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EVALUATION OF VETIVER (*Vetiveria nigritana*) PLANT EXTRACT AS ECO-FRIENDLY WOOD PRESERVATIVE

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Abstract

The preservative potentials of Vetiver (*Vetiveria nigritana*) plant extracts on *Ceiba pentadra* wood against termites and wood borers was investigated. Samples were extracted using water and methanol. The wood samples were treated with the extracts and exposed to termites and wood borers for 12 weeks. The modulus of elasticity, modulus of rupture, decay resistance and field exposure were tested for in the samples and recorded before and after treatment for comparison in accordance to ASTM standards. Results were analysed using ANOVA. Laboratory analysis on Vetiver plant indicated the following: Na (0.5%), K (0.96%), Ca (1.28%), Mg (1.06%), P (0.46%). Mechanical tests revealed that *V. nigritana* extracts do not have any significant effect on the strength properties of the wood. Grave yard test showed that the untreated and *V.nigritana* water extract treated wood samples were damaged up to 40%, while no significance deterioration was observed in those treated with *V.nigritana m*ethanol extract. These results showed that that *V.nigritana* methanol extract could be used as effective eco-friendly wood preservative against termites and wood borers.

Keywords: Vetiver, Solignum, *Ceiba pentadra,* Solvent and wood preservative.

1. Introduction

Most of the synthetic preservatives used in the treatment of wood are found to be quite effective. However, Some contaminants are potentially included in wood preservatives such as chromated copper arsenate (CCA), arsenic, creosote consisting of various polycyclic aromatic hydrocarbons (PAHs), chlorophenols (CPs), pentachlorophenol (PCP), heavy metals including Hg, Cu and Ni, polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/DFs) as impurities in CPs, and organochlorine insecticides such as drin compounds and chlordane compounds (Sakai *et al*., 2001; Yasuhara *et al*., 2003; Asari *et al.*, 2004; Baldrian, 2003). These, coupled with the fact of their chemical toxicity, low efficacy, high cost, or corrosiveness (Murphy, 1990) necessitate the source for alternative preservatives. Preservatives from ligno-cellulosic biomass have been found to show similar effective properties (Onuorah, 2000) but are yet to be adequately utilized. These ligno-cellulosic biomasses are abundant, renewable, eco-friendly and are a reservoir for inestimable source of innocuous fungicides and pesticides which are non-toxic to mammals and easily biodegradable than synthetic chemicals (Onuorah, 2000). Recently, there has been an increasing awareness of the potentials of natural products to serve as preservatives which may eventually lead to the development of much-needed new preservatives (Tagboto and Townson, 2001, Singh and Singh, 2012, Verna *et al.*, 2009). The ability of wood and natural plant extractives to protect wood against wood degrading fungi and insects has been one possible approach for developing new wood preservatives (Kartal *et al*., 2004, Kirker *et al.*, 2013). The leaves of *Ipomea carnea*, fruit of linseed, and root of tall oil have been reported to possess a number of organic constituents which exhibit high toxicity against wood- destroying microbes (Onuorah, 2000). Similarly, the plant extracts of

Zingiber officinale, Piper guinensis and *Zanthoxylum zanthoxyloides* were found to control fungal growth on wood (Nurudeen *et al* 2012).

Vetiveria nigritana is a perennial grass species in the family of Poaceae. It is widely distributed in Africa and most commonly found in Nigeria, Northern Africa, Eastern Africa and tropical parts of Southern Africa (Champagnant *et al*., 2007). The *V.nigritana* root system is dense, hardy but rarely extends beyond 75 cm in length. The plant has been reported to contain active components used in traditional medicine and pesticide (Chomchalow, 2001; Chamagnant *et al*., 2008). Vetiver grass is widely known for its effectiveness in erosion and sediment control (Babalola *et al*., 2007; Donjadee and Tingsanchali 2013). In the present study, the preservative potential of *Vetiveria nigritana* extract against wood decaying fungi and termites was evaluated.

2. Materials and Methods

2.1 Sample Preparation

The Vetiver (*Vetiveria nigritana*) grass was collected from University of Ibadan (Lat 7^{o}22'N and Long 3^{o}53'E). The samples were air dried for about 72 hours, ground to about 2mm particle size and extracted using water and methanol in accordance with the method employed by Nurudeen et al (2012). *Ceiba pentadrata* wood was obtained from Ondo State (Lat 7^{o}05'N and Long 4^{o}50'E), Nigeria. Wood samples were collected from the top, middle and base of the tree stem. The wood species were crosscut and air dried for 2 weeks to about 12% moisture content.

2.2 Elemental Analyses

The elemental composition of the plants was determined using AOAC 1990. 0.5g of the ground sample was furnaced at 600°C for 3hrs and cooled for 24hrs. 10ml HCl solution was added to it and sample heated for 2 mins and standardized to 100ml. Na and K standards were read on flame photometer while Ca, Mg, Zn, Mn, Cu and Fe were determined by Atomic Absorption Spectrophotometer.

2.2.1 Ether Extract Determination

Dried sample weighing 1g was extracted with petroleum ether using Soxhlet extractor for 6hrs, and the ether left to siphon over for a cycle of 10 times until it is fully siphoned over. The weight of the extract obtained was then determined.

2.2.2 Tannin Acid Determination

Sample weighing 1g was soaked in acetone/glacial acetic acid (80/20) for 5hrs and filtered. The absorbance of the filtrate was read at 500mm on a spectronic 20 spectrophotometer, and the percentage tannin was determined.

2.3 Wood treatment

Twenty five samples each of Ceiba pentadra wood were treated with *Vetiveria nigritana* water and methanol extracts and Solignum preservatives. Untreated samples were used as control. Test samples were initially weighed, then dipped independently for 20mins into the solutions. At the end of the dipping, each test sample was withdrawn from preservatives and allowed to drain, and weighed. The absorption percentage was calculated as:

$$Absorption = \frac{final\ weight - initial\ weight}{initial\ weight} \times 100 \qquad (1)$$

Eighteen samples were deliberately exposed to beetles and termite for open field test (OFT) and grave yard test (GYT) using the Bureau of Indian Standards (Anon, 1968) while another set of 100 samples were used for mechanical tests. Sample dimensions used are 150 x 38 × 15mm (OFT & GYT) and 150 x 60 × 10mm (Mechanical Tests). The modulus of rupture, modulus of elasticity, bending strength and permeability were evaluated in accordance to ASTM Standards D2555-06 (2001), D1036-99 (2012), D5795-95 (2008) respectively. The flexural tests were conducted on a Universal Testing Machine at a cross-head speed of 1mm/min. For GYT, Treated and untreated test samples were installed in test yard as per Indian Standard (No.4833-1968). Nine matched replicates were taken from each treatment. Wood destroying insects' activity and percentage of damage to the test samples was recorded weekly by visual observation. Specimens were reinstalled in their respective positions after each inspection. The knife test or sound test was carried out when necessary to determine the extent of decay or destruction due to insect attack, till the sample was destroyed. Percentage of deterioration and increase in durability were calculated with reference to the control samples. Nine matched replicated of treated and control test samples were left in the open field for OFT. The test also was done in accordance with Indian Standard (No 4833-1968) Beetle activity and percentage of damage to the test samples were recorded by visual observation and weight reduction.

3. Results and Discussion

3.1 Chemical composition

The chemical composition of the plant is shown in Table 1.The plant contains key elements such as Cu and Zn which can serve as a biocide (Pizzi, 1998; McDonald *et al.*, 1996). However, these are in trace quantities. The percentage of Copper is within the limit of acceptable toxicity (Venmalar and Nagaveni, 2005) Also the presence of tannin, alkaloid and other phenolic compounds as reported in the Vetiver grass makes it fit as an environmentally friendly preservative as Cu and Zn have been reported to have capacity to bind with this group of phenolic compounds and make it a non-toxic preservative (Choi *et al.*, 2002, De Groot and Woodward, 1999, Zhang and Jiang, 2006).

Table 1: Chemical analyses tests on *Vetiveria nigritana* extracts

Parameter	**Value %**
Na	0.58
K	0.96
Ca	1.28
Mg	1.06
P	0.46
N	0.78
Zn	0.02
Mn	0.003
Cu	0.005
Fe	0.009

Tannin	0.93
Alkaloid	0.48
Saponin	1.20
Phenol	0.31

3.2 Modulus of Rupture (MOR) and Modulus of Elasticity (MOE)

Table 2 revealed that there was no significant difference between the extracts from the samples collected at the top part. However, the ANOVA (Table 3) revealed that for samples collected at middle part of the tree, there was significant difference among the MOR of all samples treated. This difference is found to be associated with solignum treated samples whose mean value was about 25% less than others. This suggests that solignum drastically reduced the strength properties of the wood species. At the bottom part, there was no significant difference among the MOR of all treated samples. However, the postmortem analysis revealed that the samples collected at the top had no significant difference between all mediums of extraction and strength. That is, methanol, solignum and water did not affect the strength properties of *Ceiba pentadra*, Solignum affected the MOR of the wood species at the middle level while samples collected at the bottom were all affected by the chemical application. The mean values for MOE of the samples treated are presented in Table 4. Statistical analysis (ANOVA) of MOE (Table 5) indicated that at 95% confidence interval there was no significant difference in the modulus of elasticity of all wood samples and this means that water extracted Vetiver, methanol extracted Vetiver and Solignum reduced the strength properties of Ceiba *pentadra*, however, the effect is very minimal.

Table 2: Mean Values for Modulus of Rupture of all samples treated

Sample	Top (g)	Middle (g)	Bottom (g)
Control	58.2	61.9	70.4
Water extracted	56.8	59.7	66.2
Methanol extracted	53.6	57.5	63.9
Solignum	55.1	46.9	59.6

Table 3: ANOVA for Modulus of Rupture of all samples treated

	df	Mean Square	F	Sig
MOR_top	3	8.308	.236	.867
	4	35.185		
	7			
MOR_middle	3	87.900	10.779	.022
	4	8.155		
	7			
MOR_bottom	3	41.297	.643	.627
	4	64.269		
	7			

Table 4: Mean Values for Modulus of Elasticity of all samples treated

Sample	Top (g)	Middle (g)	Bottom (g)
Control	8514.0	7953.8	10270.0
Water extracted	8199.9	8564.9	8984.2
Methanol extracted	7718.0	8613.0	8411.5
Solignum	7559.4	6765.4	7730.5

Table 5: ANOVA for Modulus of Elasticity of all samples treated

	df	Mean Square	F	Sig
MOE_top	3	385112.180	770	.568
	4	499975.475		
	7			
MOE_middle	3	1478950.375	1.644	.314
	4	899617.252		
	7			
MOE_bottom	3	2321001.025	1.162	.427
	4	1996826.841		
	7			

3.3 Open field decay resistance

The decay resistance of treated wood samples against wood borers was analyzed by weight loss (Figure 1). The weight losses in treated and control wood samples are shown in Table 6. Weight losses in solignum and *V.nigritana* methanol extract treated wood are very minimal when compared with that of control (untreated sample) and *V.nigritana* water extract treated wood. The apparent higher weight loss in *V.nigritana* water extract treated wood compared with methanol extract treated samples could be due to moisture movement in the wood in the water extract treated wood, It has also been reported that alcohol provides a particularly effective way of maximizing the bioavailability of the actives extracted from the plant which in turn have toxic effects against bioagent, thus could be preferred for protection of wood or wood based objects against destroying organisms (Schltz and Nichollas, 2000) This result shows that the *V.nigritana* methanol extract is very active in protecting the wood sample against decay this result compares well with the findings of Chang *et al*. (1998) who reported that α–cardinal obtained from Taiwania heart-wood possess high antifungal effectiveness. Similarly, Digrak *et al*. (1999) investigating the antimicrobial activities of extracts of Mimosa bark, reported the anti-bacteria activity of its extracts.

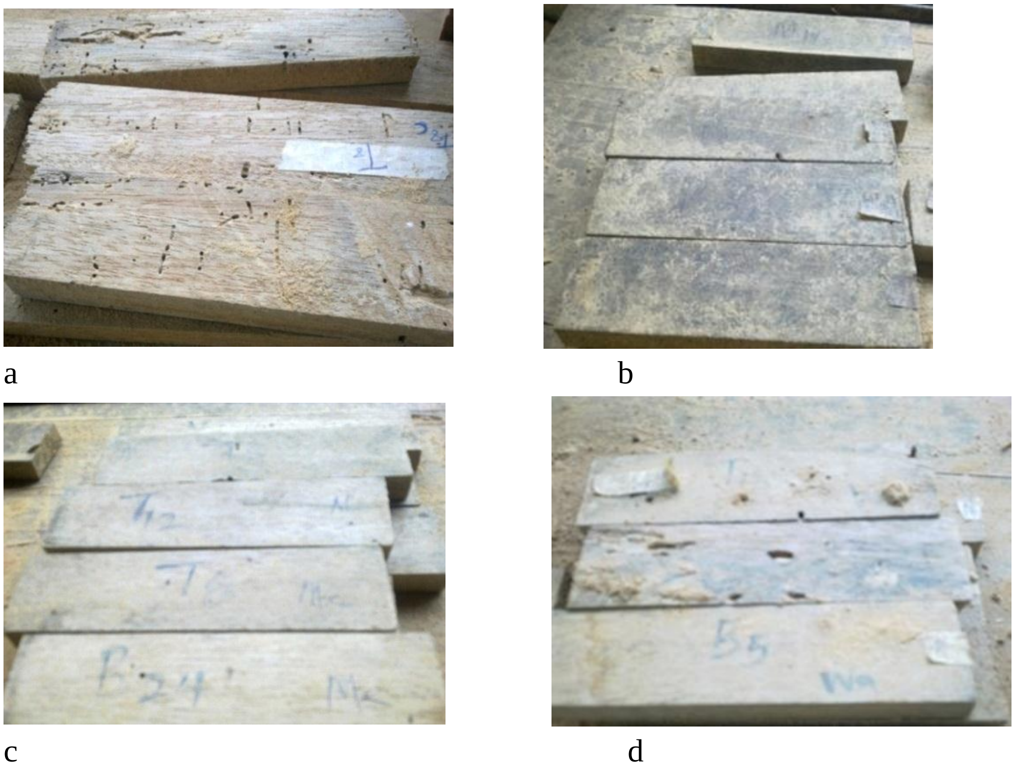

Figure 1: Effect of decay on *Ceiba pentadra* subjected to Open field decay tests after 12 weeks of exposure: (a) untreated wood (control), (b) solignum treated (c) methanol extract treated and (d) water extract treated

Table 6: Weight loss of samples subjected to open field tests

Treatment	Mean weight (final) (g)	Mean weight (initial) (g)	% weight loss
Control	33.8	42.6	22.5
Solignum	38.5	42.4	4.5
Methanol extracted	39.0	43.5	10.3
Water extracted	34.7	44.3	19.9

3.4 Grave yard decay resistance

Wood samples taken from the base of *Ceiba petandra* appeared much more durable to serve as control because of its older heartwood component. *Ceiba petandra* samples impregnated with solignum and *V.nigritana* methanol extract were more resistant against deteriorating organisms than the untreated and *V.nigritana* water extract treated samples. The untreated and *V.nigritana* water extract treated samples were damaged up to 40% after 12 weeks of exposure (Plate 2). However, no significance deterioration was observed in woods treated with *V.nigritana m*ethanol extract and solignum after 12 weeks of exposure. This observation (Figure 2) may indicate that *V.nigritana* methanol extract could be used as effective eco-friendly wood preservative against termites and wood borers.

Figure 2: Effect of decay on *Ceiba pentadra* subjected to Grave yard decay resistance tests after 12 weeks of exposure: (a) untreated wood (control), (b) solignum treated (c) methanol extract treated and (d) water extract treated

4. Conclusion

The effectiveness of *V.nigritana* methanol and water extracts as wood preservatives in treating *Ceiba pentadra* wood against termites and wood borers was determined. The test on mechanical properties of the samples revealed that *V.nigritana* extract does not have any significant effect on the strength properties of the wood. Methanol extract of *V.nigritana was* found to be effective in preserving the wood against termites and wood borers. *V.nigritana* methanol extract compared favorably well with solignum, a standard chemical preservative.

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