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Identification and Isolation of Microorganisms Associated with Wood Degradation from Timber Market, Umuahia North, Abia State, Nigeria

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ABSTRACT

Microorganisms have been known to be associated with wood degradation and wood products all around the world. Consequently, this study examined some of the microorganisms associated with wood degradation in the Umuahia Timber market, Abia State, Nigeria. Hard, soft and intermediate woods according to the timber dealers' specifications were collected and evaluated based on symptoms of wood degradation. Three of each type of soft, hard and one intermediate were analysed for bacteria and fungi loads. The sampled woods include Redwood, Birch and Cedar for soft wood; Gmelina for intermediate and Cherrywood, Mapple and Mahogany for hardwood. A total of five bacterial and six fungal isolates were found to be responsible for the deterioration of the wood samples and these microorganisms were isolated using the pour plate technique. Of the wood samples investigated, cedarwood had the highest bacteria count at 3.13 x 10^4 cfu/100cm³, while the least was recorded for cherry wood 1.53 x 10^4. The fungi result showed that Birch wood had the highest counts at 7.67 x 10^2 cfu/100cm³ while cherry wood recorded the least fungi counts at 3.67x10^2 cfu/100cm³. It was also observed in this study that Bacillus species and Staphylococcus aureus were the most frequently occurring isolates with a high percentage occurrence of 7(100%) each. Amongst the various woods accessed for its degradation potentials, cherry wood had the highest number of bacteria species 7(100%). This suggests that cherry wood can easily be degraded by microorganisms. Among the fungal isolates, Aspergillus flavus and yeasts (100%) had highest frequency.

1. INTRODUCTION

Microorganisms are known to be pervasive in nature and can use a wide range of substrates for their nutrients. This ranges from simple sugars to complex molecules to high toxic substances. Hence, it is not surprising that certain micro-organisms can dwell in standing trees and also colonize, and attack harvested wood and wood products (Jones, 2017). The degradation patterns produced by bacteria are extraordinarily different from decay pattern produced by fungi which makes it possible to differentiate bacterial degradation from fungal degradation. (Eriksson *et al.*, 2010).

Wood is decomposed by a range of biological agents, including fungi, bacteria, and insects. Fungi colonize wood and degrade cell wall components to form brown, soft, or white rot. While brown-rot fungi, which degrade primarily the polysaccharide components of wood, leave a lignin framework, white-rot fungi may degrade all cell wall components. The rate and extent of lignin, cellulose, and hemicelluloses removal varies among species of white-rot fungi. Soft-rot fungi erode the secondary wall or form discrete cavities within the cell wall (Boddy, 2019). Each type of decay has many forms and can be classified by microscopic and ultra-structural characteristics. Bacteria can directly attack wood to cause erosion, cavitation, and tunneling patterns of deterioration. They may have a synergistic or antagonistic effect on other microorganisms inhabiting the wood.

Globally, fallen wood stores more than 73 billion tonnes of carbon (Pan *et al*, 2011) and provides habitat for a wide range of saproxylic (dead wood-inhabiting agents) organisms (Sreedevi *et al*, 2013). Understanding the rate, mechanisms and control of wood decomposition is of ecological and economic importance to consumers of wood products. Therefore, the key to understanding wood degradation lies in the knowledge of microbial communities that effect and regulate decomposition in wood. However, Fungi are the dominant agents of wood decomposition, but it is a known fact that bacteria also inhabit dead wood. There are indications of great bacterial diversity within wood but its activities are poorly understood when compared with Fungi in the same environment (Zhang *et al*, 2008; Větrovský *et al*, 2011; Sun *et al*, 2014; Hoppe *et al*, 2015).

Wood is obviously used for domestic use in Nigeria, but its degradation has created major problem for its sustainability. Therefore, the problem of wood utilization in Umuahia North has grown from a point of poor method of harvesting, poor seasoning methods and improper storage methods. Indeed, trees/wood undergoing degradation by microorganisms in the study area are commonly visible. Therefore, it is essential to isolate and identify the specific microorganisms responsible for wood degradation in Umuahia timber market in order to develop effective mitigation and preservation strategies; hence this study.

2. MATERIALS AND METHODS

2.1. Study Area

The Study area is Umuahia timber market which is located along Ikot Ekpene road in Ibeku, Umuahia North L.G.A Abia State. Umuahia North LGA has a population density of 137,993 (National Population Commission, 2006) with an area of 108 sqm (281 km^2). The timber market serves Umuahia Township and its environment. Both local and imported woods are sold in the market which has been existing since 2012. Industrial activities like furniture manufacturing goes on within the market premises. The wood mark*et al*so serves as a source of employment for youths who serve as labourers in the market (Goodluck, 2017). Figure 1 show the map of the study area indicating the location of the study.

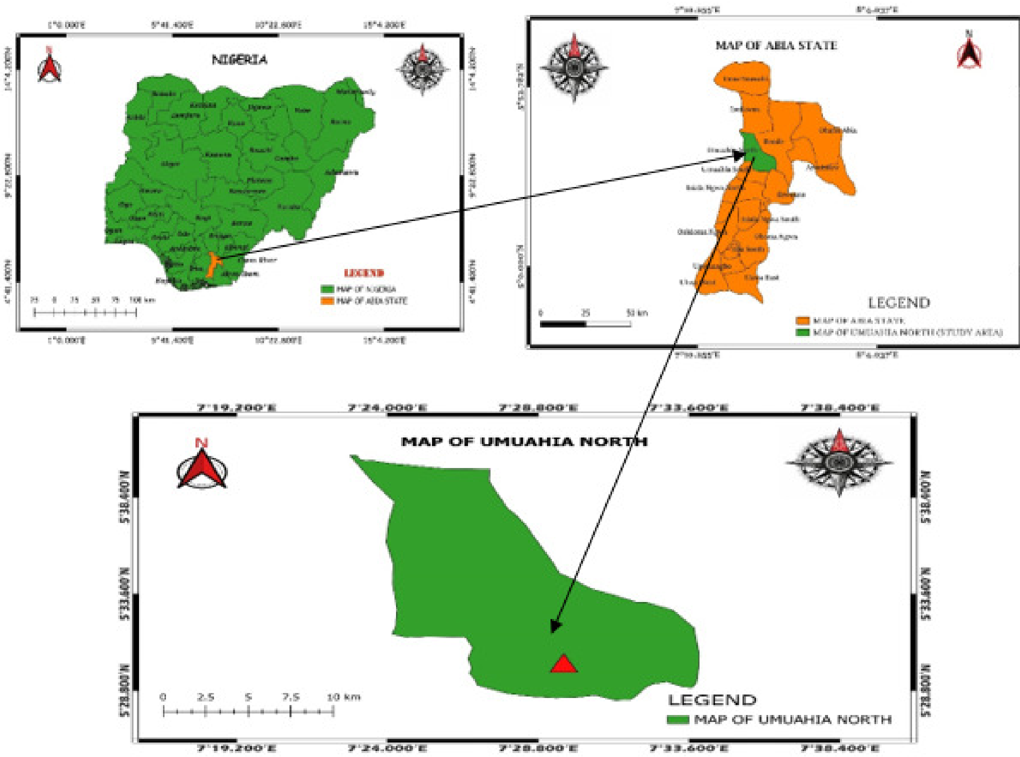

Figure 1: Abia State showing Umuahia North LGA

2.2. Materials

The different materials and the reagents used in this research include, weighting balance, petri dish, non-absorbent cotton wool, 70% ethanol, aluminum foils, test tubes, wire loops, incubators, microscope, nutrient agar, potato dextrose agar, mannitol salt agar, mackonkey agar, distilled water.

2.3. Methodology

Seven different species of wood were collected aseptically from Umuahia North timber market using a sterile polythene bag, well labelled and transported to the laboratory for analysis. This was done to avoid the introduction of microorganisms during handling and collection. Degraded parts from wood samples (based on visible symptoms such as discoloration, presence of fungal mycelium (growth) on the wood were halved out and put in sterilized polythene bags (sterilized by radiation) and closed and labelled based on guidance of experience wood taker. Hard and soft woods were identified and collected from three different spots while some identified medium wood samples were collected at a place Collection was done on only woods with symptoms (signs) of degradation.

3. RESULTS AND DISCUSSION

Table 1 shows the microbial load of the degraded wood samples for fungi and bacteria. The results showed that there were significant differences in the microorganism loads in the soft and hard woods degraded from bacterial load in 100 cm square of the hardwoods specimens. The bacterial load for hard wood was within the range of 1.37 $\times 10^4$ cfu/ 100cm^3 - 2.17 x 10^4 cfu/ 100 cm^3. The corresponding values for the soft wood specimen varied between 2.43 x 10^4cfu/ 100 cm^3 - 3.13 x10^4 cfu/ 100 cm^3 of the woods and the mean bacterial load of the moderately hardwood was an average of 2.3 x10^4 cfu/100 cm^3.

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Table 1: Microbial load (cf/100cm^3) of degraded wood samples

Sample	THBC ($x10^4$ cfu/100cm^3)	TFC ($x10^2$ cfu/100cm^3)
Cherry wood	1.53 x $10^4 \pm 2.51^e$	3.67 ± 1.15^c
Maple wood	2.17 x $10^4 \pm 1.15^{cd}$	5.00 x $10^2 \pm 1.00$
Mahogany	1.37 x $10^4 \pm 2.52^e$	6.00 x $10^2 \pm 1.00^{ab}$
Gmelina	2.30 x $10^4 \pm 1.73^{bcd}$	5.33 x $10^2 \pm 0.58$
Redwood	2.67 x $10^4 \pm 1.15^b$	6.33 x $10^2 \pm 1.15^{ab}$
Birch wood	2.43 x $10^4 \pm 3.05^{bc}$	7.67 x $10^2 \pm 1.53^a$
Cedar	3.13 x $10^4 \pm 4.51^a$	5.33 x $10^2 \pm 1.53$

Values shows mean of triplicate analysis ± standard deviation. Figures with different superscripts in the column are significantly different (P<0.05). TFC = Total Fungal Count, THBC = Total Heterotrophic Bacterial Count

Although there could be decomposition of wood due to weather as well as due to other microorganisms and insect pest, however, the abundance of bacteria in the degraded wood indicate possible significant contributions of bacteria in the degradation process of woods. It is known however that's some transient bacteria which may not be directly part of the causative agents of the wood spoilage maybe part of the inhabitants in the microbiome of the woods (Singh et al, 2015). Again, some saprophytic bacteria take advantage of rotting in degraded woods to settle and multiply thereby becoming part of the degraded wood environment. Table 1 equally showed that fungi load in the degraded wood samples were within the range of 3.67 x10^4 cfu/ 100 cm² - 7.67x10^4 cfu/ 100 cm² of the degraded wood .The range for the soft wood specimen show higher values 5.33 x10² cfu/ 100 cm² - 7.67x10² cfu/ 100 cm² than the hard wood specimen (3.67x10² - 6.0x10² cfu/ 100 cm²) .The moderately hardwood specimen recorded the same value (5.33 x 10² cfu/ 100 cm²) with some of the softwoods there were also significantly different at (p<0.05). The variations in the fungi load of the woods irrespective of been hard, moderate or soft wood types on the whole showed less fungi populations in the degraded woods than that of bacteria. Although it is known that bacteria proliferates and multiplies at a higher rate than fungi and may account for the differences recorded in their populations in the degraded wood (Singh et al, 2015). This may not be used as a direct determination of which was none pathogenic to wood.

The result of bacterial occurrence in Table 2 showed that many species of bacteria were found to be present in the degraded Wood specimen, however, there were differences in their respective prevalence as seen in their varied levels of occurrences. *Bacillus species* and *Staphylococcus species* were present in all the wood samples thus having a 100% occurrence in the samples. *Alcaligenes* were mostly found only in all the soft wood specimens, except for one hardwood harboring the organisms (57.14%). *Actinomyces* was present in all the softwood samples but absent in one of the three hardwood samples and recorded a general occurrence of (85 .71%) while *Pseudomonas species* were present in three of the test wood samples, two softwoods and one hardwood at 42.86. Only three of the five bacterial isolates (*Bacillus, Staphylococcus* and *Actimycetes*) were present in the moderately hardwood.

Table 2: Occurrence of bacterial isolates in woods

Sample	*Bacillus*	*Alcaligenes*	*Staphylococcus*	*Pseudomonas*	*Actinomycetes*
Cherry wood	+ve	+ve	+ve	-	-
Maple wood	+ve	-	+ve	-	+ve
Mahogany	+ve	-	+ve	+ve	+ve
Gmelina	+ve	-	+ve	-	+ve
Redwood	+ve	+ve	+ve	-	+ve
Birch wood	+ve	+ve	+ve	+ve	+ve
Cedar	+ve	+ve	+ve	+ve	+ve
Total	7	7	7	7	7
Number of occurrences	7	4	7	3	6
% occurrences	100%	57.4%	100%	42.86	85.71

Table 3 show the presence of the fungal species including yeast in the degraded wood specimens. The most prevalent fungi species in the degraded wood samples were *Aspergillus* and yeast with 100% occurrence respectively. *Trichoderma* species was present in all the degraded softwood samples as well as in the moderately hardwood. However, only one of the three hardwood samples had the organism, thus having a total occurrence of (71.43 %). *Fusarium* species had the least occurrence of 28.57% only in two soft wood samples. *Penicillium* species was found in all the softwood samples and the moderate hardwood and one only in hardwood with a total of (71.43%) occurrence. The mean occurrence of *Cladosporium spp* was 57.14% and was isolated only from two of soft and hardwoods but was absent in the moderately hardwood. Generally therefore there were differences in the relative occurrences of the different fungal isolate in the degraded woods. However, a trend was observed showing that the softwoods harbored more fungi species than the hardwoods and there were variations in their distribution pattern.

Table 3: Occurrence of fungi isolates in woods

Sample	*Trichoderma viride*	*Cladosparium spp*	*Fusarium*	*Penicillium*	*Aspergillus*	Yeast
Cherry wood	-	+ve	-	+ve	+ve	+ve
Maple wood	+ve	-	-	-	+ve	+ve
Mahogany	-	+ve	-	-	+ve	+ve
Gmelina	+ve	-	-	+ve	+ve	+ve
Redwood	+ve	+ve	+ve	+ve	+ve	+ve
Birch wood	+ve	-	+ve	+ve	+ve	+ve
Cedar	+ve	+ve	-	+ve	+ve	+ve
Total	7	7	7	7	7	7
Number of occurrences	5	4	2	5	7	7
% occurrences	71.43%	57.14%	28.57%	71.43%	100%	100%

4. CONCLUSION

Based on the results obtained in this study, it could be concluded that large populations of microorganisms (fungi as well as bacteria) inhabit the environment of woods causing their degradation. Many bacteria species were isolated from the different degraded wood specimens including *Staphylococcus, Bacillus, Pseudomonas* and *Actinomycetes* and at varying percentages of occurrences. Also, different species of fungi were also found in the degraded woods such as *Aspergillus Penicillium, Cladosporium, Trichoderma, fusarium* and yeasts. The large varieties of fungi and bacteria isolated from the wood specimen buttressed the high population of organisms in the wood samples. The abundance of microorganisms going by their high counts (loads) leads to the conclusion that these organisms (fungi and bacteria) may have contributed adequately to the degradation of wood in Umuahia timber market. The work further shows that more of microbial species of fungi and bacteria were isolated from softwood than in the hardwood, which suggests that there is higher susceptibility of softwood to spoilage than the hardwoods. Also, the variations in their pattern and distribution of the microorganisms show that some woods appear to be more resistant than others to microbial attack and eventual spoilage since none of the wood was treated with preservatives.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Akindahunsi, A.A. (2004). Physicochemical studies on African oil bean (*Pentaclethra macrophylla* Benth) seed. *Journal of Food, Agriculture and Environment,* 2(3-4), pp. 14-17.

Akintayo, E. T. (2004). Characteristic and composition of *Parkia biaglobbosa* and *Jatropha curcas* oil and seeds. *Bioresource Technology*, 92, pp. 307-310.

Akpan, U. G., Jimoh, A. and Mohammed, A. D. (2006). Extraction, characterization and modification of castor seed oil. *Leonardo Journal of Sciences,* 8, pp. 43-52.

Akubugwo I. E, Chinyere G. C. and Ugbogu A. E. (2008). Comparative studies on oils from some common plant seeds in Nigeria. *Pakistan Journal of Nutrition,* 7(4), pp. 570-573.

Al-Harbawy, A. W. and Al-Mallah, M. K. (2014). Production and Characterization of Biodiesel from seed oil of Castor (*Ricinus communis L.*) plants. *International Journal of Science and Technology,* 3(9), pp. 508-513.

AOCS (1990). *Official Methods of analysis of the American Oil Chemists' Society*, edited by Helrich, K., 15th ed., vol. 2, Association of official Analytical Chemists, Vergina, USA.

Aransiola, E. F., Daramola, M. O., Ojumu, T. V., AremuM. O., Layokun, S. K. and Solomon, B.O. (2012). Nigerian *Jatropha Curcas* Seeds Oil: Prospect for Biodiesel Production in Nigeria. *International Journal of Renewable Energy Research,* 2(2), pp. 83-89

ASTM (2008). *An Overview of ASTM D6751*: *Biodiesel Standards and Testing Methods*. Edited by Burton, R. Alternative Fuels Consortium, Central Carolina Community College Piedmont Biofuels, Carolina, USA.

Audu, T.O.K. Aluyor, E.O. Egualeona, S. and Momoh, S. S. (2013). Extraction and Characterization of *Chrysophyllum albidum* and *Luffa cylindrica* Seed Oils. *Petroleum Technology Development Journal,* 3(1), pp. 1-7

Aworanti, O.A. Agarry, S. E. and Ajani, A. O. (2012). A Laboratory Study of the Effect of Temperature on Densities and Viscosities of Binary and Ternary Blends of Soybean Oil, Soy Biodiesel and Petroleum Diesel Oil. *Advances in Chemical Engineering and Science,* 2, pp. 444-452.

Babu P. S. and Venkata R. M. (2012). Significance of biodiesel use as I.C. engine fuels. *International Journal of Advanced Engineering Research and Studies,* 1(2), pp.40-43.

Balogun, B.I. (2013). Evaluation of the Nutritional Potentials of Fermented Oil Beans Seed *Pentaclethra macrophyllah* Benth. *Production Agroculturer Technonlogy,* 9(2), pp. 73-87

Demirbas, A., (2009). Progress and recent trends in biodiesel fuels. *Energy Conversion and Management,* 50, pp. 14-34.

Ding, J., He, B. and Li, J. (2011) Biodiesel Production from Acidified Oils via Supercritical Methanol. *Energies*, 4, pp. 2212-2223.

Enujiugha, V. N. and Agbede, J. O. (2000). Nutritional and anti-nutritional characteristics of African oil bean (*penaclethra macrophylla*) seed. *Applied Tropical* Agriculture, 5, pp. 11-14.

Evwierhoma E. T. and Ekop I. E (2016). Extraction and Characterization of oils from local seeds. *International Journal of Scientific & Engineering Research*, 7(5), pp.1280-1294

Gonabad, M.A., Noghabi, M. S. and Niazmand, R. (2015). Evaluation of Extraction Percentage and Physicochemical Properties of Walnut Oil. *Journal of Applied Environmental and Biological Sciences,* 4, pp.74-82.

Igwenyi, I. O. Isiguzo, O. E. Aja, P. M. Ugwu Okechukwu, P. C. Ezeani N. N. and A.J. Uraku (2015). Proximate Composition, Mineral Content and Phytochemical Analysis of the African Oil Bean (*Pentaclethra macrophylla*) Seed. *American-Eurasian Journal of Agriculture and Environmental Science,* 15(9), pp.1873-1875.

Ikhuoria, E. U., Aiwonegbe, A. E., Okoli, P. and Idu, M. (2008).Characteristics and composition of African oil bean seed (*pentaclethra macrophylla* benth). *Journal of Applied sciences,* 8(7), pp.1337-1339.

Kazadi M., Kaaya, A. N., Kansiime, F., Tabuti, J. R.S. and B. Samvura (2011). Oil content and physicochemical characteristics of some wild oilseed plants from Kivu region Eastern Democratic Republic of Congo. *African Journal of Biotechnology,* 10(2), pp.189-195.

Ma, F., Clements, L. D., and Hanna, M. A. (1999). The effect of mixing on transesterification of beef tallow. *Bioresource Technology,* 69, pp. 289–93.

Mathiyazhagan, M., Ganapathi, A., Jaganath, B., Renganayaki, N. and Sasireka, N. (2011). Production of Biodiesel from Non-edible plant oils having high FFA content. *International Journal of Chemical and Environmental Engineering*, 2(2), pp.119-122

Meinshausen, M., Meinshausen, N., Hare, W., Raper, S. C. B., Frieler, K., Knutti, R., Frame, D. J. and Allen, M. R. (2009). Greenhouse gas emission targets for limiting global warming to 2°C. *Nature* 458, pp. 1158 – 1162

Moser, B.R. (2009). Biodiesel production, properties, and feedstocks. *In vitro Cell Development* 45, pp. 229-266

Nita I. and Geaca S. (2012). Study of density and viscosity for ternary mixtures biodiesel, diesel fuel, and bio-alcohols. *Ovidius University Annals of Chemistry,* 23(1), pp. 58-62

Okoye, E.I. (2016). Extraction, characterization and pharmaceutical screening of oil obtained from seeds of *Pentaclethra macrophylla* benth (African oil bean seed). *The Pharmaceutical and Chemical Journal,* 3(2), pp. 88-91

Prugh, W.R. (2007). The relationship between flash point and LFL with application to hydrid mixture. In: Proceedings of the 41st annual loss prevention symposium, American Institute of Chemical Engineers, April 22-26, Houston, Texas, USA.

Rukunudin, I.H., Whitea, P.J., Bern, C. J. and Bailey, T. B. (1998). A Modified Method for Determining Free Fatty Acids from Small Soybean Oil Sample Sizes. *Journal of American Oil and Chemical Society*, 75(5), pp. 563-568

Shridhar, B.S., Beena, K. V., Anita, M. V and Paramjeet, K. B. (2010). Optimization and Characterization of Castor Seed Oil. *Leonardo Journal of Sciences,* 17, pp. 59-70

Ugbogu O.C. and Akukwe A. R. (2009). The antimicrobial effect of oils from *Pentaclethra macrophylla* Bent, *Chrysophyllum albidum* G. Don and *Persea gratissima* Gaerth F on some local clinical bacteria isolates. *African Journal of Biotechnology,* 8(2), pp. 285-287

Van-Gerpen J., Shanks B., Pruszko R., Clements D. and Knothe G. (2004). *Biodiesel Analytical Methods*. NREL/SR-510-36240. Available electronically at http://www.osti.gov/bridge. Accessed on May, 2011

Wu, X. and Leung, D. Y. C. (2011). Optimization of biodiesel production from camelina oil using orthogonal experiment. *Applied Energy,* 88(11), pp. 3615-3624.