.4 - 1.5m in diameter were the sizes of the trees. The boles of the three trees selected were divided into three sections to determine the within and among tree variations (butt, middle, and top) each measuring about 4m in length. The billets were then converted into lumber using the quarter sawing method and then transported to the laboratory for conditioning and performing the graveyard test for natural durability. The merchantable length of the clear boles between where the first branch begins and the terminal point of buttresses of each species was measured.

The diameter at breast height (DBH) of the trees ranged between 1.4 - 1.5m while the total heights from the stump level to the top of the crown were in the range of 12.0 – 12.5 m. Each tree was cut 15cm from the ground to the first branch and further cut into three sections namely; the butt, middle, and top of the tree stem, respectively. The boles were used for the determination of the durability property of the neem wood.

- *Field Test of Azardirachta indica stakes for Durability (Graveyard)*

Azardirachta indica specimen with a dimension of (500 × 50 × 25 mm) were prepared and oven-dried at a temperature of 103±2℃ until there was no significant change (0.01g) between two successive weighing of specimen according to the EN (252 2014). The specimen were prepared and labeled appropriately for easy identification. They were oven-dried to a moisture content (M.C.) of 10-12%. The weights of the various replicates were measured and recorded using an electronic balance. The replicates from the timber were buried 50cm apart into the soil to cover one-third of their lengths (50 × 60 mm) using a Completely Randomized Design (Tascioglu et al., 2012). Regular inspection of the stakes was made once every month for the assessment of deteriorating features and to also make sure stray animals do not exhume specimens during the period of study. The test samples were left in the field for 6 months after which debris was brushed off the stakes. Percentage mass weight loss was carried out to determine the percentage of destruction by the termites. Their weights were recorded and dried in an oven until constant moisture content was attained. The constant weights were recorded as weights after the field test and the percentage mass loss was determined using the formula;

$$\text{Weight Loss} = \frac{M1-M2}{M1} \times 100$$

Where:
M1 = the weight of specimens before the graveyard test (kg)
M2 = the post-exposure weight (kg).
Percentage mass losses of samples were determined as an indication of durability using the process of mean weight loss rating. The extent of damage caused by the termite to the wood was rated according to the scale proposed by (BS EN 252, 1989) (Table 1)

Table 1.0 Natural durability rating based on percentage mean weight loss against termites

Weight Loss (%)	Rating
0 - 5	Very durable
6 – 10	Durable
11 – 40	Moderately durable
41 - 100	Non-durable

Source: (BS EN 252, 1989)

- *Description of Experimental Area*

Decay resistance of the (*Azardirachta indica)* was determined at the Durability Test Site of the Department of Wood Science and Technology at the Faculty of Renewable Natural Resources (FRNR) Demonstration Farm of KNUST. The main vegetation formations as described by Benneh et al.(1990) are coastal savannah, coastal strand and mangrove, evergreen forest, semi-deciduous forest, and savannah. Kumasi, the location for the field test, is of the semi-deciduous forest type. The town is within the plateau of the southwest physiological region, which ranges between 250 and 350 meters above sea level. The metropolis has a wet sub-equatorial type of climate. Both temperature and humidity are moderate. It contains many termite mounds and has a high decay hazard index. Common insects at the test field include subterranean termites, Anobium spp., Ancistrotermes spp., and Nasutitermes latifrons (Usher, 1975). According to Ravenshorst et al.(2013), the use of the field test is mostly preferred to the laboratory type since the former allows the collective effects of many biotic and abiotic factors of deterioration to be evaluated. Antwi–Boasiako and Baidoo (2010)and Sonowal and Gogoi (2010) explained that the duration for field tests could be shortened to produce useful results for reliable prediction of the durability of LUS.

III. RESULTS OF THE STUDY.

- *Percentage mass loss of various portions of A. indica*

The stem sections of Tree 1 heartwood recorded an average mass loss of 6.65% while the sapwood had an average mass loss of 7.53% (Figure 2.0). Tree 2 heartwood recorded a mass loss of 5.36% and 7.54% for the sapwood portion. Finally, tree 3 heartwood recorded 5.69% while the sapwood also recorded 8.06% mass loss. (Figure 2.0). The mass loss increased from the butt to the top portion of all three *A. indica* specimens, radial variation indicates that there was a higher percentage of mass loss in the sapwood than the Heartwood which according to (Anish et al., 2022; Keržič & Humar, 2021) is as a result of the presence of extractive in the heartwood than the sapwood that caused the sapwood of the tree to experience a higher mass loss than the heartwood. Also, the results obtained from the experiment indicated that, whereas the heartwood of *A. indica* may have a higher service life when in contact with the ground, the sapwood of *A. indica* may have similar service lives when subjected to the in-ground or outdoor application(Cookson, 2004). Hence for in-ground and outdoor applications such as garden furniture, and fences for ornamental plants among other uses. The Heartwood of *A. indica* appears to have a relatively long service life than its corresponding sapwood. However, sapwood also appears to exhibit better resistance to biodeterioration and can therefore have a relatively long service life. Therefore, it could be stated that both the heartwood and sapwood could be used for in-ground applications especially at termite-prone sites since the percentage mass loss was less than 10%. In addition, density is a determinant of wood durability, the higher the density of wood the higher its resistivity to wood distractive organisms (Kollmann & Cote, 1968). One-way ANOVA was conducted among BMT of the heartwood and

BMT of the sapwood of all three trees for the Mass loss recorded q-values ≥ 0.05. There was no significant difference in the percentage mass loss of the three *A.indica* (Figure 2.0).

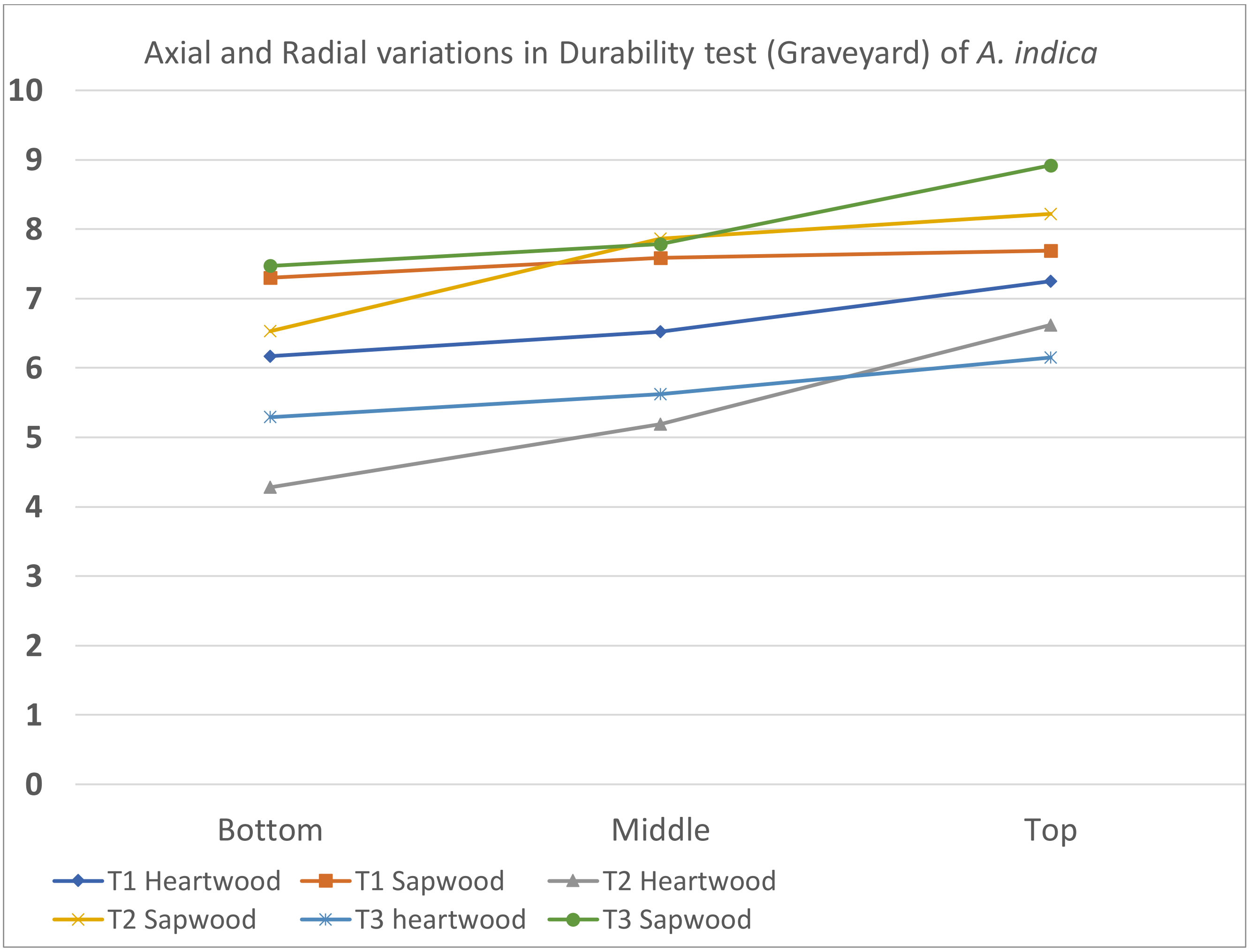

Fig 2 Representation of axial and radial variations in the Durability test (Graveyard) of individual Neem trees.

The determination of the natural durability of neem wood specie was carried out through the graveyard tests in 24 weeks (6 months). This was done by finding the percentage weight loss in 24 weeks when wood samples of the neem wood specie were exposed in the field to termites and other wood bio-deteriorating agents. After the exposure, the neem specimen was observed to only have a slight nibbling, amounting to less than 10 % of the volume of the sample. The results from the field test in Table 2.0 indicate that *A. indica* could be used as a substitute for the commercial timber species.

According to the durability classification by (BS EN 252, 1989) as cited by (Antwi-Boasiako et al., 2017). The standard references indicated that *A. indica* wood was highly resistant to termite attack and fall under (the **Durable** class), which was supported by the result of the graveyard tests in this study. This result corresponds with studies conducted by (Ashokhan et al., 2020; Kilani-Morakchi et al., 2021; Ley et al., 1993; Mordue & Nisbet, 2000; Qin et al., 2020; Veitch et al., 2008) which concluded in their studies that the high resistivity of a timber specie is as a result of the presence of pyrethroids natural chemicals. In all instances of this study, the sapwood had a higher mass loss than the heartwood which according to Keržič and Humar (2021) is a result of the presence of extractives in the heartwood than the sapwood. Neem wood is a Durable timber species as a result of the presence of azadirachtin which serves as an Antifeedant/repellent to insects and other biodegradable organisms (Gahukar, 2010). This study, therefore, shows that *A. indica* wood could be used as a substitute for commercial timber species in areas where durability is of concern.

IV. CONCLUSION OF THE STUDY

The durability properties of the *A. indica* evaluated indicated that the specie is a durable timber since the percentage of mass loss of the specimen when subjected to the graveyard test is less than 10% classifying *A. indica* wood as a **durable** timber.

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