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Assessment of Quantity and Typology of Wood Species Used in the Production of Charcoal in Kaduna, Nigeria

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Abstract: *Traditional fuel in the form of firewood and charcoal has been, and is still the predominant source of energy for domestic cooking in sub-Saharan Africa. However, charcoal burning is associated with deforestation. The research assessed the quantity and typology of wood species used in the production of charcoal in Kaduna State, Nigeria. Purposive sampling was used to select Kajuru, Kachia and Chikun local government areas. Tree parameters (diameter at bottom middle and top) were used to determine wood volume while displacement method was used to determined charcoal volume. Research shows that Prosopis africana has the highest mean while Dialium guinees has lowest mean. A simple linear regression analysis was used to determine the relationship between wood volume of the species and the yield of charcoal (kg). The results showed a significant relationship between wood volume and the yield of charcoal for all species with exception of D. guinees with (R^2 =0.334), (P=0.103). The conversion efficiency of the studied species ranged from 75.45 to 39.92%. the finding of the study reveal that P. Africana, Azadrachta indica, and Anogeissus leocarpus tree species were threaten by charcoal production due to the quantum of yield extracted.*

Keywords: *charcoal, typology, regression, volume, displacement, Kaduna State, Nigeria.*

Introduction

The growing demand of charcoal derived high wood extraction rate over increasing area of forest (Müller, Michaelowa, & Eschman, 2011). Nigeria ranks among the countries with the highest deforestation rates in the world (Jonathan *et al*., 2013). Despite the current ban on timber and charcoal trade, there was rampant exploitation taking place. At this rate, experts warn, the country would lose all its forests by 2047. And a prime reason for this is Nigeria's growing appetite for charcoal-a cheap source of energy produced through pyrolysis, or burning of wood under high temperature in the absence of air (Goswami, 2018).

Consumption of traditional fuels has negative environmental, economic and health impacts. Increased use of firewood and charcoal leads to deforestation, leading to environmental imbalance, and increased use of agricultural residues and animal dung for heating deprives the land of important nutrients that are necessary for soil fertility. Furthermore, smoke from the use of fuel wood and dung for cooking contributes to acute respiratory infections (Gamtessa, 2011).

Charcoal is the dark grey residue consisting of impure carbon obtained from vegetation substance, and is produced by slow pyrolysis, the heating of wood or other substances in the absence of oxygen (World Bank, 2018). FAO (2017) sees charcoal as a soft, brittle, lightweight, black, and porous material that resembles coal. Charcoal burning is probably the oldest chemical process known to man. Commercial charcoal is found in either lump, briquette or extruded forms (Brieland, 2015). The lump charcoal which is the commonest is made directly from hardwood material and usually produces far less ash than briquette. Briquettes are made by compressing charcoal, typically made from sawdust and other wood by-products. Extruded charcoal is made by extruding either raw ground wood or carbonized wood into logs without the use of a binder.

Collection of wood for charcoal production play tremendous changes to species structure and composition of the forest. Species diversity is significantly fewer in harvested than undisturbed area. Only wide spread species are regenerating capable of replenishing the existing population. The rare species, precisely larger softwood, fewer hard wood and fruit trees will deficiently cover up the population (Tee, Ancha, & Asue, 2009).

A number of literatures have dwelt on the various uses of charcoal for various purposes, beside its household use in cooking and boiling (FAO, 2017; Brieland, 2015; and World Bank 2018). In addition to these, Timothy (2013) stressed that distinct uses of charcoal make it unique as household fuel that is charcoal is cleaner, easier, and less smoky and smelling than other biomass fuels. Conversion of wood into charcoal reduces its weight, and makes it easier and cheaper for transportation. It can also be used in smaller quantities, with cheap burning devices for domestic applications. The calorific value of charcoal primarily depends on its quality, amount of water, volatility and ash content. Charcoal commonly used for domestic purposes have a net calorific value of 28Mj/kg. This net energy value is roughly twice as much as air dried fuelwood. This big difference makes charcoal cheaper to transport over a longer distance compared to fuelwood, (Mapesa *et al*., 2013).

Materials and methods

Kaduna State (7°25'E longitude, 10°31'N latitude) which is located in the northern part of Nigeria, occupies 48,473.2 km^2 and has a projected population of over 6.1 million, over 80% of them were involved in agriculture (Olujimi and Ogunsey, 2016).

Sampling Procedure

The research purposively selected Kajuru, Kachia and Chikun Local Governments Area of Kaduna state. The local governments were purposively selected due to their forest potentials that support charcoal production.

Data Collection

Data were collected through field enumeration and measurement of tree parameters (diameter at base, middle and top) to determined wood volume, while burning of wood samples at various production centres was done to determine the volume of charcoal product using displacement method together with the species of trees used.

Data Analysis

Data were analyzed using descriptive statistics (frequencies and percentages), Volume of charcoal produced per species was achieved using mean and standard error, and linear regression was employed to test the relationship between wood volume and charcoal volume.

RESULTS AND DISCUSSION

Volume of charcoal produce per species in the study area

Average value obtained by species from the study area were computed and it was discovered that *P. Africana* (0.090) *and A leocarpus* (0.080) give better yield in charcoal production, this conformed with the reports of (Pastor-Villegas et al., 2006 & Liza et al., 2018). According to (Garedew & Simon, 2018), the quantum of yield defend on the specie used as well the environmental factor charcoal (moisture content, volatile matter, ash content and duration time).

Table 1: Volume of charcoal produce per species from the study area

Species	Volume of charcoal produced (m^3/Kg) Means ± Standard Error
Prosopis africana	0.090±0.012
Vitellaria paradoxa	0.068±0.006
Detarium microcarpum	0.064±0.023
Anogeissus leiocarpus	0.080±0.023
Mangifera indica	0.067±0.006
Dialium guineese	0.062±0.008
Parkia biglobosa	0.067±0.006
Azadrachta indica	0.080±0.009

Source: Survey

Relationship between wood volume and charcoal volume produced

A simple linear regression analysis was used to establish relationships between wood volume and charcoal yield (kg/m^3) of the studied species. The results showed a significant relationship between the wood volume and the charcoal yield for *A. leiocarpus*, *M. indica* (R^2=0.797), *P. biglobosa* (R^2=0.796) and *A.* indica (R^2=0.756). Conversely *D. guinees* (R^2=0.334) showed non-significant relationships. Misginna & Rajabu (2013), investigated whether was there a relationship between charcoal yield and wood density of the studied species. Their findings revealed that there was no significant relationship between wood density and charcoal yield. The results of this study revealed that *Anogeissus leiocarpus had* the highest charcoal yield of 38.80% among the three species. The highest yield recorded by *P. africana* could be due to the higher wood density of *P. africana* as compared to other species. It was reported by (Menemencioglu, 2014) that, high-density wood species were reported to give more charcoal than low-density wood species. Furthermore, Charcoal yield and quality is related to tree species and some raw material characteristics such as size, wood sections, physical properties, and proportion of chemical components (Menemencioglu, 2014). According to Girard, (2002) genetic characteristics of species such as; basic density and chemical composition of wood, especially high contents of lignin and low contents of extractives are the properties that had more influence on charcoal yield.

Table 2: Relationship between wood volume and charcoal volume obtained

Species	A	B	R^2	R	S.E	Sig
Prosopis africana	0.002	0.078	0.429	0.574	0.0217	0.005
Vitellaria paradoxa	-0.012	0.093	0.564	0.751	0.0131	0.012
Detarium microcarpum	-0.111	0.211	0.636	0.797	0.0140	0.001
Anogeissus leiocarpus	-0.332	0.404	0.997	0.999	0.0031	0.034
Mangifera indica	-0.090	0.184	0.797	0.893	0.0171	0.001
Dialium guineese	-0.039	0.121	0.334	0.058	0.2119	0.103*
Parkia biglobosa	-0.134	0.238	0.796	0.892	0.0109	0.000
Azadrachta indica	0.085	0.187	0.758	0.871	0.1461	0.000

* indicates a significant linear relationship at (P<0.05). R=correlation coefficient, R^2 =coefficient of determination, SEE = standard error of estimate, F-value = significance of F-test

Conclusion and Recommendations

Conclusively, the research shows that charcoal production is now widespread and the commodity is sold along most roads in Kaduna state, signaling that more forests are being, and will continue to be, affected until there is a deliberate policy shift.

It was discovered that certain trees species especially *Prosopis*, *Vitalleria* and *Deterium* species are most widely use species in the study area due to the high quality charcoal produced from such species couple with good conversion efficiency. The amount of pressure exerted on these tree species cannot be over emphasized due to the number of volume exploited day in day out, of which if proper management practice is not taking could eventually lead to threat.

Availability of plant materials in the area and choice of species for charcoal production is based on the quality of the wood. The environmental degradation concerns the irreversible extinction of biodiversity and the decline of reproduction potential of ligneous resources, pasturage, and soil fertility. It is important to embargos the exploitation of wild species for charcoal production into the reforestation plans, especially multi- purpose species that are already considered to be endangered locally.

The result of investigation revealed that the plant diversity in the study area was progressively being depleted. While the majority of the communities, entirely depends for their daily livelihood on the local environmental resources. Thus, conservation and sustainable utilization of these resources are crucial. Therefore, in order to alleviate the challenges, it may better to take the following measures:

- It is recommended that further studies should be carried out to provide more information on number of producers as well as the quantum of yield and species of trees used for charcoal production from the state.
- There should be aggressive campaign on regulating the impact of forest trees destruction for charcoal production especially from *P. Africana and A. leocarpus*.
- The quantum of yield produce from the study area suggest that expansion of alternative energy source to reduce dependency on charcoal should be provided.

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