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Fire extinguishing strength of the combustion product of wood saw dust (ash)

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ABSTRACT: Forty saw dust samples from four mature hard wood plants grown in southwestern part of Nigeria were analyzed for their ash contents, moisture contents, metallic contents and hence the fire extinguishing strength of the saw dust ash by classical and instrumental methods of analyses. Mahogany (Khaya ivorensis) wood saw dust ash had the highest mean metallic content (5.989±2.51ppm) followed by Opepe (Sarcocephalus latifolius) , 4.704±0.21ppm while Poro poro (Sorghum bicolour) wood ash had the least metallic content(1.611±0.48ppm). Mahogany also had the highest mean moisture content (2.6615±0.64) while Opepe had the least moisture content (0.9362±0.45). The fire extinguishing strength of Mahogany was the highest, and had a positive correlation with its metallic content as depicted by their correlation coefficient (0.850). Poro poro had the least fire extinguishing strength. The comparison of the extinguishing strength of wood saw dust samples and the commonly used ABC fire extinguisher showed that ABC fire extinguisher has more extinguishing strength than the wood saw dust ash. Hence, improvement on the extinguishing strength of the saw dust ash is necessary. © JASEM

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INTRODUCTION

Fire incident is a recurring problem worldwide. Yearly, cases of fire incidents are reported in different countries. The initiation and growth of fire is determined by a multitude of factors including the type of fuel(caloric value), fuel load, fuel size (area), oxygen content in the flame, wind speed, and whether the fire is within an open or enclosed space.

In the case of polymer composites exposed to fire, the material itself can be a rich source of fuel that causes the temperature to rise and the flame to spread (Mouritz and Gibson, 2006).

According to reports, residents of Ojoo Area of Ibadan, Nigeria watched helplessly as fire from an oil tanker burnt their loved ones to ashes. In a similar development, the Central Bank of Nigeria building situated in the heart of Yenagoa, the capital of Bayelsa State, Nigeria was gutted by fire on July 1, 2011. The damage to the building was estimated at millions of naira (Mann, 2012). Fire outbreaks in residential and commercial buildings have become a common occurrence in Nigeria, worsened by the rising insurgency of the Boko Haram terrorist group in the northern part of Nigeria.

In the United States of America alone, between 1996 and 2005, an average of 3,932 human loss and another 20,919 injuries (excluding the events of September 11, 2001) were reported annually as a result of fire accidents (National fire protection association, 2008). The story is not different in Canada, Switzerland to mention but a few. These, amount to huge economic and sociological casualties every year.

Most of the flame retardants and fire extinguishers currently in use are expensive and are not easily affordable by some individuals even for home applications. Besides the cost implication, most of the flame retarding and extinguishing materials have post impact, either environmental or aesthetics. For example, the polyhalogenated diphenyl ethers, the commonly used halogen flame retardants, produce highly toxic dioxins, furans, acidic and corrosive fumes during non flaming thermal decomposition (Horrocks and Price,2001; Zaikov and Lomankin, 2002). These toxic by- products may contaminate living organisms from whale bladder to dolphins to human blood. They could also be present in household dust and sludge (Lomakin and Zaikov, 2003).

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The CO_2 fire extinguisher which contains highly pressurized carbon dioxide, does not leave a harmful residue, but it has no post fire security, meaning that if it is not able to displace enough oxygen, the fire could re-ignite (Anusol R-102, 2013) The existing fire extinguishers obviously have one shortfall or the other. Therefore, a fire fighting system that is inexpensive and environmentally friendly is a necessity. This investigation sought to evaluate ashes from wood saw dusts from some common tropical trees grown in the rain forest zone of the southwestern part of Nigeria.

Literature review: Wood has a wide range of excellent physical and mechanical properties (Tuula *et al.*, 2005). It is made of 50% cellulose and burns naturally if exposed to severe fire conditions, constituting a serious fire hazard (Akpabio and Jauro, 2002).

Sawdust , a by-product of the process of cutting wood or timber either with a saw or other cutting machines burns faster than the solid wood because of its fine particle composition. As a result of its combustibility properties it is mostly regarded as a fuel with little or no anti-combustibility attribute. Generally, a sample will continue to burn due to the presence of agents, elements or compounds that facilitate combustion. When these agents are exhausted, combustion stops. At this point, the residual ash would conversely and most likely contain anti combustion agents, assuming at the end of combustion the sample remaining as ash is less than 1% of the wood material, if it is from temperate climate or higher, if it is from tropical climate(Wagh and Collins, 2011).

MATERIALS AND METHODS

Sample collection: The forty sawdust samples (comprised of ten samples from each wood type) used in this investigation were obtained from mature hard woods grown in the rainforest zone of southwestern Nigeria, from ten different sawmill collection, cutting and distribution plants in Lagos State.

Each wood sample was recognized and distinguished from another by the sawmill operators who gave the local names of the wood prior to cutting and sawing.

The saw dust samples were collected by hand from the freshly sawed wood and transferred into transparent polythene bags which were properly labeled. Precautions were taken during the collection such as using hand gloves to avoid contamination of the samples and screening to remove any impurity like stone or any other wood shavings found in the sample. All the samples were sun-dried for two days to discard any residual moisture which may have been introduced during lumbering, transportation or cutting.

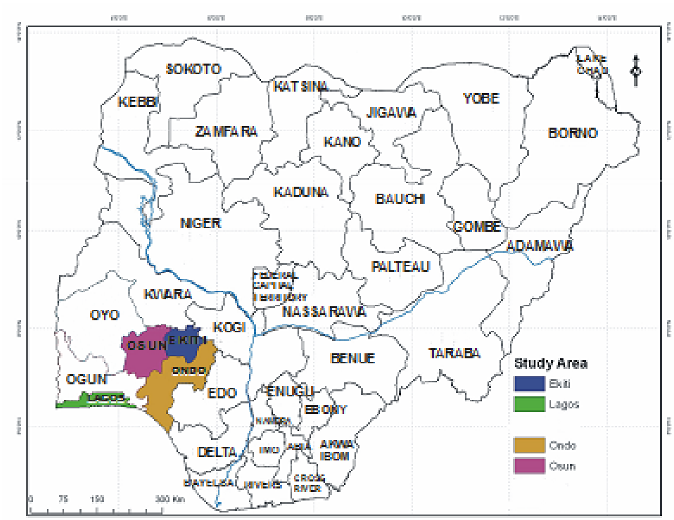

Fig. 1: Map showing locations of the wood samples

Table 1: Common and Botanical names of the wood samples

S/N	Common names	Botanical names
1	Mahoghany	Khaya ivorensis
2.	African Peach or Opepe	Sarcocephalus latifolius
3.	Peculiar	Botyrchium paradoxum
4.	Poro poro	Sorghum bicolour

Determination of moisture content: The moisture content of the wood samples is important because moisture supports combustion. This is as a result of the production of steam during combustion of the samples. As heat developes, the steam produced is increased influencing the extent to which the sample combusts (Pettersen, 1984). 10g of each sample was weighed into a crucible. The crucible containing the sample was placed in an oven. The temperature of the oven was adjusted to 105^oC(Pettersen, 1984). In 30 minutes, the temperature of 105°C was attained and maintained by the oven. The 'dried' sample was allowed to cool for 3hr and the weight taken. The crucible and its content were placed again in the oven and heated. This process was repeated every 3hours until a constant weight was obtained. The moisture content of each sample was determined by weight difference.

Ash content determination: According to Tappi Standard T15 and ASTM Standard D1102, ash is defined as the residue remaining after dry ignition of the wood at 575°C. 10g of each sample in a porcelain crucible was placed in a furnace one at a time using an insulated metal tong. The thermostat dial of the furnace was set at 600°C. As the temperature of the furnace reached the set temperature the sample was left in the furnace for another 20minutes. After combustion, the porcelain crucible was removed with the insulated metal tong and kept to cool for 3 hours before weighing. The furnace was switched off before putting or removing the samples. The process was repeated every three hours until a constant weight was obtained. The mass of the ash was determined by weight difference. The samples were placed in a dessicator prior to further analyses.

Aspiration of the ash powder suspension in water: 0.5g of each ash powder was mixed with water in the barrel of a 10ml syringe up to 8mls. The water served a dual purpose; as the carrier medium or suspending agent and the pressurizing agent while the ash was the extinguishing powder. A 15cm wooden splint and $1cm^3$ of gasoline (representing classes A and B fire materials) were used for the extinguishing test. They were lit with a gas lighter and the ash powder in water suspension aspirated from the syringe. The volume of the ash suspension that extinguished the flame was read from the calibration on the syringe. The syringe was cleaned and properly rinsed each time with de- ionized water before another ash suspension was put in.

The time taken to put off the flame and the burning to stop was recorded. There was no residue emanating from the test extinguisher after the burning. For the purpose of comparison, crystal A B C dry chemical powder fire extinguisher, a product of China but used commonly in Nigeria was equally used in extinguishing the same classes of fire materials and the volumes that extinguished the flames correspondingly recorded. Before using the syringe, the pressure handle was tested for a smooth movement on the barrel wall.

Metal analysis: The determination of metal concentration was carried out using an Atomic Absorption Spectrophotometer (GBC Scientific equipment), according to the American Public Health Association guidelines (APHA, 1995). The following metals were analyzed for: Iron (Fe), Manganese (Mn), Zinc (Zn), Magnesium (Mg) and Calcium (Ca). These metals were selected for determination because they are commonly found in wood (Akpabio and Jauro, 2002) The sawdust and sawdust ash samples were digested using 20ml of Perchloric acid ($HClO_4$), Nitric acid (HNO_3) and Sulphuric acid (H_2SO_4), in the ratio 1:2:2 by volume. A calibration curve was plotted using a five point calibration standard and hence a regression equation obtained. The sample blank was aspirated into the AAS. The energy of the system was zeroed, before the aspiration of the samples. The absorbances obtained were used to calculate the concentration of the analyte from the regression equation.

RESULTS AND DISCUSSION

Moisture and ash content: Mahogany (Khaya ivorensis) has the highest moisture content while opepe(Sarcocephalus latifolius) has the least. Poro poro(Sorghum bicolour) has the highest ash content while opepe(Sarcocephalus latifolius) has the least ash content as shown on table 2. The mean moisture content ranges from 0.9362±0.45 to 2.6615±0.64 which represents a percentage variation of 9.36% to 26.62% while the mean ash content ranges from 0.6083±0.25 to 2.0997±0.64 which represents a percentage variation of 6.08% to 20.99%. Thus, the moisture and the ash contents constitute approximately between 15- 48% of the wood saw dust studied

*Metal content***:** Mahogany (Khaya ivorensis),has the highest concentration of all the metals for both saw dust and saw dust ash while Poro poro (Sorghum bicolour) has the lowest concentration of all the metals for both saw dust and saw dust ash.

Magnessium has the highest concentration of all the metals while zinc has the lowest concentration. Two factors may contribute to this variation; the natural abundance of the metals in the wood and the extent of decomposition of their carbonates. The carbonates of these metals, one of the forms in which they occur in the wood are thermally unstable. So, they break down on heating, to their metal oxides and carbon dioxide. The carbon dioxide is known to aid fire extinguishing. However, the extinguishing effect of the carbon dioxide is offset by the steam generated by the contained moisture which is known to aid combustion.

The correlation between the mean metal concentration and the mean moisture content was tested with the mean magnesium and zinc concentrations. The coefficients of correlation were 0.813 and 0.867 respectively for magnesium and zinc against the mean moisture content. This positive coefficient of correlation suggests that the moisture content may influence the sorption of metals in the wood plants

Extinguishing strength: The extinguishing strength of the saw dust ash was determined from the volume of the ash suspension used to put off the burning flames of the splint and the gasoline. The smaller the volume of the suspension used to put off the flame, the more the extinguishing strength. The mean volumes of the ash suspension of mahogany and opepe used to put off the burning flames of the wooden splint and the gasoline were comparatively the least. Therefore, the wood ashes of mahogany and opepe have the greatest extinguishing strength while the wood ash of poro poro has the least extinguishing strength. The metal concentrations of mahogany and opepe are the highest among the wood samples studied; and therefore may suggest that the metallic content of an ash sample has a positive influence on the extinguishing strength. However, the same may not be said of the moisture content because while mahogany has corresponding highest moisture content, opepe has the least moisture content.

The mean extinguishing volumes of crystal ABC fire extinguisher for both the wooden splint and the gasoline were less than the extinguishing volumes of the ash suspension. This implies that the crystal ABC fire extinguisher has more extinguishing strength than the four wood ash suspensions studied. Therefore, some improvements on the wood ashes may be necessary to enhance their extinguishing strength. Saw dust is a waste. So, it costs little or nothing, other than the cost of collection and transportation. The residue of ash left after the extinguishing is not harmful.

Table 2: Mean moisture and ash contents

S/N	Sample	Moisture content(g)	Ash content (g)
1	Poro poro	1.0863±0.45 (10.86%)	2.0997±0.64 (20.99%)
2	Peculiar	0.9895±0.15 (9.90%)	1.0633±0.75 (10.63%)
3	Opepe	0.9362±0.45 (9.36%)	0.6083±0.25 (6.08%)
4	Mahoghany	2.6615±0.64 (26.62%)	1.5483±0.35 (15.48%)

Table 3: Mean metal concentration of (a) sawdust and (b) sawdust ash (ppm**)**

S.N.	Sample	Fe	Mn	Mg	Ca	Zn
1	Poro poro	**a** 1.749±0.85	1.114± 0.54	1.932±0.67	1.213± 0.56	0.997±0.75
		b 2.012±0.5	1.281±0.86	2.222±0.73	1.394±0.86	1.146±0.45
2	Peculiar	**a** 2.876±0.43	2.082±0.34	3.385±0.75	2.569±0.25	1.032±0.25
		b 3.308±0.45	2.394±0.95	3.892±0.35	2.954±0.21	1.187±0.24
3	Opepe	**A**4.090±0.73	3.438±0.32	5.191±0.45	4.640±0.95	1.445±0.78
		b 4.704±0.21	3.954±0.21	5.970±0.45	5.336±0.45	1.662±0.35
4	Mahoghany	**a** 5.881±0.21	4.439±.54	7.874±0.55	5.911±0.65	1.980±1.23
		b 6.764±0.35	5.105±0.56	9.055±0.31	6.789±0.55	2.277±0.55

Table 4: Mean extinguishing volume of ash suspension (Ml)

Sample	Substrate Splint	Gasoline
Poro poro	2.50± 1.32	4.10± 2.54
Perculiar	1.35 ±0.65	2.50±0.11
Opepe	0.95±0.25	2.0±0.35
Mahogany	0.85±0.65	1.80±0.54

Conclusion: Mahogany (Khaya ivorensis) and Opepe (Sarcocephalus latifolius) wood ashes showed promise for use in fire extinguishing, but may need some chemical or physical modification to enhance their fire extinguishing strength.

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