Original Article

Combustion Rate of Ten Wood Fuel tree Species in Bauchi State

Wakili, A[1]., Abdullahi. M. B[2]., Gani, A. M[2] . and Bello, A. A[3].

[1] Forestry department, College of Agriculture, Bauchi, Bauchi State-Nigeria
[2] Biological Sciences Programme Abubakar Tafawa Balewa University Bauchi,Bauchi State,Nigeria
[3] Production/Mechanical Engineering programme, A T B U Bauchi, Bauchi State, Nigeria.

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ABSTRACT

Identification of major tree species used as wood fuel was carried out in six randomly selected Local Government Areas (LGAs), two from each of the three ecological zones of Bauchi state. These LGAs are Bogoro and Toro from Northern Guinea Savannah, Bauchi and Alkaleri from sudan savannah and , Giade and Katagum from sahel savannah zone. A quadrant of two hectares was laid in wood fuel collection center in the affected LGAs. The moisture content and combustion rate of the ten most frequent wood fuel tree species were determined. The result for the analysis of variance shows that the moisture content of the species at the time of the determination of combustion rate was the same. The highest temperature of 520 °C was recorded for *Combretum glutinosum* during combustion within 8 minutes and lowest temperature of 230 °C was recorded for *Pterocarpus erinaceus* for the same period. *Terminalia glaucescens* maintained temperature 100 °C for the longest period of 30 minutes and *Pterocarpus erinaceus* maintained temperature above 100 °C for only 8 minutes. Due to their natural features of maintaining heat for a considerable period of time, wood fuel users were advised to be making use of tree species which have good combustion properties. To guard against extinction of these ecologically important species, massive production and planting by government and individuals were recommended among others.

Key words: Wood fuel species-Moisture content-Combustion rate

Corresponding Author: adamuwakili1@gmail.com

INTRODUCTION

Forest is a storehouse for food and feed, ameliorator of weather and a primary source of renewable energy for some industrial and domestic uses. Bio fuel is a major source of energy in rural areas of Nigeria aside from energy of animal and human sources. Cooking and most food processing are dependent on wood fuel. Indirectly, therefore, wood fuel supplies affect the stability and quality of food supplies (Wak ili,2008). The non sustainable wood fuel extraction and as well as expansion for urban development have made one third of Nigerian estimated 96 million hectares of forest cover vulnerable to deforestation (FEPA, 1992). The trend of deforestation due to increased demand for fuel wood and consequent exploitation of the vegetation tends to be escalating on daily basis without knowing the specific species that are suppose to be utilized and those which possesses the combustion ability of gradual release of the energy content of the wood to enhance cooking and heating. The better the combustion ability of wood, the lesser the amount of the same quantity of wood required to carry out a heating and cooking exercises.

It was highlighted by Wakili. and Abdullahi (2010), that since cutting of trees and collection of wood fuel entails little or no financial implication, it is likely to remain the dominant source of fuel for rural and semi urban communities for more years to come.

The indiscriminate felling of trees for wood fuel results in deforestation leading to the disappearance of valuable species of trees that have little combustion value and its attendant environmental degradation (desertification, erosion, flood, soil infertility, decline in water table, drought, extinction of both flora and fauna species). It is in line with these threats; this research intends to evaluate the combustion rate of the ten most common wood fuel tree species in Bauchi state with a view to identifying the most efficient tree species in terms of the rate at which the calories content of the wood are released as energy. The result of this work is expected to serve as a guide for energy plantation project in Nigeria and beyond, and a means of reducing indiscriminate felling of environmentally friendly tree species but with poor combustion rate.

MATERIALS AND METHODS

Study area

Bauchi state has a land area of 49,259.01 km2 with a population of 4.6 million people and located between latitude 90° 30^1 and 12° 30^1 North of the equator and longitude 80° $50^1$and 11° east of the green wich meridian. The state has a typical tropical climate marked clearly by the dry and rain seasons. The average annual rain fall is 700mm in the northern parts and 1300mm in the southern parts. The wettest months are July; August and September, dry season starts in November and ends in April, this is a period of harmattan, when the dust loaded North East trade wind from Sahara desert has a marked drying effect on the vegetation and the general climate of the state. Bauchi state is one the state in northern part of Nigeria that span three distinct vegetation zones, namely, the Northern Guinea Savannah, Sudan Savannah and Sahel Savannah with Sudan Savannah dominating. Northern Guinea Savannah become manifest as one moves along a belt that stretches from extreme western part of the state to the extreme southern part covering Local Government Areas of Toro, Tafawa Balewa, Dass and Bogoro.

The Sudan Savannah type of vegetation covers six LGAs of Ningi, Warji, Darazo, kirfi, Alkaleri and Bauchi. The Sahel zone also known as semi desert type, becomes manifest on the middle of the state

as one moves from south to the north. The character vegetation of the zone is isolated stance of thorny shrubs interspersed by short trees (Bauchi state official diary, 2008).

Procedures for data collection

In order to identify representatives of woody tree species used for wood *fuel*, in Bauchi state, two local government areas (LGAs) were randomly selected from each of the three ecological zones; Northern Guinea savannah, Sudan savannah and Sahel Savannah.

In each of the six randomly selected LGAs, quadrants of two hectares were laid in an area identified as the major center for the collection of wood fuel. The LGAs randomly selected were katagum and Giade from sahel zone, Bauchi and Alkaleri from Sudan savannah zone, and Bogoro and Toro from Northern Guinea savannah zone. Katagum and Giade LGAs have madara and kurba forest reserves, respectively as major center for collection of wood fuel. Bauchi and Alkaleri LGAs had kumbuli and Gwaram communal forest, respectively while Toro and Bogoro had tatu forest reserve and Gwabbiya forest as the wood fuel collection centers.

In each of the quadrant, wood fuel tree species were identified with the help of texts (Hutchinson and Dalziel, 1954, Keay *et. al.*, 1964).

Determination of combustion rate of wood fuel

The equipments used were: Pyrometer, stopwatch, thermocouple, thermometer, crucible vice, hammer chisel and weighing balance.30 gram of fuel wood sample was weighed and burnt. The combustion was initiated by addition of little kerosene. The temperature of the burning sample was taken at every two minutes intervals until it completely burn.

Determination of moisture content

The moisture content of wood samples was determined with an electric oven (DHD9101). Other equipment used was: digital weighing machine, wet and dry bulb thermometers. Wood fuel samples were weighed and dried in an oven between one to four hours at 105°C and repeatedly weighed until uniform weight was attained. The moisture content was determined in accordance with ASTM-D143 (1982)

RESULTS AND DICUSSION

Moisture content of ten most frequent Wood fuel tree species in Bauchi state

The moisture content of ten most frequent wood fuel tree species as at the time of the determination of combustion rate ranges from 3.14% to 4.04%(Table 1).This shows that the wood samples contains little moisture at the time of the test compared to the combustible percentage moisture of 15% (Akpan *et al.,* 2007). The higher the moisture content of wood the lesser the energy output because moisture content of wood is the major determinant of its combustion rate (Wakili *et al.*,2009).From this test, *Prosopis africana* had the highest moisture content (4.04%) and followed by *Pterocarpus erinaceus* (3.95%), while *Combretum molle* had the less moisture content(3.14%) as evident in table 1. However, the result for analysis of variance indicated there were no significant differences among the values signifying that there will be no much difference in their temperature output.

Combustion rate of ten most frequent wood fuel species in Bauchi state

Combustion rates of ten most frequent wood fuel tree species are presented in Table 2. The burning trend showed that temperature from the peak gradually dropped closed to room temperature over time because of the residual heat of the ash and the wood sample maintained their

shapes even in the ash form. The temperature of the burnt samples were influenced by the density and specific gravity of the wood at the time of the test, because, these parameters expressed how much wood substance is present in a given volume of wood (Zobel and Van Bujitenen, 1989).

Table 1: The moisture content of ten most frequent wood fuel tree species as at the time of the determination of combustion rate from six LGAs of Bauchi State

Wood species	Moisture content (%)
Pterocarpus erinaceus (Madobiya)	3.95
Prosopis africana (Kirya)	4.04
Terminalia glaucescens (Baushe)	3.83
Anogeisus leiocarpus (Marke)	3.78
Balanites egyptiaca (Aduwa)	3.81
Vitellaria paradoxum (Tabo)	3.51
Combretum hypopilinum (Farin ganye)	3.47
Combretum glutinosum(Jan faringanye)	3.41
Combretum molle (Wuyan damo)	3.14
Acacia hebecladoeids (Bakar kaya)	3.42

Not significant (P>0.05)

Most wood burns relatively easily, though the wood of some species (e.g species of *syncapia*) is fire retardant and will not burn except in hot fire in mixture with more flammable woods. Other woods, while they burn readily, may not be suitable because of excessive spark production or odorous, toxic or irritating smoke. The wood of *Sesbania grandiflora* for example is not highly regarded as fuel because of excessive smoke it produces while burning, *Prosopis africana* produces excessive spark and *Terminalia glaucescens* excessive smoke when burning (FAO,1994).The importance of these factors for domestic wood fuel use depends on the type of stove used, cooking method and adequacy of ventilation. Local preferences may also be important depending on the effect of the wood fuel on the flavor of the cooked food (Kataki and Konwer,2002).

As different wood possesses varied burning properties, so also the tested wood samples differ in the intensity and duration of temperature;

Species A showed the combustion rate of *Pterocarpus erinaceus (Madobiya)*. It attained the temperature of about 290°C in less than 6 minutes then gradually falls to about 45° C in 18 minutes. It can sustain a temperature above 100 °C for a period of about 8 minutes.

Species B showed the combustion rate of *Prosopis africana* (Kirya) that attained a temperature of about 340° C in less than 14 minutes. The temperature gradually fell to 80 °C in 22minutes. It can sustain a temperature above 100 °C for a period of about 18 minutes.

Species C indicated the combustion rate of *Terminalia glaucescens* (Baushe).It attained a temperature of 350° C in 8 minutes, which gradually dropped to 18 .

Species D represented combustion rate of *Acacia hebecladoeids* (Bakar kaya). It attained a temperature of 335° C in 10 minutes, the temperature gradually dropped to 11 °C in 26 minutes. A temperature above

100 °C can be sustained for a period of 24 minutes.

Species E showed the combustion rate of *Anogeisus leiocarpus* (Marke). The temperature reaches 335°C in 8 minutes and gradually dropped to 105°C in 26 minutes. It maintained a temperature above 100°C for a period of 24 minutes.

Species F showed the combustion rate of *Balanites egyptiaca* (Aduwa). It attained temperature of 500°C in 8 minutes and gradually fell to 100^0C in 28 minutes. Temperature above 100^0C can be maintained for a period of 24 minutes.

Species G showed the combustion rate of *Vitellaria paradoxum* (Tabo). It attained a maximum temperature of 440°C in 8 minutes. The temperature gradually fell to 95°C in 26 minutes. Temperature above 100°C can therefore be maintained for a period of 22 minutes.

Species H showed combustion rate of *Combretum glutinosum* (Farin Ganye). It attained a maximum temperature of 520°C in 8 minutes gradually dropped to 65°C in 18 minutes Temperature above 100 ^{0}C can be maintained for a period of 14 minutes . .

Species I showed the combustion rate of *Combretum hypopilinum* (Jan farin ganye). It attained a temperature of 415°C in 12 minutes. It gradually fell to 80°C in 28 minutes. This showed that temperature above 100^0C can be maintained for a period of 22 minutes.

Species J showed the combustion rate of *Combretum molle* (Wuyan Damo). It attained a maximum temperature of 335°C in 8 minutes and gradually dropped to 55°C in 18 minutes. Temperature above 100^0C can be maintained for a period of 14 minutes.

Table 2: Combustion rate of ten most common wood fuel tree species from six LGAs in Bauchi state

	TEMPERATURE (C)									
TIME (mins)	SPEC A	SPEC B	SPEC C	SPEC D	SPEC E	SPEC F	SPEC G	SPEC H	SPEC I	SPEC J
0	32	32	32	32	32	30	30	30	32	30
2	65	40	88	90	60	98	75	85	90	90
4	290	120	208	190	230	210	180	180	150	330
6	280	270	340	330	300	410	300	340	270	340
8	230	325	350	335	335	500	440	520	320	335
10	200	340	345	335	325	425	400	410	370	335
12	95	340	340	330	310	360	350	320	415	280
14	50	260	340	310	310	310	310	185	370	210
16	45	210	335	290	285	290	280	121	345	140
18		160	335	250	260	270	240	65	335	55
20		115	335	170	240	240	215		330	
22		80	330	140	190	200	180		280	
24			320	120	125	170	150		250	
26			290	110	105	130	95		150	
28			250			100			80	
30			220							
32			170							
34			80							

CONCLUSION AND RECOMMENDATION

The combustion test was conducted in a form of open fire under indoor condition. After ignition, the wood samples were allowed to flame until completely burnt into ash. The test was conducted for the ten most frequent wood fuel tree species from six LGAs in Bauchi State.

The test indicated that the burning trend followed similar pattern of starting with low temperature to the peak temperature through time as reported by Kyauta (2006). The temperature from the peak gradually dropped close to room temperature over time because of the residual heat of the ash and the wood samples maintained their shape even in the ash form.

Majority of the species: *Combretum hypopilinum, Vitellaria* p*aradoxum, Balanites egyptiaca, Anogeisu*s *leiocarpus, Acacia hebecladoeids* and *Teminalia glaucescens* can sustain temperature above 100^0C for comparatively longer period of more than 20 minutes. These species, which are also high yielding and fast growing, could be good for energy plantation (Dean, 1998).

These species when made to be the major components of energy plantation projects would drastically reduce the amount of wood utilization because of their natural ability to maintain heat for a considerable period of time. This special feature can reduce the rate of forest destruction and there by improving its productivity and enhance proper management of the environment.

There is an urgent need to enlighten wood fuel users on the economic importance of using tree species of better combustion properties. This is because not much quantity of such wood is needed to carry out a cooking or heating exercise. Using such higher combustion rates species would reduce the amount of money being spent on fuel wood there by redirecting such funds for other uses. However, to guard against extinction of these ecologically important species, there is the need for massive production of these species by silvicultural specialist and be made available at little or no cost to wood lots developers and should as well be encouraged to raise these important tree species through a well-coordinated extension services.

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