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Variation in Extractive content of some Freshwater and Mangrove Species in the Niger Delta, Nigeria

EMERHI E. A.
Delta State University, Department of Forestry and Wildlife, Asaba Campus, Abraka, Delta State, Nigeria
eaemerhi@yahoo.com.

Abstract

Extractives have significant impacts on wood utilization. They vary from species to species. This study was carried out to evaluate the variation in the extractive components of some selected tropical hardwood species in Nigerian mangrove and fresh water ecosystem. The species are *Rhizophora racemosa, R. harrisonii Avicennia africana and Langucularia racemosa* in the mangrove region and *Symphoia globulifera, Alstonia boonei and Anthostema aubryanum ,* in the fresh water ecosystem. *Wood s*amples and samples from their barks were collected from mangrove and fresh water forests and chemically analyzed to determine their extractive contents. The results indicated that the extractive content (E.C.) of the wood varied significantly with the species ($p < 0.01$). The overall mean value for all the species was 17.92%. The wood of the two red mangrove species (*R. racemosa and R. harrisonii*) had higher values of E. C. when compared with other wood species (*Laguncularia racemosa, Avicennia africana, Symphoia globulifera, Alstonia boonei and Anthostema aubreyanum*). The results also revealed some level of significant variations between the two forest types where the species were collected. The E. C. of both wood and bark varied amongst trees of the same diameter, and of different species. Heartwood's E. C. was 1.44 times more than that of sapwood. Bark and wood's E. C. decreased up the bole.

Keywords: Extractive Content, Mangrove species, Freshwater species, Variation, Age, Wood, Bark

Introduction

Nigeria's forest resources have been diminishing at a very fast rate due to poor management and human population pressures. According to the revised deforestation figures of FAO (2005), Nigeria has the world's highest deforestation rate of primary forests. The deforestation rate has been put at 3.4% annually and several authors have attempted to estimate what is left and they reported that less than 10% of this forest will be left by the end of this century (Fuwape et al, 2003, Adekunle, 2006). Meanwhile, wood requirement for all purpose will triple by the year 2020 (Mantau, 2005, FAO, 2006). In many countries, the demand for wood has already exceeded the local supply. To meet the demand for wood, more supply will have to come from new sources, such as the mangrove and fresh water ecosystems.

In Africa alone, the estimated total area covered by mangrove forest is over 60,000 km^2 (World Bank, 1995, Valiela, *et al*, 2001). The Niger Delta of Nigeria, where this study was carried out, had the most extensive concentration of the mangrove forest in Africa. The mangrove forest zone was estimated to cover between 70,000-10,000km^2 (Adegbehin, 1993 and Ogon, 2006). It is a fragile environment that is very sensitive to natural resource exploitation. In a report, World Bank (1995) estimated that about 10% of the Niger Delta mangroves had been lost due to deforestation from the oil exploration and exploitation activities of big multinational oil corporations. This ecosystem has also witnessed serious depletion owing primarily to the dependence of rural dwellers in the region on the forest and its resources for livelihood (Mmom, 2007). The mangrove forest is the only source of fuel wood, stake and pole, raw material for the production of fish traps, for boat carving, fishing, and shoreline protection.

Those substances that are extraneous components of the tree, and do not form an integral part of the cellular structure are commonly called extractives (Prestemon, 1994). Extractive components are “small” molecules that can be extracted with a solvent from wood, bark, or foliage. -Generally, extractives are present in small amounts. -Extractives vary tremendously within species, between species, and within trees. -There are thousands of different extractives present in wood. The chemical components of hard wood extractives are Fatty acids about 60-90%, while phenols and resins and some preservatives make up the remainder. If the mangrove species are to be used for the production of pulp and paper, it will be imperative to reduce the extractive content of the pulp wood in order to avoid shutdowns of operations and economic losses as suggested by (Taylor *et al.* 2002). A better understanding of how environmental factors influence heartwood extractive formation could lead to the development of silvicultural methods that enhance the production of naturally durable wood.

The wood extractives from mangroves are well known by the natives for its preservative qualities as it is used to preserve fishing nets. Trees contain a great variety of substances extractable with water or with neutral organic solvents, such as alcohol, benzene and ether. Although extractives are normally minor constituents in trees, interest in them is increasing. Not only are they of considerable value in understanding the biochemistry and taxonomy of trees, they also contribute to many of the properties of wood such as odour, colour, light-stability, decay and insect resistance (natural durability), strength, density, flammability, hygroscopicity, permeability, pulping and paper production, paintability and texture (Prestemon, 1994, Taylor *et al*, 2003,).

Wood is mainly composed of cellulose, hemicelluloses, lignin and extractives. The extractives include many different classes of organic compounds ranging in complexity from relatively simple molecules such as sugars and phenols to highly complex colouring matters such as tannins and resins (Gutiérrez *et al*, 1998). Silverio *et al.* (2008) noted that lipophilic wood extractives commonly referred to as pitch, are causing significant problems in pulp and paper industries. Therefore the removal of these extractives is of great concern to wood industries worldwide today.

In addition to the extractives formed normally, there are those that can be formed in the sapwood by injury, insect or fungal attack (Hillis, 1972). In the following species decay resistance have been found to be directly related to the amount of toxic extractive found; *Sequoia sempevirens,* (Orozco, 2008) Douglas fir, (Taylo*r et* al 2003, and 2007, Via, *et al*, 2007), *Populus tremuloides* (Fernandez, *et al*, 2002), *Eucalyptus gobulus* (Guiterrez and Romeroo, 1998) *Tectona grandis (* Moya and Berrocal, 2009) and Larch,(Harju, *et al* 2001). The quality of tannins present in mangrove species is directly related to the quantity of extractives in them: The average chemical content of wood has been given by Croan and Haight (2001), their values are: carbon 45 -50%, Oxygen 38 – 42%, Hydrogen 6 – 6.5% , Nitrogen 0.1 – 0.5% and sulphur with a maximum value of 0.05. Wood extractives can be divided into three subgroups: (i) terpenes and terpenoid, (ii) aliphatic compounds (mainly fats and waxes), and (iii) phenolic compounds. Extractives are primarily low molecular weight compounds that are soluble in neutral, nonpolar, organic solvents and cold water and are usually found in resin canals (Croan and Haight, 2001). Some extractives are toxic to bacteria, fungi, and termites, but other extractives give color and odor to wood (Croan and Haight, 2001)

Materials and Method

Wood samples for the study were collected from Olague Forest Reserve located on latitude 5^{o} $45^{'}$ North and longitude 5^{o} $10^{'}$ East in Delta State (site 1), and Stubbs Creek Forest Reserve (Fresh water swamp) located on Latitude 4^{o} $30^{'}$ North and Longitude 8 ^{o} $7^{'}$ East in Akwa Ibom State (site 2), all in the Niger Delta of Nigeria. Olague Forest Reserve has a 20km sea- face to the Bight of Benin, while Stubbs Creek Forest Reserve is about 45km to the Bight of Biafra.

The climate is equatorial with rainfall throughout the year but with well- defined wet and dry seasons. Although the dry season is nominally from November through April, there are heavy clouds and sporadic heavy rainfall in

November, March and April. The two driest months, December and January, coincide with the harmattan season. The day temperature fluctuates between a minimum of 22^{o}C and a maximum of 32^{o}C with little variation throughout the year. Relative humidity remains high at about 90% throughout the year, fluctuating diurnally but not markedly monthly (Anon, 1980, Bell-Gam, 1982).

Wood samples of *Rhizophora racemosa, R. harrisonii, Avicennia africana and Languncularia racemosa* were collected from the swamp forest in Olague Creek and those of *Symphoia globulifera, Alstonia boonei* and *Anthostema aubryanum* were collected from mangrove forest reserves in Stubbs Creek in the Niger Delta area of Nigeria. The wood samples from each tree were categorized into diameter classes (5-15, 15-30 and 30-40 cm) and one disc was collected from each class and labeled. The barks were removed, labeled and preserved fresh in polythene bags and transported to the Department of Forest Resources Management, University of Ibadan, Ibadan, Nigeria where all analyses were carried out.

With the aid of bench saws, the heartwood was separated from the sapwood. The bark, heartwood and sapwood of each sample were chipped separately into small particles and ground with a grinding machine to pass through a sieve. The hot water leaching extraction method was used in this study. The hot water extractive content was determined according to standard ASTM D1110-84 for freshly sawn wood.

Statistical Analysis of Data

Data was analysed using the Analysis of Variance (ANOVA) procedure for factorial experiment in completely randomized design. The main effects considered were those due to sites, species, size and positions (i.e. variation in the radial direction-heartwood, sapwood and bark) which constituted the four factors. In addition, the interaction effects between the main effects were considered.

Table 1: Species Selected for Preliminary Determination of Extractive content

Name of Species	Colour of Slash	Colour of Heartwood	Exudates
Anthostema aubryanum	Brown		A copious and caustic latex
Alstonia booneii	light brown with white	white and soft	exuding a copious white latex strands
Symphonia globulifera		reddish yellow	exuding a yellow gum
Laguncularia Racemosa	Yellowish		
Rhizophora racemosa	Reddish	reddish and very hard, close textured brittle and gummy	red exudates
Rhizophora harrisonii		Reddish	slightly red exudates
Avicennia africana	white heartwood	pale brown	

Results

The variation in the extractive content associated with species was statistically significant both for wood and bark. Species variation in E.C for wood was highly significant having a variance component of 39.23 percent. Differences in bark E.C. due to species were also significant with a variance component of 30.37 percent (Tables 2 and 3). A ranking of the means of the species for both wood and bark show that the mangrove species had higher extractive content than the fresh water species (Table 4). The mean for mangrove species was 27.7% for bark and 20.75% for wood. For fresh water species, the means for wood and bark were 22.68% and 16.6% respectively and the mean EC for the bark and wood of all the species were 25.58 and 18.99% respectively (Table 4). These values were significantly different at ($p<0.05$) as shown in the table and figures. The E.C of the bark of the mangrove species was 1.2 times more than that of the fresh water swamp species. For the wood EC, the value for mangrove species was also 1.25 times more than that of the fresh water swamp species.

The interaction effects of species x site, species x position and species x size (for bark) were highly significant at (p<0.05), showing that the patterns of variation in extractive content from pith to bark of the trees and in different sizes of trees were not the same in the two different sites. Trees of different sizes had different extractive content in both wood and bark. But there was no significant difference in the interactions among the three and four factors. The mean extractive values for wood were 24.80, 24.15 and 26.37 percent for the bark and diameter classes of 5-15, 15-25 and 25-35 respectively. Variations in E.C between species for different sizes were high but variation in E.C within each species for different sizes was low. The extractive contents within the sizes for each species were as follows: 1.23, 1.13, 1.13, 1.19, 1.3, 1.09, 1.29, for species: *Anthostema aubryanum, Alstonia boonei, Symphonia globulifera; Laguncularia racemosa, Rhizophora recemosa, Rhizophora harrisonii, Avicennia africana* respectively. But in all three tree size classes, the E.C was higher in the mangrove species than the fresh water swamp species.

The effect of positions (age of cambium) was very significant with a variance component of 14.66%. The heartwood extractive content was about 1.35 times more than the E.C of sapwood

Table 2: Analysis of variance for comparing the extractive content from the wood of the selected mangrove and fresh water swamp species

Source of Variation	DF	Some of Squares	Mean Square	F	Significance
Sites	1	18.923	18.923	26.466	*
Species	6	778.778	129.796	181.53	*
Sizes	2	64.935	32.468	45.41	*
Positions	1	515.149	515.149	720.49	*
Site x Species	6	34.352	5.725	8.01	*
Site x size	2	2.685	1.342	1.877	NS
Size x Position	1	4.499	4.499	6.292	*
Species x size	12	17.373	1.448	2.025	NS
Species x Position	6	44.021	7.337	10.261	*
Size x Position	2	2.784	1.392	1.947	NS
Site x Species x Size	12	9.270	0.772	1.079	NS
Site x Species x Position	6	1.590	0.265	0.370	NS
Site x size x Position	2	0.634	0.317	0.443	NS
Species x size x Position	12	13.078	1.090	1.524	NS
Spp x Sizes x Position x Sites	12	14.255	1.188	1.661	NS
Residual	12	8.582	0.715		
Total	95	1530.908			

**** Significant (P<0.05) NS – Not significant (P>0.05)***

Table 3: Analysis of variance for comparing the extractive content from the bark of mangrove and freshwater species.

Source of Variance	Sum of Squares	DF	Mean Square	F	Significance
Site	1	42.28	42.28	5.83	**
Species	6	319.943	53.32	7.35	***
Size	2	16.05	8.03	1.11	NS
Site x species	6	74.363	12.39	1.71	NS
Site x size	2	7.922	3.96	0.55	NS
Species x size	12	252.862	21.07	2.91	*
Spp x Size x Site	12	12.615	1.051	0.145	NS
Residual	12	86.999	7.25		
Total	53	815.043			

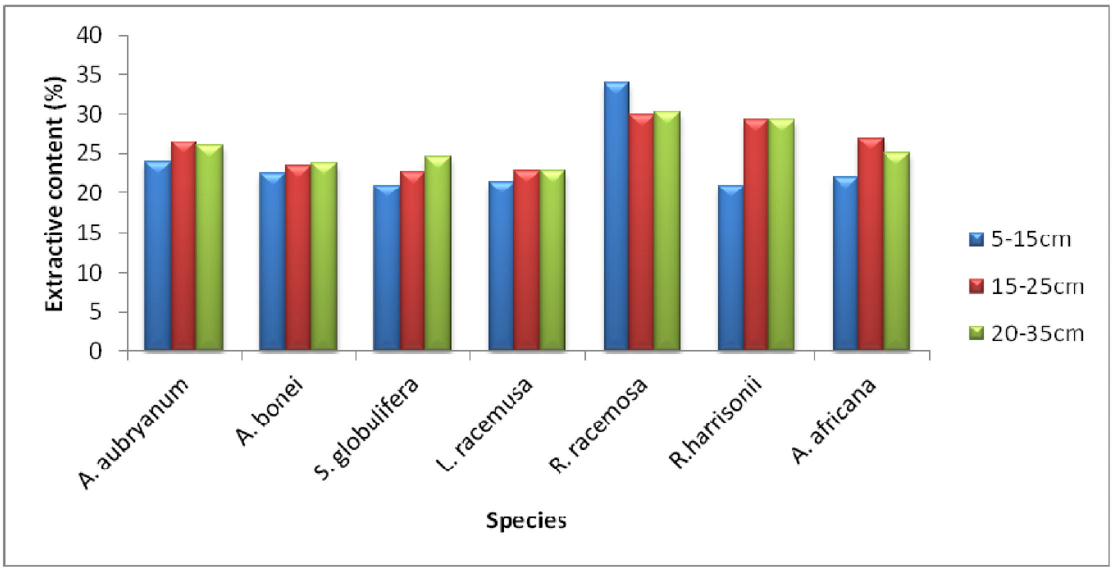

Fig. 1: Extractive content of Bark according to species and stem sizes

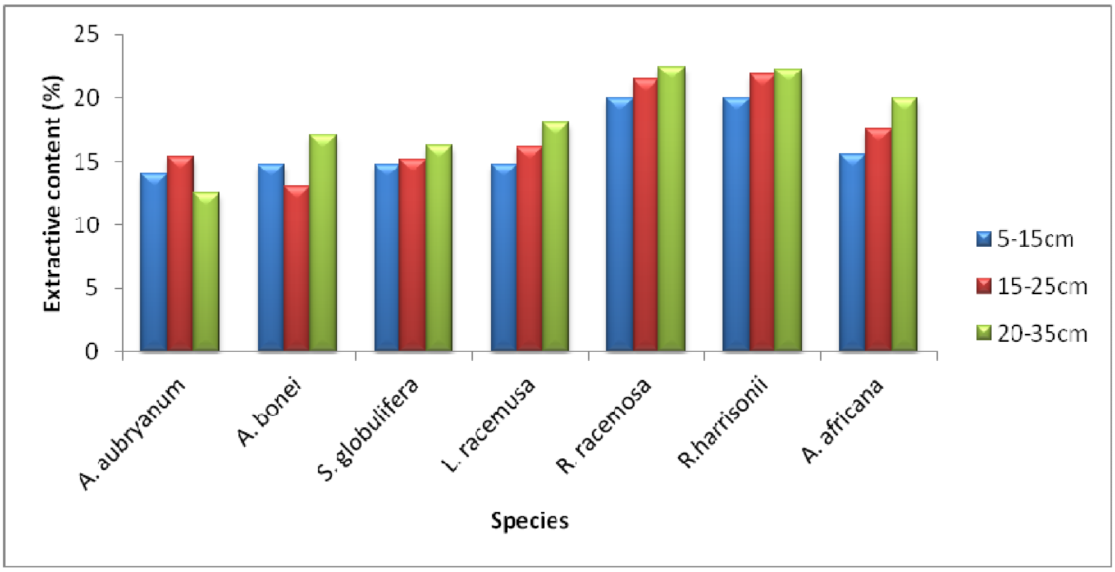

Fig.2: Extractive content of wood according to species and stem diameter

Table 4: Mean values of Extractive content of the Wood and Bark of the Selected Tree Species

Species	Bark	Wood	Remark
Rhizophora harrisonii	29.698	23.75	*
Rhizophora racemosa	28.795	23.35	*
Avicennia africana	26.278	18.8	*
Laguncularia racemosa	26.278	17.1	*
Symphonia globulifera	22.742	16.82	*
Alstonia boonei	22.723	16.68	*
Anthostema aubryamum	22.572	16.45	*
Mean for Mangrove Species	27.76	20.75	*
Mean for freshwater swamp species	22.68	16.65	*

* Significant ($P<0.05$)

Discussion

The mangrove species *R.harrisonii, R. racemosa* and *Avicennia africana* had higher extractive content than the fresh water swamp species. Between species variation in extractive content is of very high practical importance. This shows that different species have different extractive contents, and this can cause the woods from one group to have different wood quality from that of another. The amount of extractive formed in any species is controlled by the amount of carbohydrates and the ability of the enzymes present in particular cells to synthesize extractives (Nicholls, 1965). Therefore, it can be said that a greater proportion of between species variation in extractive contents was probably genetic, although other factors such as site, growth rate, etc can affect E.C. to some extent. The within tree extractive content variation observed in this study was significant at

0.01level agreeing with within tree variation in E.C of other species, e.g. *Eucalyptus camandulensis* (Suleman and Kauser, 1990), and in the wood of Black Locust (Robinia pseudoacacia) (Stringer and Olson, 1987 and Magell *et al* 1994). Such difference in properties between the top and bottom segments of the tree should disseminate an important point: the tree is a 3-dimensional structure with different multivariate properties in the vertical versus the radial direction. As a result, it may be incorrect to label the first few rings from the pith for upper part of the stem as juvenile wood. This is because the micro fibril angle and extractive content were lower in this location than the core section of the butt log (Tables 2–4). Burdon *et al.* (2004) recently addressed this issue and recommended that the upper part of the stem should not be classified as juvenile wood and instead developed a 2-dimensional categorization scheme and, as such, it is recommended that juvenile wood should not be defined solely on the radial demarcation point of any one individual trait. Instead, one should consider the interaction of tree height by ring number (position in the radial direction) and its effect on multiple traits when defining juvenile wood.

Conclusion

This study examined the extractive content of some tropical hardwood species from mangrove and rainforest ecosystem. The extractive contents were studied according to sites, species, plants' parts (wood and bark) and diameter sizes. The results revealed a significant difference in the amount of extractives in the species. Extractive content was also discovered to vary according to plant parts (with higher composition in the bark than wood stem) and stem diameters. Further work could be done on the chromatographic study of the mangrove trees extractive content to see if it can be extracted for other industrial purposes before the wood is used for pulp and paper.

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